

Instruction Manual



TCPA300/400 Amplifiers & TCP300/400 Series AC/DC Current Probes

071-1183-02

This document applies for firmware version 1.0 and above.

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

Copyright © Tektronix, Inc. All rights reserved. Licensed software products are owned by Tektronix or its suppliers and are protected by United States copyright laws and international treaty provisions.

Use, duplication, or disclosure by the Government is subject to restrictions as set forth in subparagraph (c)(1)(ii) of the Rights in Technical Data and Computer Software clause at DFARS 252.227-7013, or subparagraphs (c)(1) and (2) of the Commercial Computer Software - Restricted Rights clause at FAR 52.227-19, as applicable.

Tektronix products are covered by U.S. and foreign patents, issued and pending. Information in this publication supercedes that in all previously published material. Specifications and price change privileges reserved.

Tektronix, Inc., P.O. Box 500, Beaverton, OR 97077

TEKTRONIX and TEK are registered trademarks of Tektronix, Inc.

WARRANTY

Tektronix warrants that the products that it manufactures and sells will be free from defects in materials and workmanship for a period of one (1) year from the date of shipment. If a 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.

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 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.

Table of Contents

Preface	xv
Contacting Tektronix	xvi

Getting Started

System Configuration	1-1
Options	1-3
Standard Accessories	1-4
Optional Accessories	1-5
Probe Covers	1-6
Travel Case	1-7
Connecting the Amplifier to an Oscilloscope	1-8
Power on the Amplifier	1-8
Connecting a Current Probe to the Amplifier	1-9
Operating the Current Probe Slide	1-10
Degaussing and Autobalancing the Current Probe	1-11
DC Measurements	1-12
AC Measurements	1-14

Operating Basics

Control Summary	2-1
TCPA300 and TCPA400 Controls	2-2
PROBE DEGAUSS AUTOBALANCE Button and Indicator	2-2
MANUAL BALANCE Buttons and Indicator	2-3
PROBE OPEN Indicator	2-3
OVERLOAD Indicator	2-3
NOT TERMINATED INTO 50 Ω Indicator	2-4
NONCOMPATIBLE PROBE TYPE Indicator	2-4
ON/STANDBY Button	2-4
RANGE Button (TCPA300 only)	2-4
COUPLING Button and Indicators	2-4
PROBE INPUT Connector	2-5
OUTPUT Connector	2-5
Probe DC Gain Adjust (located on probes)	2-5
GPIB Operation	2-6

Reference

Reference Notes	3-1
Degaussing a Probe with an Unpowered Conductor in the Jaws	3-1
Measuring Differential Current	3-2
AC and DC Coupling	3-3
Maximum Current Limits	3-4
Measuring Noncontinuous Current with the TCP404XL Probe	3-6
Extending Current Range	3-8
Increasing Sensitivity	3-10
Application Notes	3-11

Automobile Charging Systems	3-11
Inductance Measurements	3-13
Continuity Test of Multiple-Conductor Cable	3-15
Measuring Inductor Turns Count	3-16
Power Measurement and Analysis Software	3-17
Troubleshooting and Error Codes	3-19
Displaying Error Codes with the Probe Degauss Autobalance Button	3-22
Correcting the Cause of an Error Code	3-24
Shutdown Error	3-24

Specifications

Warranted Specifications	4-1
Nominal and Typical Characteristics	4-2
Mechanical Characteristics	4-3
Environmental Characteristics	4-5
TCP404XL Maximum Measurement Times	4-12

Performance Verification

Performance Verification Overview	5-1
Performance Verification and Functional Checks	5-1
Test Procedure Conditions	5-2
Equipment Preparation	5-2
TCPA300 and TCPA400 Performance Verification	5-3
Equipment Required	5-3
Making DC Current Loops	5-4
Front-Panel Display	5-5
DC Gain Accuracy	5-6
Bandwidth	5-9
AC Coupling	5-12
Degauss	5-13
Current Overload Test	5-14
TCPA300 Amplifier Test Record	5-16
TCPA400 Amplifier Test Record	5-17
TCP305 and TCP312 Performance Verification	5-19
Required Test Equipment	5-20
DC Gain Accuracy	5-21
Rise Time	5-24
Bandwidth	5-26
TCP305 Current Probe Test Record	5-29
TCP312 Current Probe Test Record	5-30
TCP303 and TCP404XL Performance Verification	5-31
Equipment Required	5-32
DC Gain Accuracy	5-33
Rise Time	5-36
Bandwidth (TCP303)	5-39
Bandwidth (TCP404XL)	5-41
TCP303 Current Probe Test Record	5-42
TCP404XL Current Probe Test Record	5-43

Adjustment Procedures

Adjustment Procedures Overview	6-1
TCPA300 and TCPA400 Amplifier Adjustments	6-3
Required Test Equipment	6-3
Accessing the Adjustments	6-3
TCPA300 Amplifier	6-4
TCPA400 Amplifier	6-5
TCP305 and TCP312 Adjustments	6-7
Required Test Equipment	6-7
Accessing the Adjustments	6-7
TCP305 and TCP312 DC Gain Adjustment	6-8
TCP303 and TCP404XL Adjustments	6-11
Required Test Equipment	6-11
Adjustment Locations	6-12
TCP303 and TCP404XL Transient Response and Coarse Gain Adjustment ..	6-13
DC Gain Adjustment	6-18

Maintenance

Customer Maintenance	7-1
Service Strategy	7-1
Preventive Maintenance	7-1
Disassembly	7-3
Amplifiers	7-3
Equipment Required	7-3
Removing the Outer Case and Internal Covers	7-4
Replacing the Front Panel Assembly	7-7
Replacing the Amplifier Board	7-8
Replacing the Power Supply	7-10
Replacing the Fan	7-11
Probes	7-13
Equipment Required	7-13
TCP305 and TCP312	7-14
TCP303 and TCP404XL	7-18
Isolating Hardware Faults	7-21
Determining the Amplifier Firmware Version Number	7-22

Replaceable Parts

Replaceable Parts	8-1
Parts Ordering Information	8-1
Using the Replaceable Parts List	8-1
Amplifier Replaceable Parts	8-3
Current Probes Replaceable Parts	8-9

Glossary and Index

List of Figures

Figure 1-1: Typical TCPA300/400 current measurement system . . .	1-1
Figure 1-2: Using the probe holders	1-6
Figure 1-3: Equipment locations in the travel case	1-7
Figure 1-4: Connecting and disconnecting a current probe to the amplifier	1-9
Figure 1-5: TCP312 and TCP305 slide operation	1-10
Figure 1-6: TCP303 and TCP404XL slide operation	1-11
Figure 1-7: Current probe polarity	1-13
Figure 2-1: The TCPA300 front panel	2-1
Figure 3-1: Measuring differential current and nulls	3-3
Figure 3-2: Effect of AC or DC coupling on low-frequency signals .	3-3
Figure 3-3: Applying the amp-second product rule	3-5
Figure 3-4: Duty cycle calculation	3-6
Figure 3-5: Increasing the DC measurement range	3-9
Figure 3-6: Increasing probe sensitivity	3-10
Figure 3-7: Setup for measuring charging current	3-12
Figure 3-8: Charge Current Waveforms	3-12
Figure 3-9: Measuring inductance with a low-impedance source . .	3-13
Figure 3-10: Linear current vs. time ramp	3-14
Figure 3-11: Measuring inductance with a high-impedance source .	3-15
Figure 3-12: High-impedance source current ramp	3-15
Figure 3-13: Measuring the number of turns in a coil	3-16
Figure 3-14: Turns measurement using reference coil	3-17
Figure 3-15: Error code display	3-22
Figure 3-16: Interpreting the error code display	3-23
Figure 4-1: Probe jaw dimensions (nominal)	4-4
Figure 4-2: Frequency derating-TCP312	4-8
Figure 4-3: Frequency derating-TCP305	4-8
Figure 4-4: Frequency derating-TCP303	4-9
Figure 4-5: Frequency derating-TCP404XL	4-9
Figure 4-6: Insertion impedance graphs for the current probes . . .	4-10
Figure 4-7: Specified operating area of the probes	4-11

Figure 4-8: Measuring 750A noncontinuous at 50 °C ambient temperature	4-12
Figure 4-9: Measuring 600A noncontinuous at 50 °C ambient temperature	4-12
Figure 4-10: Measuring 750A noncontinuous at 23 °C ambient temperature	4-13
Figure 5-1: Check LED functionality	5-5
Figure 5-2: Equipment setup for DC gain accuracy test	5-6
Figure 5-3: Bandwidth test setup	5-9
Figure 5-4: AC coupling test setup	5-12
Figure 5-5: Setup for degaussing the current probe	5-13
Figure 5-6: Overload test setup	5-14
Figure 5-7: DC gain accuracy test setup for TCP305 and TCP312 .	5-21
Figure 5-8: Rise time test setup for the TCP305 and TCP312	5-24
Figure 5-9: Bandwidth test setup for TCP305 and TCP312	5-26
Figure 5-10: DC gain accuracy test setup for the TCP303 and TCP404XL	5-33
Figure 5-11: Rise time test setup for the TCP303 and TCP404XL .	5-36
Figure 5-12: Bandwidth test setup for TCP303	5-39
Figure 6-1: Amplifier adjustments	6-4
Figure 6-2: Gain adjustment locations	6-5
Figure 6-3: TCP305 and TCP312 DC gain adjustment location ...	6-7
Figure 6-4: DC gain adjustment setup for TCP305 and TCP312 ..	6-9
Figure 6-5: TCP303 and TCP404XL adjustment locations	6-12
Figure 6-6: TCP303 and TCP404XL transient response and coarse gain adjustment setup	6-14
Figure 6-7: DC gain accuracy adjustment setup	6-18
Figure 7-1: Removing the case from the amplifier	7-4
Figure 7-2: Removing the right-side inner panel	7-5
Figure 7-3: Removing the left-side inner panel	7-6
Figure 7-4: Disconnecting the front panel assembly	7-7
Figure 7-5: Removing the three heat sink clips	7-8
Figure 7-6: Removing the amplifier board	7-9
Figure 7-7: Replacing the power supply	7-10
Figure 7-8: Removing the AC power connector	7-11
Figure 7-9: Removing the fan	7-12

Figure 7-10: Removing the strain relief boot	7-14
Figure 7-11: Removing the top half of the probe	7-15
Figure 7-12: Removing the probe slide	7-15
Figure 7-13: Removing the current transformer	7-16
Figure 7-14: Removing the circuit board and cable assembly	7-17
Figure 7-15: Removing the handle	7-18
Figure 7-16: Removing the current transformer	7-19
Figure 7-17: Displaying the amplifier firmware version number ..	7-22
Figure 8-1: TCPA300 and TCPA400 replaceable parts	8-3
Figure 8-2: TCPA300 and TCPA400 standard accessories	8-6
Figure 8-3: TCPA300 and TCPA400 optional accessories	8-7
Figure 8-4: TCP305 and TCP312 replaceable parts	8-9
Figure 8-5: TCP303 and TCP404XL replaceable parts	8-11

List of Tables

Table 1-1: Amplifier options	1-3
Table 1-2: Service options	1-3
Table 3-1: Unpowered circuit degauss limits	3-1
Table 3-2: Automobile charging systems test setup	3-11
Table 3-3: Troubleshooting	3-19
Table 3-4: Amplifier error codes	3-23
Table 4-1: Warranted TCPA300 and TCPA400 specifications	4-1
Table 4-2: Nominal and typical amplifier characteristics	4-2
Table 4-3: TCPA300 and TCPA400 mechanical characteristics ...	4-3
Table 4-4: Probe mechanical characteristics	4-4
Table 4-5: Shipping weights and dimensions	4-4
Table 4-6: Environmental characteristics	4-5
Table 4-7: Certifications and compliances	4-6
Table 5-1: Amplifier checks	5-1
Table 5-2: Probe performance verification checks	5-1
Table 5-3: Required test equipment	5-3
Table 5-4: Equipment settings	5-7
Table 5-5: DC gain accuracy test for the TCPA300 and TCPA400 .	5-7
Table 5-6: Equipment settings for bandwidth check	5-9
Table 5-7: TCPA300 bandwidth measurements	5-11
Table 5-8: TCPA400 bandwidth measurements	5-11
Table 5-9: TCPA300 AC coupling measurements	5-13
Table 5-10: Maximum current ratings for TCPA300-compatible probes	5-15
Table 5-11: Required test equipment	5-20
Table 5-12: Equipment settings for DC gain accuracy	5-21
Table 5-13: DC gain accuracy test for the TCP305 and TCP312 ..	5-23
Table 5-14: Equipment settings for rise time	5-25
Table 5-15: Equipment settings for bandwidth	5-27
Table 5-16: Bandwidth test for the TCP305 and TCP312	5-28
Table 5-17: Required test equipment	5-32
Table 5-18: Equipment settings for DC gain accuracy	5-33

Table 5-19: DC gain accuracy test worksheet for the TCP303 and TCP404XL	5-35
Table 5-20: Equipment settings for rise time	5-37
Table 5-21: Equipment settings for bandwidth	5-40
Table 5-22: Bandwidth test for the TCP303	5-41
Table 6-1: Amplifier and probe adjustments	6-1
Table 6-2: Required test equipment	6-3
Table 6-3: TCPA300 gain adjustments	6-4
Table 6-4: TCPA400 gain adjustments	6-5
Table 6-5: Required test equipment	6-7
Table 6-6: Settings for DC gain adjustment	6-8
Table 6-7: DC gain accuracy adjustments for the TCP305 and TCP312	6-9
Table 6-8: Required test equipment	6-11
Table 6-9: Settings for transient response and preliminary gain adjustments	6-14
Table 6-10: Equipment settings for DC gain accuracy	6-19
Table 6-11: DC gain accuracy adjustments for the TCP303 and TCP404XL	6-19
Table 7-1: Equipment required	7-3
Table 7-2: Equipment required	7-13
Table 7-3: Amplifier hardware faults	7-21
Table 7-4: Probe hardware faults	7-22
Table 8-1: Power cord identification	8-5

General Safety Summary

Review the following safety precautions to avoid injury and prevent damage to this product or any products connected to it. To avoid potential hazards, use this product only as specified.

Only qualified personnel should perform service procedures.

While using this product, you may need to access other parts of the system. Read the *General Safety Summary* in other system manuals for warnings and cautions related to operating the system.

To Avoid Fire or Personal Injury

Use Proper Power Cord. Use only the power cord specified for this product and certified for the country of use.

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. Connect the probe output to the measurement instrument before connecting the probe to the circuit under test. Disconnect the probe input and the probe ground 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 ground lead of the probe to earth ground only.

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

Use Proper Fuse. Use only the fuse type and rating specified for this product.

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

Do Not Operate With Suspected Failures. If you suspect there is damage to this product, have it inspected by qualified service personnel.

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.

Symbols and Terms

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.*

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.

Symbols on the Product. The following symbols may appear on the product:



CAUTION
Refer to Manual



Protective Ground
(Earth) Terminal



Do not connect
to or disconnect
from uninsulated
Hazardous Live
conductors.



WARNING
Hot Surface



Do not connect to or
remove from an
uninsulated conductor that
is HAZARDOUS LIVE.



Breakable.
Do not drop.



Use only on an
insulated wire.

Service Safety Summary

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

Do Not Service Alone. Do not perform internal service or adjustments of this product unless another person capable of rendering first aid and resuscitation is present.

Disconnect Power. To avoid electric shock, switch off the instrument power, then disconnect the power cord from the mains power.

Use Care When Servicing With Power On. Dangerous voltages or currents may exist in this product. Disconnect power, remove battery (if applicable), and disconnect test leads before removing protective panels, soldering, or replacing components.

To avoid electric shock, do not touch exposed connections.

Preface

This Instruction Manual supports the operation and basic maintenance of the TCPA300 and TCPA400 Current Probe Amplifiers, and the TCP300/400 Series AC/DC current probes that mate with the amplifiers. The current probes covered in this manual are listed below:

- TCP312 (30 amps, 100 MHz, compatible with TCPA300)
- TCP305 (50 amps, 50 MHz, compatible with TCPA300)
- TCP303 (150 amps, 15 MHz, compatible with TCPA300)
- TCP404XL (500 amps*, 2 MHz, compatible with TCPA400)
*750 amps DC derated with duty cycle

If you are not familiar with these products, please refer to the *Getting Started* and *Operating Basics* chapters of this manual for basic operating information.

If you are an advanced user, the *Reference* section contains information on advanced applications as well as user diagnostic and troubleshooting information.

The *Performance Verification* and *Adjustment Procedure* sections support the qualification and calibration of the probes when used with either amplifier.

The *Maintenance* section supports the routine maintenance and repair of mechanical parts associated with the amplifiers.

The *Glossary* and *Index* are provided as quick reference locators for important information.

Manual Conventions

The term “amplifier” is used to refer to either the TCPA300 or TCPA400 when referring to common attributes. If a subject is unique to either amplifier, the amplifier will be referred to directly by model.

The terms “current probe” and “probe” are used to refer to any of the TCP300/400 Series current probes when referring to common attributes. If a subject is unique to a particular probe, the probe will be referred to directly by model.

Contacting Tektronix

Phone	1-800-833-9200*
Address	Tektronix, Inc. Department or name (if known) 14200 SW Karl Braun Drive P.O. Box 500 Beaverton, OR 97077 USA
Web site	www.tektronix.com
Sales support	1-800-833-9200, select option 1*
Service support	1-800-833-9200, select option 2*
Technical support	Email: techsupport@tektronix.com 1-800-833-9200, select option 3* 1-503-627-2400 6:00 a.m. - 5:00 p.m. Pacific time

* **This phone number is toll free in North America. After office hours, please leave a voice mail message. Outside North America, contact a Tektronix sales office or distributor; see the Tektronix web site for a list of offices.**



Getting Started

Getting Started

The TCPA300 and TCPA400 current probe amplifiers let you use one probe to simultaneously measure AC and DC current. The amplifiers convert the sensed current into a proportional voltage signal that you can measure directly with an oscilloscope.

The TCPA300 and TCPA400 current probe amplifiers provide better linearity than other current measurement systems because of a current feedback process used with the probe. DC measurement capability and high bandwidth allow the amplifiers to accurately represent square waves and fast-rise signals.

The TCPA300 and TCPA400 and associated probes provide these features:

- Simultaneous DC and AC current measurements up to 750 A peak
- High sensitivity
- One-button autobalancing and probe degaussing
- No adjustments needed to match a current probe to an individual amplifier
- AC or DC coupling of signal
- Direct scaling and unit readout on compatible TEKPROBE level II oscilloscopes

System Configuration

A complete current measurement system consists of a current probe amplifier, a compatible current probe, and an appropriate oscilloscope. Refer to Figure 1-1.

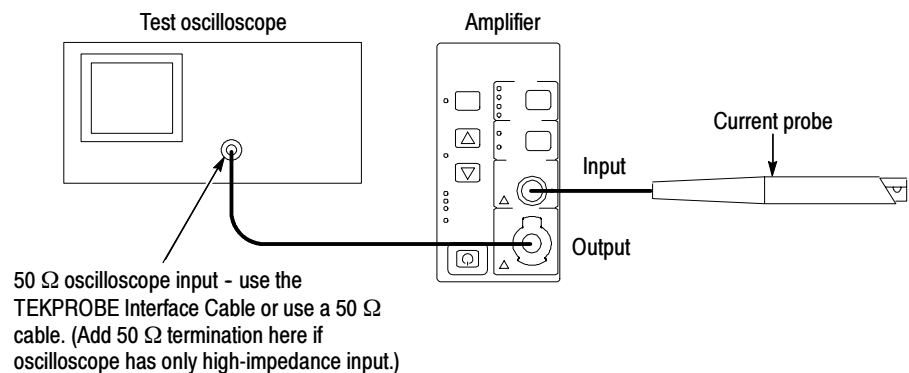


Figure 1-1: Typical TCPA300/400 current measurement system

TCPA300 and TCPA400 Current Probe Amplifiers

The amplifier amplifies the current sensed by the probe and converts the current to a proportional voltage that is displayed on an oscilloscope or other similar measuring device.

Current Probes

The following Tektronix current probes are compatible with the TCPA300 Amplifier:

- TCP312 (30 amps, 100 MHz)
- TCP305 (50 amps, 50 MHz)
- TCP303 (150 amps, 15 MHz)

The following Tektronix current probes are compatible with the TCPA400 Amplifier:

- TCP404XL (750 amps*, 2 MHz)
* 500 amps continuous, 750 amps DC derated with duty cycle

You can also use the CT-4 High-Current Transformer with the TCP305 and TCP312 current probes to extend the AC current measurement range to 20,000 peak amps.

Oscilloscope

An oscilloscope displays the output from the current measuring system. A 50 Ω cable is included to connect the amplifier to the oscilloscope input channel. A TEKPROBE-to-TEKPROBE interface cable is also included for connecting to TEKPROBE level II oscilloscopes.

If the oscilloscope does not have an input that can be set to 50 Ω impedance, you need a feedthrough 50 Ω termination. This termination is included as a standard accessory with your TCPA300 and TCPA400 Current Probe Amplifiers.

Options

Table 1-1 lists options that are available for the TCPA300 and TCPA400 amplifiers.

Table 1-1: Amplifier options

Option	Description
A1	Universal Euro power cord
A2	United Kingdom power cord
A3	Australia power cord
A5	Switzerland power cord
A6	Japan power cord
AC	China power cord
A99	No power cord
L5	Japanese Instruction Manual

Table 1-2 lists the Tektronix service options you can order for your amplifiers and probes. Designed to support tracking of calibration to requirements of ISO9000 and to provide for extended repair coverage, these options help fix your long-term maintenance costs and eliminate unplanned expenditures. Tektronix Service Options are available at the time you order your instrument. Contact your local Tektronix Sales Office for more information.

Table 1-2: Service options

Option	Description
D1	Provides the initial Test Data Report from the factory on delivery.
C3	Provides factory calibration certification on delivery, plus two more years of calibration coverage. Throughout the coverage period, the instrument will be calibrated according to its Recommended Calibration Interval.
D3	Provides test data on delivery plus a Test Data Report for every calibration performed during three years of coverage (requires Option C3).
R3	Extends product repair warranty to a total of three years.
C5	Provides factory calibration certification on delivery, plus four more years of calibration coverage. Throughout the coverage period, the instrument will be calibrated according to its Recommended Calibration Interval.
D5	Provides test data on delivery plus a Test Data Report for every calibration performed during five years of coverage (requires Option C5).
R5	Extends product repair warranty to a total of five years.

Standard Accessories

The following accessories are shipped with the amplifiers and probes. Refer to the *Replaceable Parts List* beginning on page 8-1 for Tektronix part numbers to use in ordering accessories.

Amplifiers

The following accessories are shipped with the TCPA300 and TCPA400 amplifiers.

- Power Cord (customer-chosen option)
- BNC Cable
- Termination, 50 Ω , 2W
- TEKPROBE Interconnect Cable
- Instruction Manual (English or Japanese; customer-chosen language option)
- Certificate of Traceable Calibration

Probes

When you order a current probe, you will receive these accessories:

- Probe cover
- Probe ground lead, 6 inch length (TCP305 and TCP312 only)
- Instruction Sheet
- Certificate of Traceable Calibration

Optional Accessories

You can order the following optional accessories for the amplifiers and probes. Refer to the *Replaceable Parts List* beginning on page 8-1 for Tektronix part numbers to use in ordering accessories.

- One-turn 50 Ω current loop. The current loop is used in the performance verification procedure for checking the performance of the TCPA300 Amplifier and the compatible probes.
- CT-4 High-Current Transformer. If you need to measure high-amplitude AC currents, consider using the CT-4 with the TCP303 and TCP312 probes. The CT-4 provides step-down ratios of 20:1 or 1000:1. For more information about the CT-4, consult your Tektronix sales representative.
- TCPA Calibration Adapter. Use the TCPA Calibration Adapter to verify the amplifier(s) performance independent of the current probes.
- Travel Case. The travel case includes room to store one amplifier and two current probes, along with related cables and adapters.
- Deskew Fixture. This fixture converts the PROBE COMPENSATION output or TRIGGER OUTPUT of the TDS5000 or TDS7000 into a set of test point connections that allow you a convenient way to compensate for timing differences between voltage and current probes.

Probe Covers

The TCP300/400 Series Current Probes come with a probe cover that stores the probe when not in use. Use the probe cover to hold your probe in a convenient place at your bench or workstation when you are not using it. You can attach the probe cover to the side of the bench to keep the probe off of your work surface. See Figure 1-2.

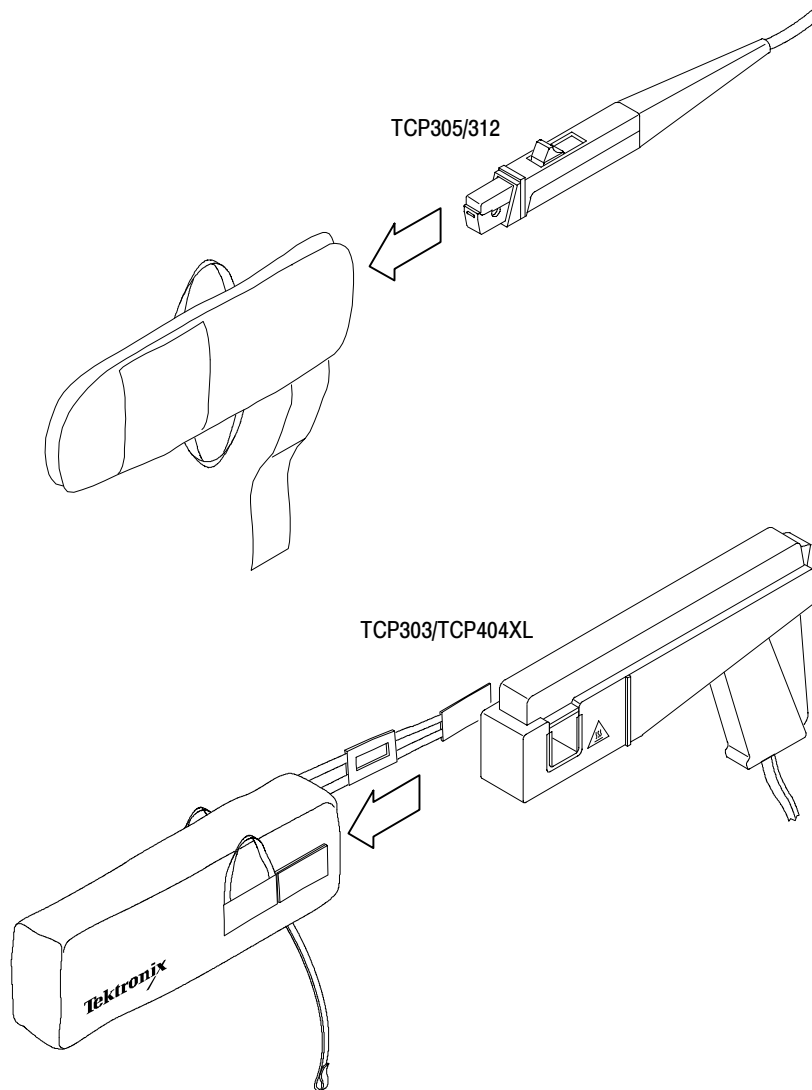


Figure 1-2: Using the probe covers

Travel Case

The travel case is a recommended accessory for the TCPA300/400 Amplifiers. The travel case includes room to store one amplifier and two TCP300/400 Series Current Probes, one of each size. (For example, you can store a TCP305 and a TCP303 probe.) A compartment is included to store associated cables and terminations. See Figure 1-3 for the proper location of the equipment.

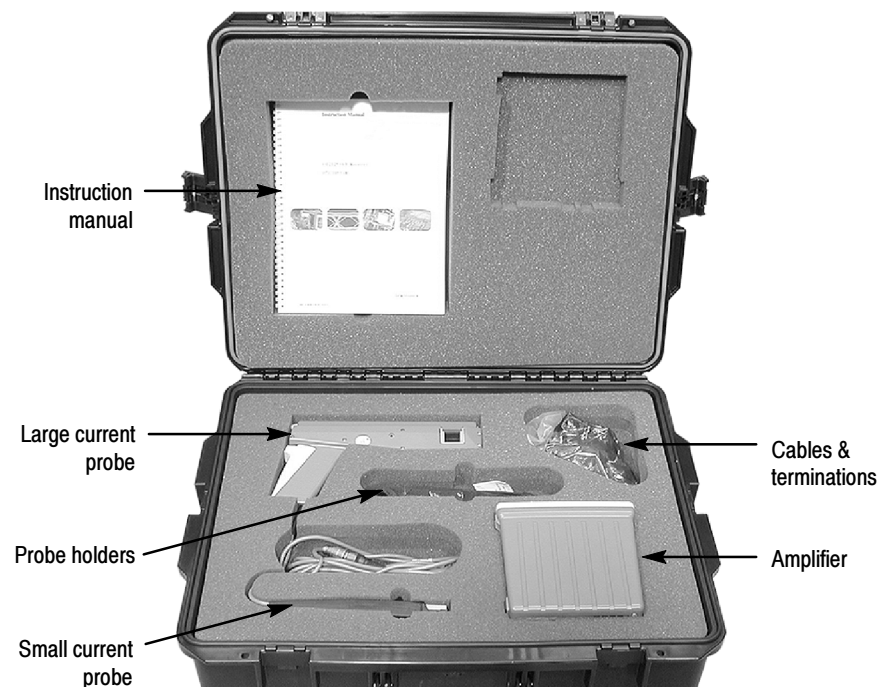


Figure 1-3: Equipment locations in the travel case

Connecting the Amplifier to an Oscilloscope

You will need an oscilloscope to display the TCPA300 and TCPA400 measurement output. To use the full dynamic range of the probe/amplifier combination, the oscilloscope must be capable of displaying a vertical scale factor of 1 mV/div to 1V/div.

If you are using a TEKPROBE II-compatible oscilloscope, use the TEKPROBE-to-TEKPROBE interface cable. Otherwise, use the supplied 50 Ω BNC cable to connect the amplifier OUTPUT connector to your oscilloscope (see Figure 1-1 on page 1-1).

The input impedance of the oscilloscope channel must be 50 Ω , or you will encounter slowed pulse response, increased aberrations, or incorrect DC measurement amplitudes. If your oscilloscope provides only 1 M Ω inputs, you need to attach a 50 Ω feed-through termination between the oscilloscope input and the BNC cable. Do not install this termination at the amplifier end of the BNC cable.

To utilize the full bandwidth capability of the TCPA300 and TCPA400 and attached current probe, the oscilloscope bandwidth must be approximately five times that of the current probe. For example, when using a TCP312 Current Probe, the oscilloscope bandwidth must be at least 500 MHz. When using a TCP305 Current Probe, the oscilloscope bandwidth must be at least 250 MHz.

After you have connected the amplifier to the oscilloscope, allow the equipment to warm up to a stable temperature; usually 20 minutes is required.

Power on the Amplifier

Connect the power cord to the power input connector on the rear of the amplifier, and then connect the power cord to your local mains supply (100 VAC to 240 VAC, 50 Hz to 400 Hz). To allow for proper ventilation, place the rear panel of the amplifier at least 2 inches away from any obstructions. Set the amplifier on the bottom rubber feet, and keep papers and other items away from the bottom of the amplifier which could restrict airflow and cause overheating.

Power on the amplifier by pressing the ON/STANDBY button at the lower-left corner of the front panel. The amplifier goes through a self-test and cycles the front-panel LEDs.

NOTE. *The amplifier stores the power state it is in when the power cord is unplugged. If you do not put the amplifier into STANDBY mode before unplugging it, the amplifier will power on immediately when you plug it in again.*

When you connect a probe to the amplifier, the amplifier uses detection circuitry to indicate probe conditions such as noncompatible probe type and probe open.

Connecting a Current Probe to the Amplifier

To connect a current probe to the amplifier input connector, align the red dot on the probe connector with the red dot on the amplifier front panel, as shown in Figure 1-4. Push the probe connector in to lock the connector. Do not twist the connector. The connector locks into place when you push it all the way into the front panel.

If you connect a probe to the wrong amplifier, (for example, a TCP312 to a TCPA400), the NONCOMPATIBLE PROBE TYPE LED illuminates. Disconnect the probe and use the correct amplifier. The TCPA400 amplifier accepts TCP3XX probes, but will only operate properly with TCP4XX probes.

To disconnect the probe from the amplifier, pull back on the connector housing and pull the connector straight off the front panel.



CAUTION. Handle current probes with care. Do not drop a probe or subject it to impact, or the core may crack.

Do not connect or disconnect a current probe while the probe is clamped around a live conductor, or the probe may suffer electrical damage.

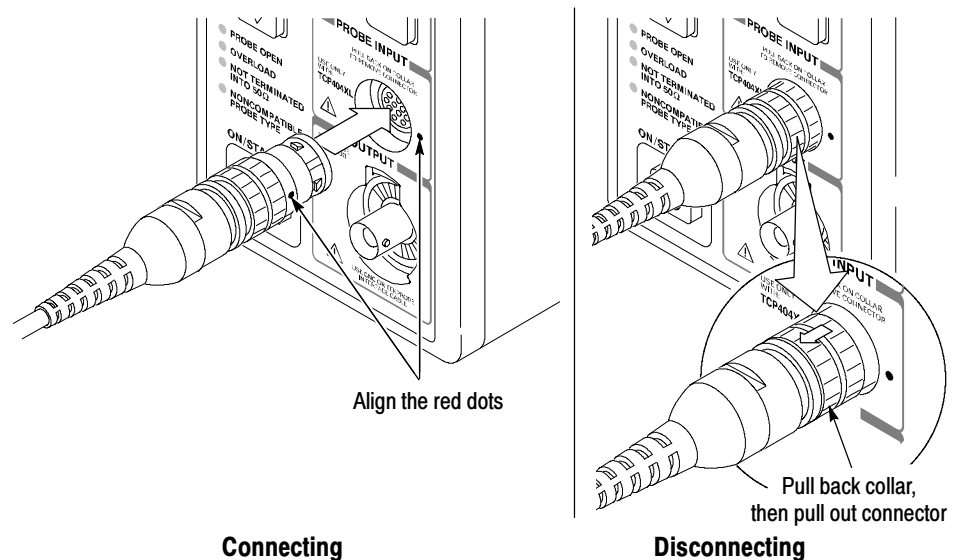


Figure 1-4: Connecting and disconnecting a current probe to the amplifier

Each current probe is calibrated before it is shipped, and should not require further adjustment. If a probe requires adjustment, refer to the *Adjustment Procedure Overview* on page 6-1 or contact your nearest Tektronix Service Center. The adjustment procedure must be performed only by qualified service personnel.

Operating the Current Probe Slide

The current probes each have a slide mechanism that opens and closes the probe jaw. This allows you to clamp the probe around a conductor under test. The slide must be locked closed to accurately measure current or to degauss the probe. If a probe is unlocked, the PROBE OPEN indicator on the amplifier will light.



WARNING. Do not clamp the TCP305 or TCP312 current probes around uninsulated wires. Damage to the probe or personal injury may result. Only use the TCP305 or TCP312 current probes on INSULATED wires.

The TCP303 and TCP404XL current probes can be used to measure current on uninsulated wires. However, the circuit must be de-energized when connecting or removing the current probe.

Figure 1-5 illustrates the slide operation of the TCP305 and TCP312 current probes. To open the probe, pull the slide back until the jaw is open. To lock the probe, push the slide forward until the detent snaps into place.

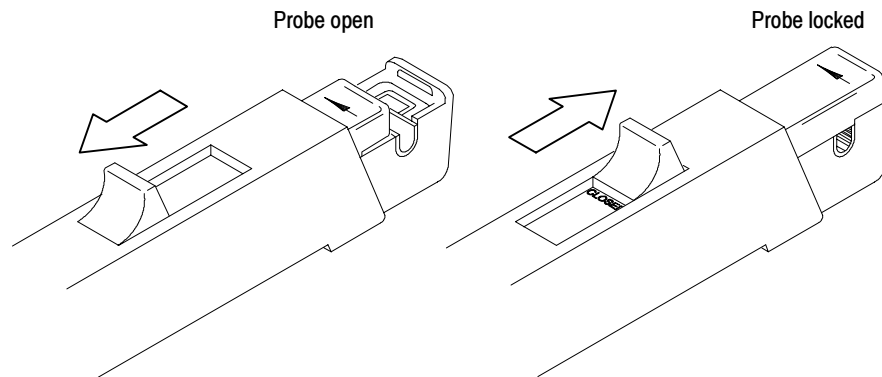


Figure 1-5: TCP312 and TCP305 slide operation

Figure 1-6 on page 1-11 illustrates the slide operation of the TCP303 and TCP404XL current probes. To open the probe, press the bottom of the lock button and squeeze the handle until the core is open. To lock the probe, release the squeeze handle and press the top of the lock button.

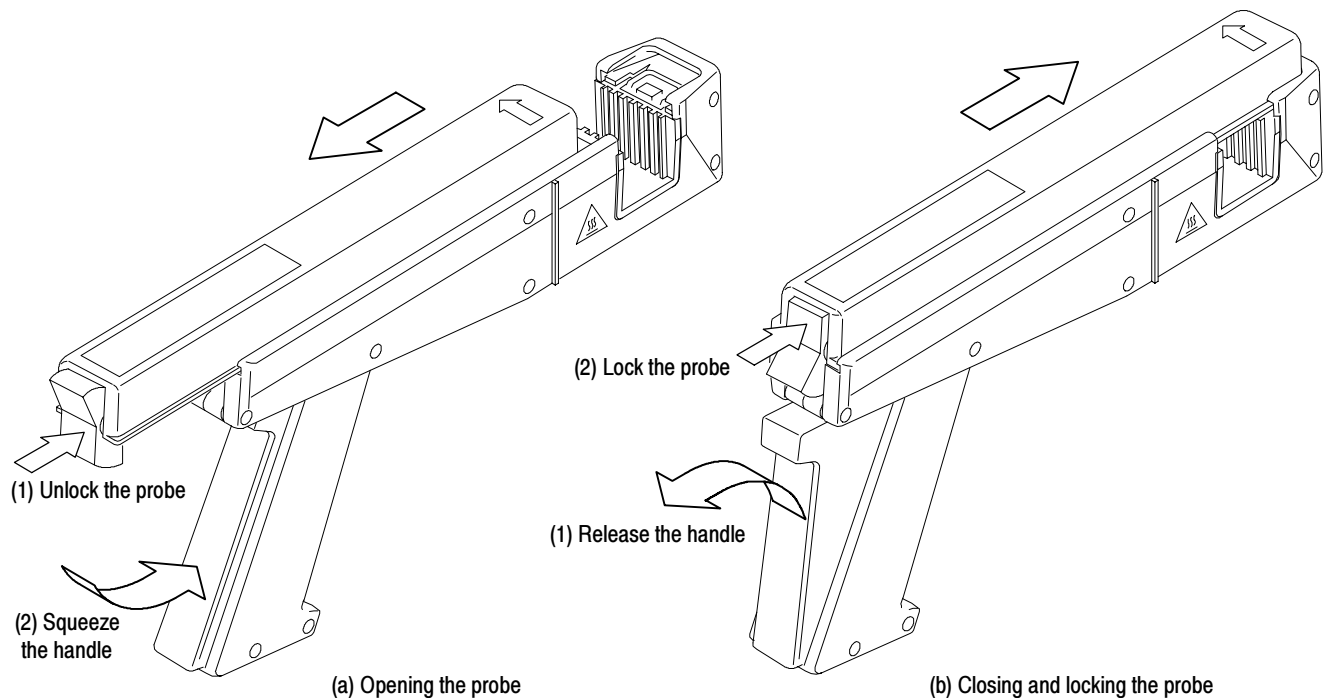


Figure 1-6: TCP303 and TCP404XL slide operation

Degaussing and Autobalancing the Current Probe

Degaussing the probe removes any residual magnetization from the probe core. Such residual magnetization can induce measurement error. Autobalancing removes unwanted DC offsets in the amplifier circuitry. Failure to degauss the probe is a leading cause of measurement errors. The DEGAUSS LED flashes until you degauss the probe.

To degauss the probe, disconnect the probe from the test circuit, or ensure that the conductor under test has no power, close and lock the slide, and then press the amplifier PROBE DEGAUSS AUTOBALANCE button on the front panel of the amplifier. To maintain measurement accuracy, degauss your probe in each of these cases:

- After you turn on the amplifier 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 connect a new probe.
- Whenever you subject the probe to a strong external magnetic field.
- Periodically during normal use.

To degauss and autobalance a current probe, perform these steps:

1. Verify that the current probe is connected to the amplifier.
2. Remove the current probe from the conductor under test.
3. Lock the probe slide closed (see Figures 1-5 and 1-6).
4. Press the amplifier **PROBE DEGAUSS AUTOBALANCE** button.
5. Wait about five seconds for the degauss procedure to complete.

The PROBE DEGAUSS AUTOBALANCE LED glows green when the operation has successfully completed. If the LED is blinking orange, the degauss operation is still in progress. If the LED is red, the operation failed, and the cause of the failure needs to be found and fixed. For more information, refer to the PROBE DEGAUSS AUTOBALANCE button discussion on page 2-2.

NOTE. *The degauss procedure will fail if the amplifier is not properly connected to an oscilloscope having 50 Ω input impedance. If this occurs, the NOT TERMINATED INTO 50 Ω LED lights on the amplifier front panel.*

After you have completed the oscilloscope adjustments and the amplifier degauss/autobalance procedure, your system is ready to measure current.

DC Measurements

To measure DC current, perform these steps:

1. Verify that the amplifier and the oscilloscope input coupling are set to DC, and the input impedance is set to 50 Ω .
2. Lock the probe closed without a conductor passing through it.
3. Adjust the ground reference of the oscilloscope to move the trace to the desired graticule line.
4. Press the amplifier **PROBE DEGAUSS AUTOBALANCE** button.

The NOT TERMINATED INTO 50 Ω LED is lighted if impedance is not 50 Ω . If this is the case, make necessary changes. (For example, use a 50 Ω termination.)

5. After the degauss/autobalance routine completes, adjust the ground reference (if necessary) using the amplifier **MANUAL BALANCE** controls.



WARNING. Do not clamp the TCP305 or TCP312 current probes around uninsulated wires. Damage to the probe or personal injury may result. Only use the TCP305 or TCP312 current probes on INSULATED wires.

The TCP303 and TCP404XL current probes can be used to measure current on uninsulated wires. However, the circuit must be de-energized when connecting or removing the current probe.

6. Open the probe slide, place the probe around the conductor under test, and then lock the slide. For correct measurement polarity, make sure the probe arrow is pointing in the direction of conventional (positive to negative) current flow. Reversing the flow will display the current waveform upside-down on the oscilloscope.
7. Adjust the oscilloscope time base, trigger, and gain as needed.

Figure 1-7 shows a current probe connected to a power supply line. Notice that the probe arrow points toward the negative terminal of the power supply to conform to the conventional current flow of positive (+) to negative (-).

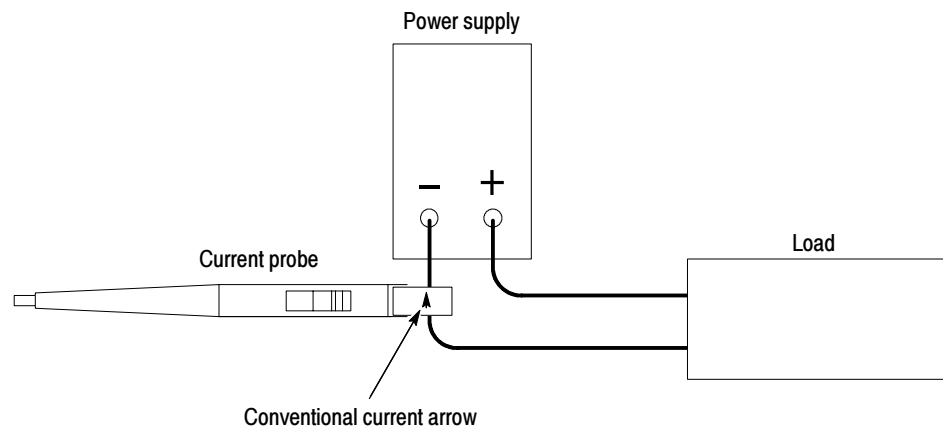


Figure 1-7: Current probe polarity

AC Measurements

To measure AC current only, and remove the DC component of the current being measured, follow the instructions below. These are identical to the instructions for DC current measurements except that the amplifier coupling in step 2 is set to AC.

1. Verify that the oscilloscope input coupling is set to DC.
2. Verify that the amplifier input coupling is AC, and the input impedance is set to 50 Ω . (The NOT TERMINATED INTO 50 Ω LED is on if impedance is not 50 Ω .)
3. Adjust the ground reference of the oscilloscope to move the trace to the desired graticule line.
4. Lock the probe closed without a conductor passing through it, and then press the amplifier **PROBE DEGAUSS AUTOBALANCE** button.



WARNING. Do not clamp the TCP305 or TCP312 current probes around uninsulated wires. Damage to the probe or personal injury may result. Only use the TCP305 or TCP312 current probes on INSULATED wires.

The TCP303 and TCP404XL current probes can be used to measure current on uninsulated wires. However, the circuit must be de-energized when connecting or removing the current probe.

5. Open the probe slide, place the probe around the conductor under test, and then lock the slide. For correct measurement polarity, make sure the probe arrow is pointing in the direction of conventional (positive to negative) current flow. Reversing the flow will invert the displayed current waveform on the oscilloscope.

NOTE. Even when making AC current measurements, leave the oscilloscope coupling on DC. Change only the amplifier coupling to AC. Using the oscilloscope AC coupling may cause the amplifier to exceed its output dynamic range.

6. Adjust the oscilloscope time base and trigger as needed.



Operating Basics

Control Summary

This section describes the function of each TCPA300 and TCPA400 front panel control and connector. The overview in Figure 2-1 is followed by a detailed description.

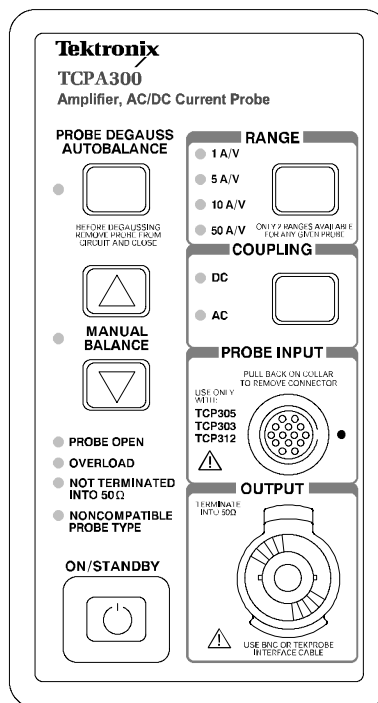
Some seldom-used functions do not appear in Figure 2-1. These functions are completely discussed in the detailed descriptions that follow Figure 2-1.

The PROBE DEGAUSS AUTOBALANCE button removes residual magnetism from the attached current probe. A multi-color LED indicates the status of the degauss circuit.

The MANUAL BALANCE buttons allow you to fine-adjust DC offset from the amplifier. The adjacent LED lights when one of the buttons has been pressed.

The four probe error lights indicate the following faults: PROBE OPEN, OVERLOAD (current or temperature), NOT TERMINATED INTO 50 Ω and NONCOMPATIBLE PROBE TYPE.

The ON/STANDBY button turns on power to the amplifier.



The RANGE button toggles between the two scale factors that are available for the attached probe (TCPA300 only). LEDs indicate the selected range.

The COUPLING button selects AC or DC probe coupling, as indicated by the LEDs.

The current probes connect to the TCPA300 and TCPA400 at the PROBE INPUT connector.

The TCPA300 and TCPA400 output appears at the OUTPUT connector. Connect this to a 50 Ω input of your oscilloscope.

Figure 2-1: The TCPA300 front panel

TCPA300 and TCPA400 Controls

PROBE DEGAUSS AUTOBALANCE Button and Indicator

These front panel controls and indicators are common to both the TCPA300 and TCPA400 current probe amplifiers, unless otherwise indicated.

When pressed, this button performs two functions that maximize measurement accuracy. First, the amplifier generates a degauss signal to remove any residual magnetism from the attached current probe. Second, the amplifier initiates an operation to remove any undesired DC offsets from the circuitry. During the degauss process, the amplifier is busy and cannot be used to measure current.

The indicator light next to the PROBE DEGAUSS AUTOBALANCE button blinks red whenever the amplifier detects that the current probe needs degaussing. The amplifier cannot detect all circumstances that require probe degaussing, so you may need to degauss the probe at times when the PROBE DEGAUSS AUTOBALANCE light is not blinking red. The red blinking light serves as a reminder to degauss the current probe when one of the following conditions occurs:

- The amplifier has just been turned on with a current probe connected.
- The current probe has been changed.
- An overload was detected.

To perform the probe degauss/autobalance function, remove the probe from all conductors (or ensure that the conductor under test has no power), make sure the probe is locked closed, and then press the PROBE DEGAUSS AUTOBALANCE button. The probe degauss/autobalance routine will not pass if the current probe is disconnected from the amplifier input, or if it is unlocked (the PROBE OPEN LED is on).

The indicator blinks orange during the time the amplifier is busy performing the probe degauss functions. When the degauss and autobalance procedure is complete, the indicator light turns green.

The PROBE DEGAUSS AUTOBALANCE indicator light will be orange if the MANUAL BALANCE buttons have been pressed after a degauss has been successfully completed. This indicates that the DC offset value has been manually changed from the original value set during the degauss routine. Depending on the amount of offset (balance) you have entered with the MANUAL BALANCE buttons, another degauss operation may be necessary to ensure accurate measurements. Generally, if you change the DC offset by more than 5 divisions, you should de-energize the circuit under test and perform another degauss routine. Then, re-energize the circuit and take your measurements.

If the degauss operation has failed, and the AC and DC COUPLING LEDs are alternately flashing, this indicates the amplifier is displaying an error code with the four status LEDs on the lower-left front panel. If this occurs, refer to

Displaying Error Codes with the Probe Degauss Autobalance Button on page 3-22.

NOTE. *The NOT TERMINATED INTO 50 Ω LED is on when the amplifier output is not properly terminated into a 50 Ω load. Make sure your amplifier OUTPUT is connected to an oscilloscope input using a 50 Ω BNC cable, and that the oscilloscope input is set to 50 Ω impedance. See Figure 1-1 on page 1-1 for proper cabling.*

If your oscilloscope does not have 50 Ω impedance settings for inputs, you can place a 50 Ω feed-through termination on the oscilloscope input and connect the amplifier output cable to the termination. Do not place the feed-through termination at the amplifier end of the BNC connecting cable.

MANUAL BALANCE Buttons and Indicator

The MANUAL BALANCE buttons allow you to fine-adjust the DC offset that appears at the amplifier OUTPUT connector. The manual balance adjustment only functions when the amplifier is set to DC coupling, and the MANUAL BALANCE indicator is only lighted after you press one of the MANUAL BALANCE buttons in DC coupling mode.

PROBE OPEN Indicator

When lit, this indicator informs you that the current probe is unlocked. You must have the probe slide locked to degauss the probe or to accurately measure current.

OVERLOAD Indicator

When this LED is red, it informs you that the measurement you are taking exceeds the *continuous* amplitude limit of the TCPA300 and TCPA400. The detection circuits detect only low frequency and DC overloads. Since overloads can magnetize the probe, always degauss the probe after an overload. When the OVERLOAD indicator flashes red, it indicates the pulsed waveform is exceeding the amplitude limit of the amplifier.

When this LED is orange, it indicates that the safe operating temperature of the probe, and possibly the amplifier, has been exceeded. Disconnect the probe from the current source and allow time for the probe head and amplifier to cool.

When this LED blinks red and orange, it indicates that both the safe operating temperature of the probe and the current limit have been exceeded.



WARNING. *To avoid personal injury or equipment damage, do not exceed the specified electrical limits of the TCPA300 and TCPA400 or any applicable accessories.*

**NOT TERMINATED
INTO 50 Ω Indicator**

When lit, this indicator informs you that the TEKPROBE interface cable or BNC cable from the OUTPUT of the amplifier is not connected to a 50 ohm input on the oscilloscope. You need to switch the termination setting on the oscilloscope to 50 Ω , or use a 50 Ω termination on the oscilloscope input.

NOTE. *NOT TERMINATED INTO 50 Ω is only detected during the DEGAUSS AUTOBALANCE operation.*

**NONCOMPATIBLE
PROBE TYPE Indicator**

When lit, this indicator informs you that the probe that is connected to the amplifier is not designed to work with the amplifier. TCP3XX probes only work with the T CPA300 Amplifier, and the TCP404XL probe only works with the T CPA400 Amplifier.

ON/STANDBY Button

Use this button to power on the amplifier. When the amplifier is in STANDBY mode, the amplifier is in a limited-power mode. Most of the secondary circuitry is disabled, but the line voltage remains connected to the amplifier power supply.

**RANGE Button
(T CPA300 only)**

Press the RANGE button to toggle between the scale factors (sensitivity settings) of the probe attached to the T CPA300. If no RANGE LEDs are lit, this indicates a probe is not connected to the amplifier.

**COUPLING Button and
Indicators**

The COUPLING button determines the coupling between the T CPA300/T CPA400 and the oscilloscope. Press the COUPLING button to toggle between AC and DC coupling. To couple the amplifier for DC plus AC measurements, use DC coupling. For AC measurements only, use AC coupling. When the amplifier is set to AC coupling, the Manual Balance adjustment is disabled since the DC offset component is not visible on the output waveform.

NOTE. *Even when making AC current measurements, leave the oscilloscope coupling on DC. Change only the amplifier coupling to AC. Using the oscilloscope AC coupling may cause the amplifier to exceed its output dynamic range.*

Under normal operation, the AC and DC COUPLING LEDs indicate the coupling mode of the amplifier. If they alternately flash after a degauss operation, this indicates the amplifier is displaying an error code with the four status LEDs on the lower-left front panel. If this occurs, refer to *Displaying Error Codes with the Probe Degauss Autobalance Button* on page 3-22.

PROBE INPUT Connector

All current probes compatible with the TCPA300 and TCPA400 attach at the PROBE INPUT connector, which is a multi-pin female connector. For information about connecting a probe, see *Connecting a Current Probe to the Amplifier* on page 1-9.

OUTPUT Connector

The amplifier current measurement output is accessed at the OUTPUT connector, which should be connected to the oscilloscope input. Attach one end of a 50 Ω BNC cable to this connector and the other end to a 50 Ω vertical input of your oscilloscope. The output impedance of the amplifier is 50 Ω .

To get a direct readout of current on your Tektronix oscilloscope, use the TEKPROBE interface cable to connect the amplifier to your oscilloscope.

NOTE. *To obtain accurate measurements, the input impedance of your oscilloscope must be 50 Ω . Make sure your amplifier OUTPUT is connected to an oscilloscope input using a 50 Ω BNC cable, and that the oscilloscope input is set to 50 Ω impedance. See Figure 1-1 on page 1-1 for proper cabling.*

If your oscilloscope does not have 50 Ω impedance settings for inputs, you can place a 50 Ω feedthrough termination on the oscilloscope input and connect the amplifier output cable to the termination. Do not place the feedthrough termination at the amplifier end of the BNC connecting cable.

**Probe DC Gain Adjust
(located on probes)**

After the PROBE DEGAUSS AUTOBALANCE routine has been run, the probe and amplifier system will meet all published specifications. However, if you want to improve the tolerance of the system accuracy, or to intentionally offset the accuracy to make up for total system errors, you can manually adjust the gain of the probe. Refer to Figures 6-3 and 6-5 on pages 6-7 and 6-12 for the adjustment locations.

NOTE. *You should be careful to note the existing position of the DC Gain Adjustment before you alter it, so that you may return it to the initial, calibrated position. By altering the DC Gain Adjustment, you may cause the probe to not meet the warranted DC Accuracy specification.*

For example, the typical accuracy of the TCP312 probe on the 1A/V range is 1%. If you want to measure a 3A p-p, 1kHz square wave and need increased accuracy (better than 0.25% is attainable), first adjust the TCP312 on the 1A/V range setting using a calibrated 3A p-p, 1kHz square wave source. Then, attach the probe to your circuit and take your measurement. Remember, altering the DC Gain Adjustment may cause the probe to not meet the warranted DC Accuracy specification.

GPIB Operation The TCPA300 and TCPA400 Current Probe Amplifiers do not have direct GPIB connections. However, you can use a computer to control the oscilloscope that the amplifier is connected to, enabling you to change the time and scale factors of your current measurements over the oscilloscope GPIB bus.

Refer to your oscilloscope manual for instructions on using the GPIB bus.



Reference

Reference Notes

These notes are provided to help you utilize the full potential of the TCPA300 and TCPA400 current probe systems.

Degaussing a Probe with an Unpowered Conductor in the Jaws

Under almost all conditions, 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 are compensated. In an automated environment, 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 the amplifier may report an inaccurate result.*

If the impedance of your circuit is higher than that shown in Table 3-1, the degauss procedure will succeed because the amplifier will be able to saturate the probe core. While degauss occurs, the probe will induce a voltage in the unpowered circuit. This also appears in Table 3-1. 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.

Table 3-1: Unpowered circuit degauss limits

Probe type	Minimum circuit resistance	Maximum induced voltage
TCP312	10 mΩ	40 mV at 200 Hz
TCP305	5 mΩ	40 mV at 200 Hz
TCP303	5 mΩ	30 mV at 200 Hz
TCP404XL	1 mΩ	15 mV at 100 Hz

Measuring Differential Current

You can place two conductors in a current probe to provide differential or null current measurement. This avoids the necessity of using two current measurement systems with a differential oscilloscope.



WARNING. Do not put more than one uninsulated conductor at a time in the TCP303 or TCP404XL probes. Do not put any uninsulated conductors in the TCP305 or TCP312 probes. An uninsulated conductor is defined as any conductor without insulation or without insulation rated for the voltage present on the conductor under test.

An insulated conductor is defined as any conductor that is surrounded by an insulating material that is capable of isolating the voltage present on the conductor. Note that 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, compromising the insulating capabilities of the lacquer coating.

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.

1. Orient the two conductors under test so that the polarities oppose each other. Clamp the current probe around the two conductors as shown in Figure 3-1. Be careful not to pinch a conductor in the probe jaws.
2. Measure the current. A waveform above the baseline indicates the conductor with the conventional current flow in the direction of the probe arrow is carrying the greater current. Conventional current flows from positive to negative.
3. To adjust for a current null, adjust the current in one of the conductors until the displayed measurement is zero.

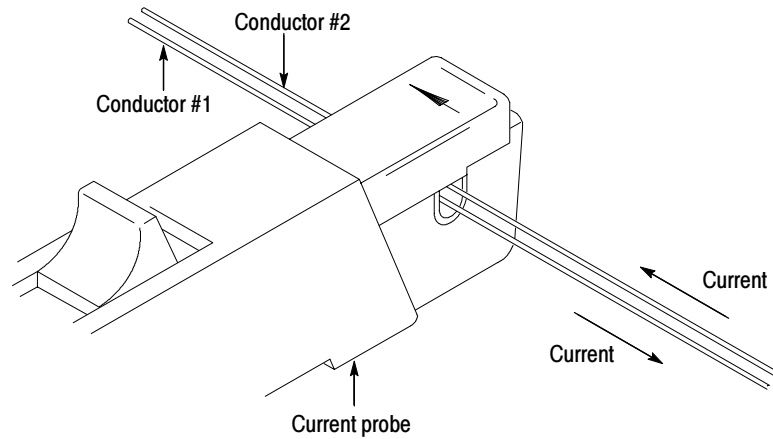


Figure 3-1: Measuring differential current and nulls

AC and DC Coupling

You can couple the signal input to the TCPA300 and TCPA400 with either DC or AC coupling. DC coupling shows the DC and AC measurement components while AC coupling removes the DC component from the displayed signal. When you use AC coupling, make sure that the input DC current does not exceed the probe specifications.

AC coupling will affect waveforms at frequencies higher than the AC Coupling Low-Frequency Bandwidth. For example, pulsed currents may exhibit rolloff or decreased amplitude. Figure 3-2(a) shows a low-frequency square wave using AC coupling. The signal exhibits low-frequency rolloff. By changing the amplifier coupling to DC, the pulse is displayed as truly square, as shown in Figure 3-2(b).



Figure 3-2: Effect of AC or DC coupling on low-frequency signals

If you are trying to examine a low-frequency signal that is superimposed on a comparatively large DC component, you can resolve the signal by performing these steps:

1. Select the range setting that will display the maximum detail without exceeding the dynamic range of the signal.
2. Adjust the oscilloscope V/div sensitivity (A/div if using the TEKPROBE interface), to display maximum signal detail.

Maximum Current Limits

Current probes have three maximum current ratings: continuous, pulsed, and Ampere-second product. Exceeding any of these ratings can saturate the probe core, magnetizing the core and causing measurement errors. See *Specifications* beginning on page 4-1 for the maximum current ratings of compatible probes.

- Maximum Continuous Current refers to 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.
- Maximum Pulsed Current refers to the maximum peak value of pulsed current the probe can accurately measure, regardless of how short (within bandwidth limitations) the pulse duration is.
- Ampere-Second Product defines 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 itself varies by frequency.

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.

To determine if your measurement exceeds the Ampere-second product, perform either Procedure A or Procedure B.

Procedure A

To determine the maximum allowable pulse width, measure the peak current of the pulse (see Figure 3-3a). Divide the Ampere-second (or Ampere-microsecond) specification of your probe by the measured peak current of the pulse. The quotient is the maximum allowable pulse width; the pulse width at the 50% point of the measured signal must be less than this value.

For example, the TCP312 Current Probe has a maximum Ampere-second product of $500 \text{ A} \cdot \mu\text{s}$ in the 10 A/V range setting. If a pulse measured with a TCP312 has a peak current of 40 A, the maximum allowable pulse width would be $500 \text{ A} \cdot \mu\text{s}$ divided by 40 A, or $12.5 \mu\text{s}$.

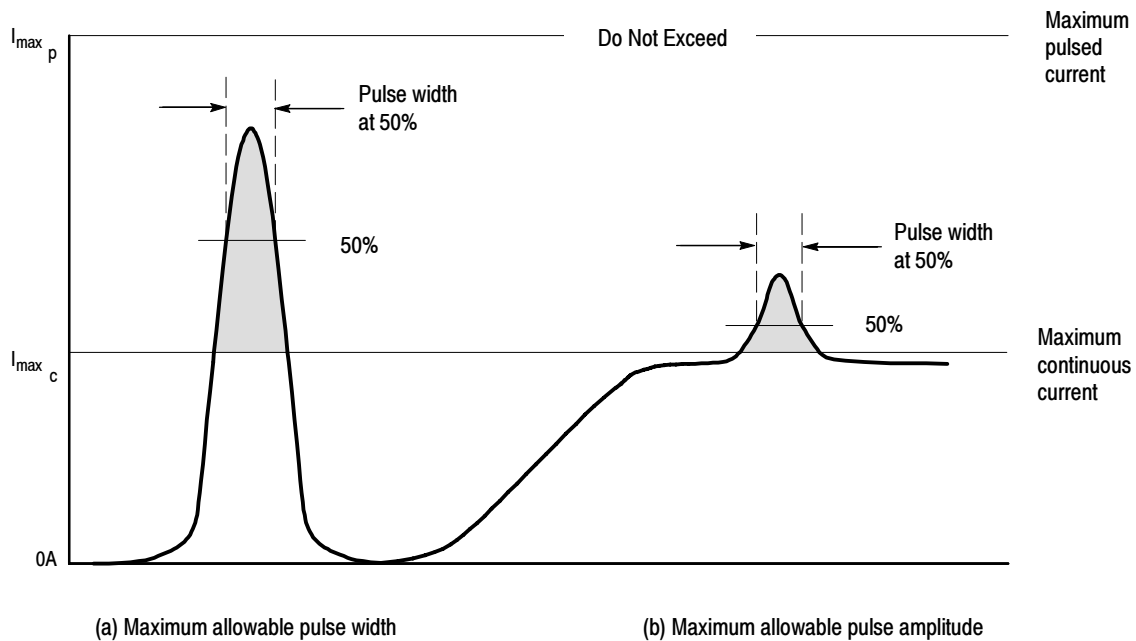


Figure 3-3: Applying the amp-second product rule

Procedure B To determine the maximum allowable pulse amplitude, measure the pulse width at the 50% points (see Figure 3-3b). Divide the Ampere-second (or Ampere-microsecond) specification of your probe by the pulse width. The quotient is the maximum allowable current; the peak amplitude of the measured pulse must be less than this value.

For example, the TCP312 Current Probe has a maximum Ampere-second product of $500 \text{ A} \cdot \mu\text{s}$ in the 10 A/V range setting. If a pulse measured with a TCP312 probe has a width of $15 \mu\text{s}$, the maximum allowable peak current would be $500 \text{ A} \cdot \mu\text{s}$ divided by $15 \mu\text{s}$, or 33.3 A.

Measuring Noncontinuous Current with the TCP404XL Probe

When you measure a noncontinuous current with the TCP404XL probe, you need to take into consideration several factors to ensure that you make accurate measurements and do not trip the thermal overload circuit. The amplitude and duty cycle of the continuous and noncontinuous current, and the ambient temperature, all affect the maximum amount of time allowed for the measurement, which defines the safe operating area of the probe.

You can calculate the duty cycle of the continuous and noncontinuous current when you know the duration of the noncontinuous current (defined in Figure 3-4 as measurement time) and the measurement period. Figure 3-4 illustrates a continuous and noncontinuous current and how to calculate the duty cycle.

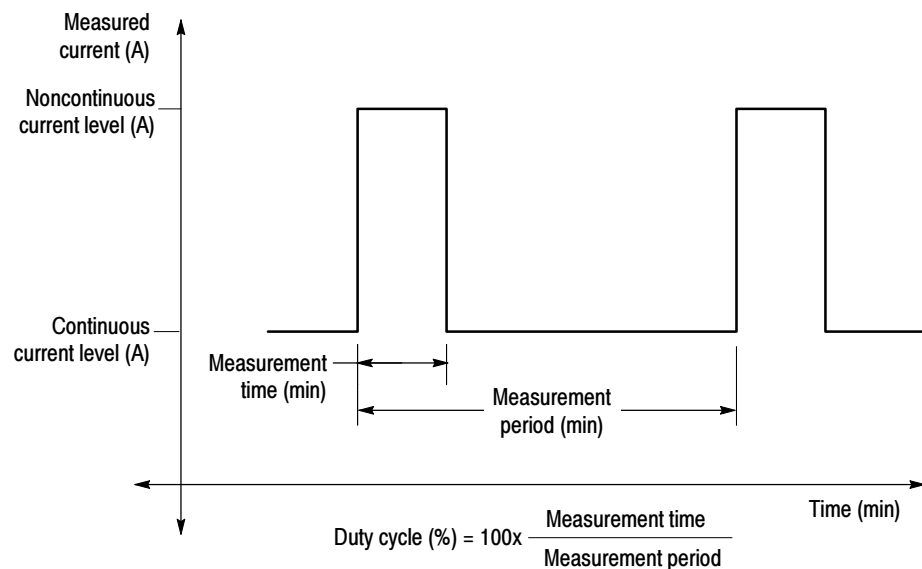


Figure 3- 4: Duty cycle calculation

After you calculate the duty cycle of the noncontinuous current you are measuring, you can use the other factors (continuous and noncontinuous current amplitude, etc.) to compare your measurement to those shown in Figures 4-8 through 4-10 in the *Specifications* section.

You can see how duty cycle affects the measurement time by looking at any of the three graphs in Figures 4-8 through 4-10. As the duty cycle increases on the x-axis, the measurement time (of the noncontinuous current) on the y-axis decreases.

Figures 4-8 and 4-9 on page 4-12 illustrate the effect of measuring two different noncontinuous current amplitudes, 750 amps and 600 amps respectively, with

varying duty cycles and levels of continuous current. The ambient temperature in these two examples is kept constant at 50 °C.



WARNING. *When using the probe near the upper current limit and maximum ambient temperature for extended lengths of time, the probe head surface can become hot to the touch. To prevent injury, keep your hands away from the probe head until it has had time to cool after disconnecting the probe from the circuit.*

To see how noncontinuous current amplitude affects measurement time, look at the curves for measurements of 200 amps continuous between the two graphs in Figures 4-8 and 4-9 on page 4-12. Compare the maximum measurement time allowed for a duty cycle of 20%: At 750 amps, you have 3 minutes of safe measurement time, versus 17 minutes for a smaller noncontinuous-current amplitude of 600 amps.

By looking at any of the three graphs, you can also see that when you measure a noncontinuous current having the same amplitude and duty cycle, the measurement time decreases as the continuous-current amplitude increases.

Finally, compare the two graphs in Figures 4-8 and 4-10 on pages 4-12 and 4-13. Here, the effect of ambient temperature on measurement time is illustrated. Given a continuous current of 200 A with a noncontinuous current of 750 A, and having a 20% duty cycle, a 27 °C increase in temperature yields a 12 minute decrease in maximum measurement time.

Keep these factors into account when taking measurements to ensure accuracy and to protect both yourself from injury and the equipment from damage.

Extending Current Range

You may encounter situations where your measurement exceeds the maximum current rating of the connected probe. This section discusses methods for extending AC and DC current ranges without exceeding specified limits.



WARNING. *To avoid personal injury or equipment damage, do not exceed the specified electrical limits of the TCPA300 and TCPA400 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.



WARNING. *Do not put more than one uninsulated conductor at a time in the probe jaws. An uninsulated conductor is defined as any conductor without insulation or without insulation rated for the voltage present on the conductor under test.*

To supply additional bucking current, place a second conductor that has a pure DC component of known value in the probe jaw with the conductor under test, as shown in Figure 3-5(a). Orient the second conductor so that the bucking current flows in the opposite direction of the DC flow in the conductor under test.

You can increase the value of the bucking current by winding multiple turns of the second conductor around the probe, as shown in Figure 3-5(b). 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.

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.*

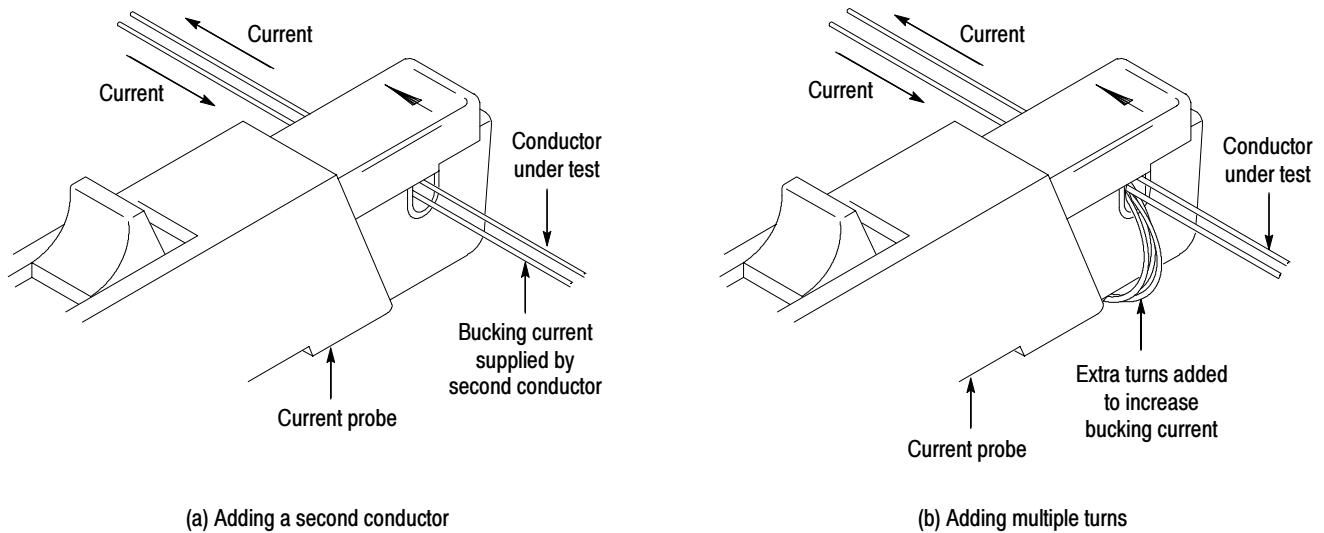


Figure 3-5: Increasing the DC measurement range

Extending AC Range

You can extend the AC amplitude limit of the TCPA300 by using the Tektronix CT-4 High-Current Transformer. The CT-4, designed for use with the TCP305 and TCP312 current probes, extends the current probe range by a factor of 20:1 or 1000:1. The CT-4 can provide external steady-state DC bucking current up to 300 A. For more information about the CT-4, consult your Tektronix sales representative.

Because the CT-4 has a lower AC bandwidth limit than the TCP305 and TCP312 current probes, set the amplifier coupling to DC when using the CT-4.

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 winding several turns of the conductor under test around the probe as shown in Figure 3-6. The signal is multiplied by the number of turns around the probe.



WARNING. Do not put more than one uninsulated conductor at a time in the probe jaws. An uninsulated conductor is defined as any conductor without insulation or without insulation rated for the voltage present on the conductor under test.

When viewing the signal on the oscilloscope screen, divide the displayed amplitude by the number of turns to obtain the actual current value. 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.

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

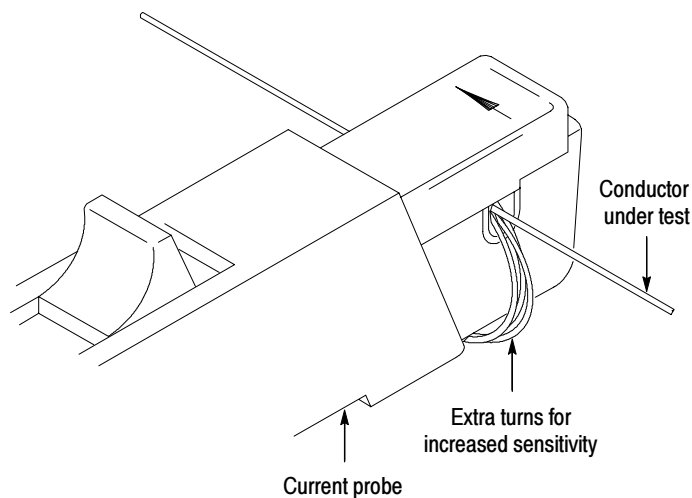


Figure 3-6: Increasing probe sensitivity

Application Notes

This section describes some of the typical measurement applications of the TCPA300 and TCPA400 Current Probe Amplifiers:

- Automobile Charging Systems
- Inductance Measurements
- Continuity Test of Multiple-Conductor Cable
- Measuring Inductor Turns Count
- Power Measurement and Analysis Software Applications

Automobile Charging Systems

Most automotive charging systems are three-phase alternators with a diode rectifier network. A meter averages current from all three phases, and cannot detect a single-phase diode problem. Observing the charge current waveform can quickly reveal if one diode is shorted or open.

The diagram in Figure 3-7 shows the equipment setup. Refer to Table 3-2 for the test equipment setup. A TCP303 Current Probe was used for this high-current, low-voltage application. The TCP303 is degaussed and clamped around the positive battery lead from the alternator. The probe arrow is pointed away from the alternator and toward the battery side of the circuit, to reflect conventional current. The automobile is started and the lights are turned on to add a significant load to the circuit.

Table 3-2: Automobile charging systems test setup

Instrument	Control	Setting
TCPA300	COUPLING	DC
	RANGE	50 A/V
Oscilloscope	Coupling	DC
	Amps/Division (Volts/Division if not using TEK- PROBE interface cable)	10 A/Div (200 mV/Div)
	Zero-Current Reference	Center graticule line
	Time Base	200 μ s/division

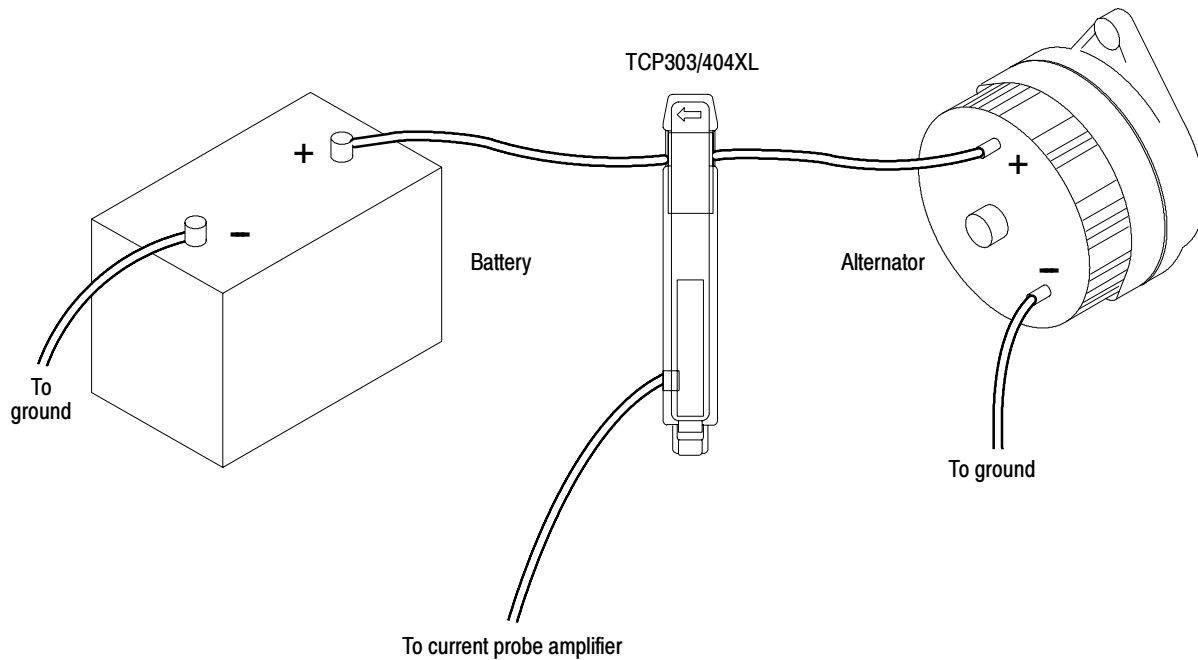


Figure 3-7: Setup for measuring charging current

The waveform in Figure 3-8(a) shows the three-phase ripple frequency. The average charge current is approximately 27 A with a minimum peak of approximately 23 A and a maximum peak of approximately 31 A. The waveform shows a continuous cycle with no dropouts, so the alternator circuit appears to be functioning properly. A single-phase diode failure normally appears as an extreme drop in charge current every third cycle, as shown in Figure 3-8(b).

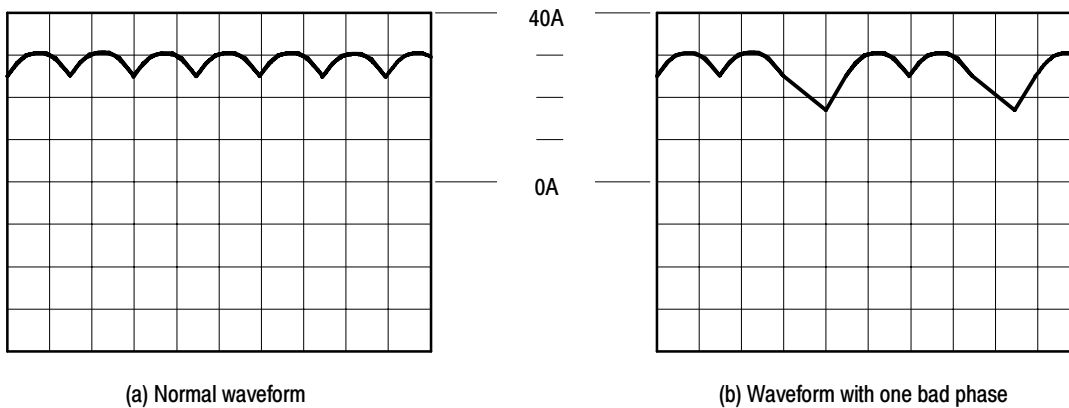


Figure 3-8: Charge current waveforms

Inductance Measurements

You can use the TCPA300 and TCPA400 to measure inductance of coils. Two different methods can be used: one for low-impedance pulse sources and another for high-impedance pulse sources of known value.

Low-Impedance Pulse Sources

Figure 3-9 shows a measurement setup using a constant-voltage pulse generator of extremely low output impedance. The inductor is connected across the output terminals of the pulse source. The current probe is attached to one of the source leads and the current ramp is measured.

The inductance is effectively defined by the slope of the current ramp, shown in Figure 3-10, and is mathematically expressed by 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.

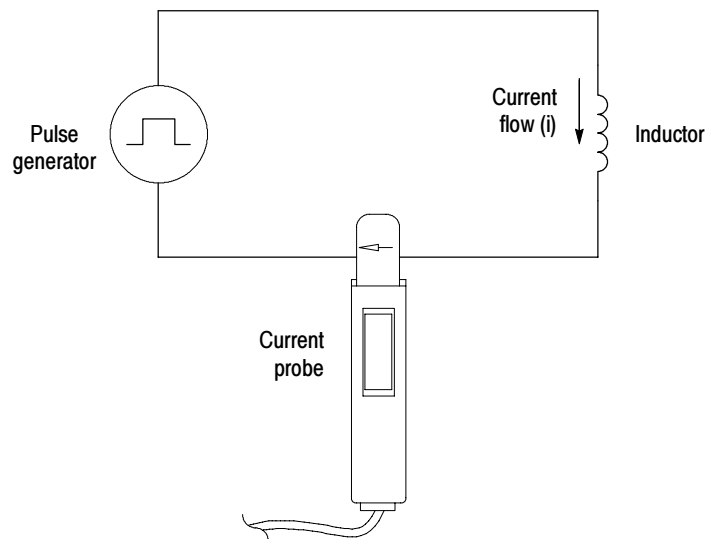


Figure 3-9: Measuring inductance with a low-impedance source

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.

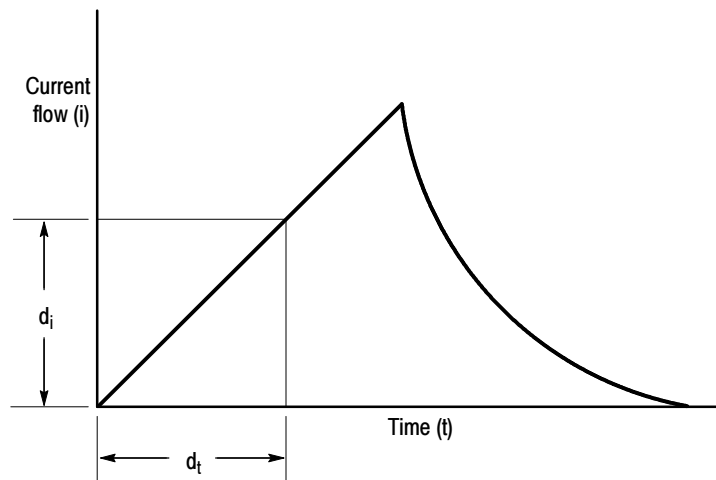


Figure 3- 10: Linear current vs. time ramp

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. Figure 3-11 shows the setup diagram, which is similar to the previous example. The current ramp represented in Figure 3-12 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.

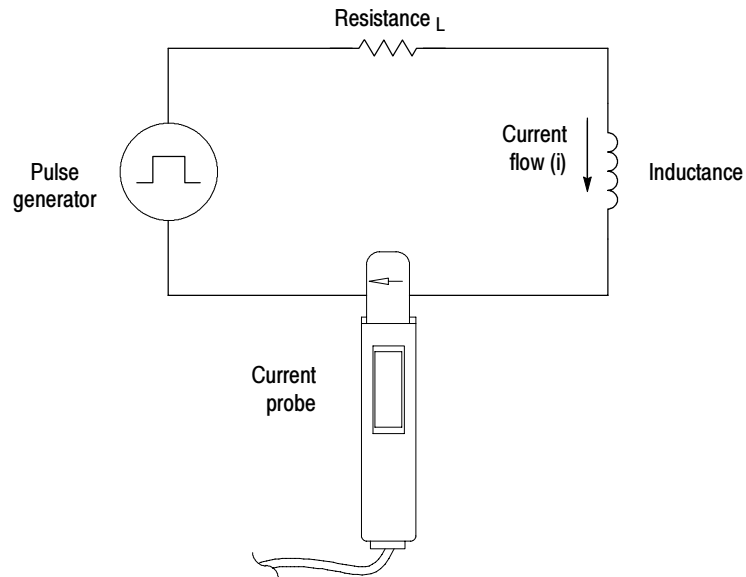


Figure 3-11: Measuring inductance with a high-impedance source

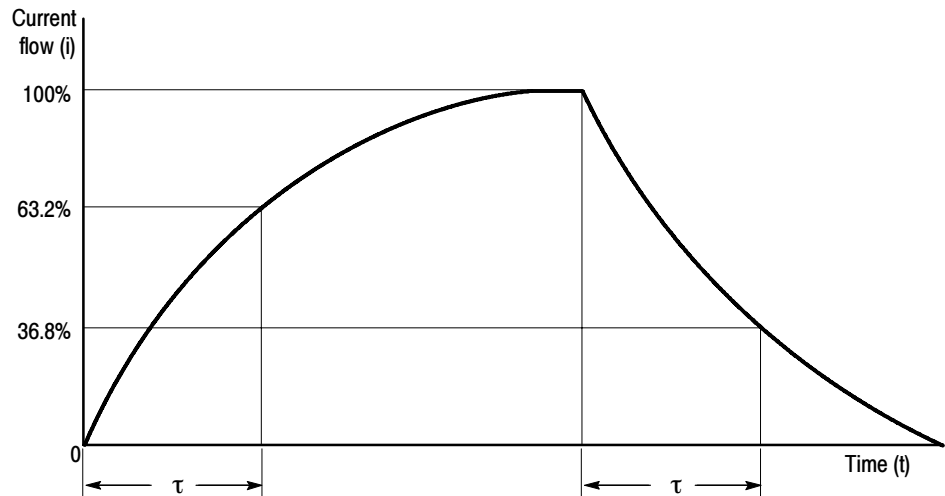


Figure 3-12: High-impedance source current ramp

Continuity Test of Multiple-Conductor Cable

Single conductors in a multiconductor cable can be tested with the TCPA300 and TCPA400. To check a conductor, clamp the current probe around the cable bundle and check for a specific, known current signal. If there is no current or the current is abnormally low, then the conductor has a continuity problem. If the current is abnormally high, then the conductor may have a short to ground.

Measuring Inductor Turns Count

To obtain an approximate turns count of an inductor, connect the inductor to a current limited source, as shown in Figure 3-13. Measure the input current on one of the inductor leads, then 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. The accuracy of this method is limited by the current measurement accuracy. The following method allows more precise turns measurement.

For a more precise turns count, you need a coil with a known number of turns to use as a reference. The measurement setup is similar to the previously described one, except the reference coil and the test coil are inserted into the current probe so that the currents oppose each other (see Figure 3-14). You must observe the polarity of coil current to determine whether the test coil has more or fewer turns than the reference coil. The turns are calculated by using the formula:

$$N_2 = N_1 \times \frac{I_m}{I_I}$$

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_I is the input current.

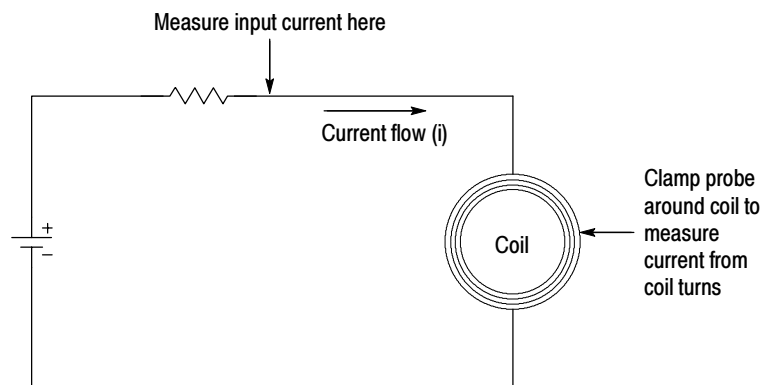


Figure 3- 13: Measuring the number of turns in a coil

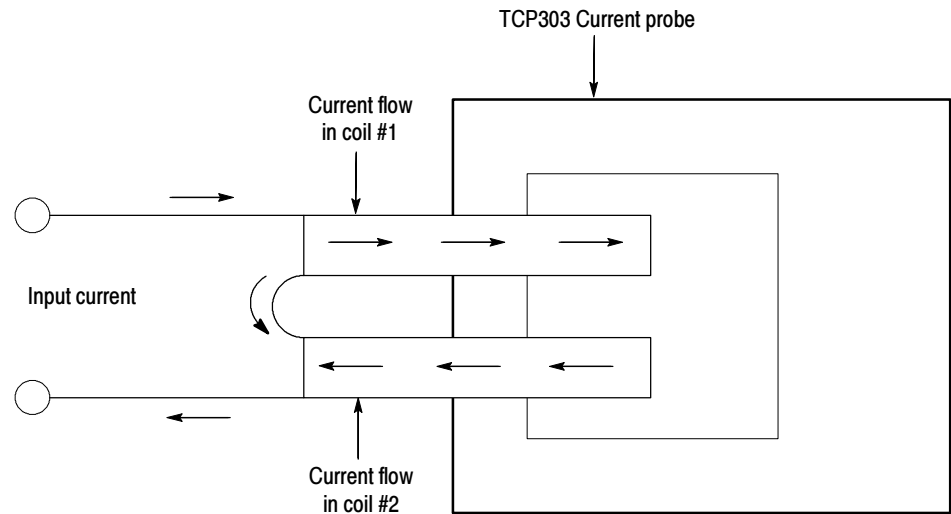


Figure 3-14: Turns measurement using reference coil

Power Measurement and Analysis Software

Power measurement software that is available for some Tektronix oscilloscopes transform your current measurement system into a sophisticated analysis tool that quickly measures and analyzes many different applications, such as:

- Power dissipation at switching devices and magnetic components in switching power supplies
- Precompliance test for EN61000-3-2 standard
- Power quality
- Modulation analysis

After making the measurements, the software generates detailed test reports in customizable formats. When the software is used with a Tektronix TDS5000 Series or TDS7054/TDS7104 digital phosphor oscilloscope and differential voltage and current probes, it forms a complete measurement system for power supply design and test.

Troubleshooting and Error Codes

Table 3-3 lists possible problems that you may encounter when measuring current with the TCPA300 and TCPA400. Use this as a quick troubleshooting reference.

Table 3-3: Troubleshooting

Problem	Remedy
Amplifier will not power on	<p>Check that the amplifier is plugged into a working AC outlet.</p> <p>Defective amplifier. See <i>HW Troubleshooting</i> on page 7-21 to help determine which module is defective, or refer the instrument to qualified service personnel for repair.</p>
Front panel displays an error status. Error Status LEDs are on the lower-left section of the amplifier front panel	<p>Note the error status and correct the condition. The error status is labeled on the front panel. For example, if the PROBE OPEN LED is lit, close and lock the probe jaws.</p>
The AC and DC COUPLING LEDs are flashing alternately	<p>The Error Status LEDs are displaying an error code. Error codes are described on page 3-22. Note the error code and turn the instrument off, then on. If the error condition persists, refer the instrument to qualified service personnel for repair.</p> <p>If the RANGE and DEGAUSS LED are both off, and one of the COUPLING LEDs is lit, this indicates the amplifier is not detecting a probe. Reconnect the probe.</p> <p>All LEDs flashing indicate a thermal shutdown. Power-cycle the system and let it cool for 15 minutes before taking measurements. In most cases, 15 minutes is sufficient.</p>
All LEDs are flashing	<p>All LEDs flashing indicates a thermal shutdown. Power-cycle the system and let it cool before taking measurements. In most cases, 15 minutes is sufficient.</p>
OVERLOAD LED remains lit red after removing probe from circuit.	<p>Probe transformer or amplifier main board is defective.</p>
OVERLOAD LED remains lit orange	<p>Degauss the probe. If the OVERLOAD LED remains lit orange, disconnect the probe from the circuit and let it cool for 15 minutes before degaussing again. If this does not clear the LED, the probe transformer or probe Hall device may be defective. Connect another probe to the amplifier, or connect the probe in question to another amplifier.</p>
Probe does not degauss successfully and LEDs are lighted in an unfamiliar pattern	<p>Amplifier is displaying an error code or is out of calibration or defective. Refer to <i>Interpreting the Error Code display</i> on page 3-23. If another amplifier is available, try to degauss the probe on the other amplifier, to help isolate the cause.</p> <p>Component failure on probe circuit board: broken adjustment/wire/etc. Disassemble probe, repair/replace component or refer the instrument to qualified service personnel for repair.</p>
Cannot degauss the probe	<p>Current Probe is not locked. Lock the current probe.</p> <p>Current Probe is improperly connected to the amplifier input connector.</p> <p>Amplifier output is not terminated into 50 Ω load. Set input impedance of oscilloscope to 50 Ω or connect a 50 Ω feed-through termination at the oscilloscope input, <i>not</i> at the amplifier output.</p> <p>Current Probe is defective or not compatible with the amplifier type.</p>

Table 3-3: Troubleshooting (Cont.)

Problem	Remedy
Degauss takes longer than 10 seconds	<p>Probe is attached to an energized circuit. Disconnect probe from circuit and retry.</p> <p>Probe is faulty - Probe transformer (defective Hall device with excessive noise or drift) may cause this symptom. May also be caused by a shorted or open wire in the probe cable assembly.</p> <p>Defective main board - If the probe is not the cause, then it is most likely a defective main board in the amplifier.</p>
Cannot make a current measurement - no measurement output from amplifier	<p>Current Probe is not locked. Lock the current probe.</p> <p>Current Probe is improperly connected to the amplifier input connector.</p> <p>Amplifier COUPLING is set to AC. Set the COUPLING to DC.</p> <p>A Degauss/Autobalance routine has not been completed successfully on the system. Degauss the probe.</p> <p>Oscilloscope/Amplifier is not set to an appropriate sensitivity setting.</p> <p>Defective interface cable (between oscilloscope and amplifier).</p>
MANUAL BALANCE will not adjust	<p>Oscilloscope or amplifier input coupling not set to DC. MANUAL BALANCE buttons only function when the amplifier is in the DC coupling mode.</p> <p>Oscilloscope/Amplifier is not set to an appropriate sensitivity setting.</p>
Stray DC component in measurement	<p>Degauss the probe using the PROBE DEGAUSS AUTOBALANCE button. (The Current Probe has been overloaded, dropped, or exposed to magnetic field.)</p> <p>You can use the MANUAL BALANCE buttons to null out any residual DC offset after performing a Probe Degauss Autobalance routine.</p>
Measurements are inaccurate	<p>Degauss the probe.</p> <p>The amplifier output is not terminated into 50 Ω load. Set the input impedance of oscilloscope to 50 Ω or connect a 50 Ω feedthrough termination at the oscilloscope input. Do not attach the termination at the amplifier output.</p> <p>The measurement exceeds the maximum continuous current or Ampere-second product ratings of the Current Probe. If possible, upgrade to a probe with a higher current rating or use a CT-4 transformer.</p> <p>Amplifier or current probe out of calibration. Refer to <i>Performance Verification</i> on page 5-1.</p> <p>The jaw mechanism is dirty - disassemble probe, clean and lubricate. Refer to the probe disassembly procedures on page 7-13.</p> <p>Defective current probe transformer.</p>
Measurements roll off at high frequencies	<p>The oscilloscope bandwidth limit is turned on. Verify that the bandwidth limit switch on the oscilloscope is set to the desired bandwidth position.</p> <p>(Be careful not to exceed the frequency limit of the probe used. Frequencies above the probe design may cause overheating and damage to the probe.)</p>

Table 3-3: Troubleshooting (Cont.)

Problem	Remedy
Measurements exhibit excessive noise	<p>Current Probe is not locked. Lock the current probe.</p> <p>Current Probe is improperly connected to the amplifier input.</p> <p>Amplifier output is not terminated into 50 Ω load. Set input impedance of oscilloscope to 50 Ω or connect a 50 Ω feed-through termination at the oscilloscope input, <i>not</i> at the amplifier output.</p> <p>Defective current probe transformer.</p>
Measurement aberrations exceed the specified limit	<p>The amplifier output is not terminated into 50 Ω load. Set the input impedance of the oscilloscope to 50 Ω or connect a 50 Ω feedthrough termination (see the replaceable parts list on page 8-6) at the oscilloscope input. Do not attach the termination to amplifier output.</p> <p>The measurement exceeds the maximum continuous current or Ampere-second product ratings of the Current Probe. (For more information, see <i>Current Limits</i> on page 3-4.) If possible, upgrade to a probe with a higher current rating or use a CT-4 transformer.</p>
Excessive low frequency droop in pulse response or low DC gain accuracy	<p>Check that the probe slider is fully closed and locked.</p> <p>Check and clean the probe transformer and lid.</p> <p>Degauss the probe.</p> <p>The amplifier or the oscilloscope may be AC coupled. Set the COUPLING to DC.</p>
Measurements exhibit excessive delay or slowed pulse response	<p>The amplifier output is not terminated into 50 Ω load. Set the input impedance of the oscilloscope to 50 Ω or connect a 50 Ω feedthrough termination (see the replaceable parts list on page 8-6) at the oscilloscope input. Do not attach the termination to the amplifier output.</p> <p>The measurement exceeds the Ampere-second product of the Current Probe. If possible, upgrade to a probe with a higher current rating or use a CT-4 transformer.</p> <p>The oscilloscope bandwidth limit is turned on. Verify that the bandwidth limit switch on the oscilloscope is set to the desired bandwidth position.</p>
Probe jaw not opening and closing freely	<p>The jaw mechanism is dirty - disassemble probe, clean and lubricate. Refer to the probe disassembly procedures on page 7-13.</p>

Displaying Error Codes with the Probe Degauss Autobalance Button

This section describes the error codes that the amplifiers display using the function indicator LEDs.

When an internal error condition exists, the amplifiers may generate error codes when you press the PROBE DEGAUSS AUTOBALANCE button. The AC and DC Coupling LEDs will flash alternately to indicate that error codes are being displayed instead of normal conditions.

The four fault indicator LEDs above the ON/STANDBY switch are used to form a four-bit binary error code. The PROBE OPEN LED indicates the most significant bit (MSB), and the NONCOMPATIBLE PROBE TYPE LED indicates the least significant bit (LSB). See Figure 3-15.

To continue past an error code, press any button except ON/STANDBY. However, the degauss will fail until the internal error condition is corrected and the degauss operation is run again.

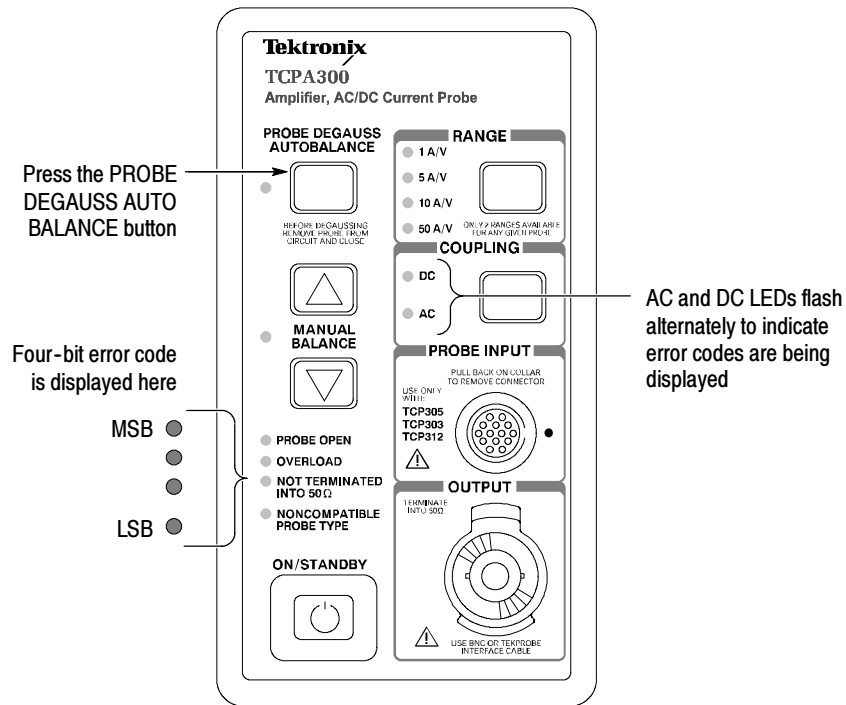


Figure 3- 15: Error code display

For example, after you press the PROBE DEGAUSS AUTOBALANCE button, if the AC and DC Coupling LEDs are flashing, and the NOT TERMINATED INTO 50 Ω LED is illuminated, this indicates an Error Code 2 - a null error in the DC offset circuit occurred. See Figure 3-16 for an illustrated example.

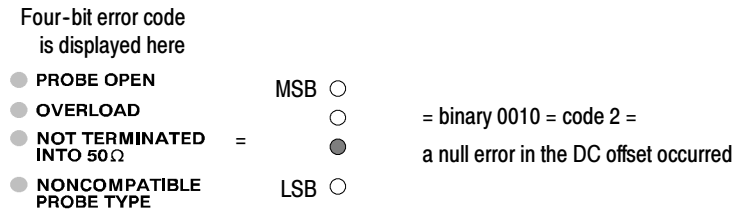


Figure 3-16: Interpreting the error code display

Table 3-4 shows the complete list of error codes for the amplifier.

Table 3-4: Amplifier error codes

Code	Description of error	Action to take
1	The amplifier detected a probe, but a valid Hall device was not detected.	Disconnect and reattach the probe to the amplifier. Power cycle the amplifier. Check probe transformer (defective Hall device). If these steps do not resolve the error, the amplifier needs service. May also be caused by a shorted or open wire in the probe cable assembly.
2 3	An error occurred while nulling out the internal DC offset of the amplifier.	Power cycle the amplifier and run the Degauss/Autobalance adjustment routine again. If the error reoccurs, then the amplifier needs service.
4 5	TCPA300 ONLY - An error occurred while the the amplifier was adjusting the power supply levels for the different Range settings.	Power cycle the amplifier and run the Degauss/Autobalance adjustment routine again. If the error reoccurs, then perform the following steps: 1) Remove the probe from the circuit. 2) Check probe - The signal path through the probe transformer may be open or shorted, which can be caused by defective probe transformer or cable assembly. If the above steps do not resolve the error, the amplifier needs service.
6 7	An error occurred while the amplifier was adjusting the Overload trip points.	Power cycle the amplifier and run the Degauss/Autobalance adjustment routine again. If the error reoccurs, then remove the probe from the circuit. If this does not resolve the error, the amplifier needs service.
8 9	Unused	
10 11	An error occurred while nulling out the internal DC offset of the amplifier.	Power cycle the amplifier and run the Degauss/Autobalance adjustment routine again. If the error reoccurs, then remove the probe from the circuit. If this does not resolve the error, the amplifier needs service.
12 13 14	The amplifier cannot null out the probe DC offset voltage.	Remove the probe from the circuit. Error 12 will most likely occur when the probe is connected to an energized circuit when a Degauss/Autobalance routine is initiated. Check probe transformer (defective Hall device). This error may also be caused by a Hall device with excessive noise or drift in the probe transformer, or a shorted or open wire in the probe cable assembly. Power cycle the amplifier and run the Degauss/Autobalance adjustment routine again. If these steps do not resolve the error, the amplifier needs service.
15	Unspecified error (internal software error)	Power cycle the amplifier and run the Degauss/Autobalance adjustment routine again. If the error reoccurs, then the amplifier needs service.

Correcting the Cause of an Error Code

After interpreting the error code, disconnect the probe from the circuit and degauss the probe again. Take the measurement again. If the error code persists, contact your Tektronix Service Center.

Shutdown Error

If all LEDs flash at the same time, a shutdown condition exists. If this occurs, turn off the amplifier and disconnect the probe from the circuit under test. Turning off the amplifier clears the error register.

A shutdown condition can be caused by exceeding the frequency/current specifications. Verify that you are not exceeding the specifications and let the probe and amplifier cool before using them again. In most cases, 15 minutes is sufficient. If the measurement you were taking was within the probe and amplifier specifications, degauss the probe and take the measurement again. If the shutdown error persists, contact your Tektronix Service Center.



Specifications

Specifications

These specifications are valid only under the following conditions:

- The probe and amplifier have been calibrated at an ambient temperature of $23 \text{ }^{\circ}\text{C} \pm 5 \text{ }^{\circ}\text{C}$.
- The probe and amplifier are operating within the environmental limits described in Table 4-6 on page 4-5 (the operating temperature limits are $0 \text{ }^{\circ}\text{C}$ to $+50 \text{ }^{\circ}\text{C}$, unless otherwise stated).
- The probe and amplifier have had a warm-up period of at least 20 minutes.
- The probe degauss/autobalance routine has been performed after the 20-minute warm-up period, and thereafter whenever the PROBE DEGAUSS/AUTOBALANCE light blinks.
- The amplifier output is properly terminated into $50 \text{ } \Omega$.

Specifications are separated into two categories: warranted specifications and nominal or typical characteristics.

Warranted Specifications

Warranted specifications, Table 4-1, are guaranteed performance specifications unless specifically designated as typical or nominal.

Table 4-1: Warranted TCPA300 and TCPA400 specifications

Amplifier	TCPA300			TCPA400
DC Gain Accuracy	$\leq 1\%$			$\leq 1\%$
Installed probe	TCP312	TCP305	TCP303	TCP404XL
Bandwidth (-3 dB)	DC to 100 MHz	DC to 50 MHz	DC to 15 MHz	DC to 2 MHz
Rise Time, 10% to 90%	$\leq 3.5 \text{ ns}$	$\leq 7 \text{ ns}$	$\leq 23 \text{ ns}$	$\leq 175 \text{ ns}$
DC Gain Accuracy:	Warranted	$\leq 3\%$	$\leq 3\%$ ¹	$\leq 3\%$
	Typical ²	$\leq 1\%$	$\leq 1\%$	$\leq 1\%$

¹ Warranted from $10 \text{ }^{\circ}\text{C}$ to $50 \text{ }^{\circ}\text{C}$. For temperature range of $0 \text{ }^{\circ}\text{C}$ to $<10 \text{ }^{\circ}\text{C}$, spec is $+3\%/-6\%$.

² $23 \text{ }^{\circ}\text{C} \pm 5 \text{ }^{\circ}\text{C}$

Nominal and Typical Characteristics

Nominal and typical characteristics, listed in Table 4-2, are not guaranteed. They are provided to characterize the configuration, performance, or operation of typical probe/amplifier combinations.

Table 4-2: Nominal and typical amplifier characteristics

Parameter	Installed probe			
	TCP312	TCP305	TCP303	TCP404XL
Ranges, nominal	1 A/V, 10 A/V	5 A/V, 10 A/V	5 A/V, 50 A/V	1 A/mV
Maximum Amp-Second Product (See Figures 4-2 through 4-5 for frequency derating)	1 A/V - 50A* μ s 10 A/V - 500A* μ s	5 A/V - 500A* μ s 10 A/V - NA	5 A/V - 3000A* μ s 50 A/V - 15000A* μ s	NA
Input Coupling, nominal	AC, DC	AC, DC	AC, DC	AC, DC
AC Coupling Low-Frequency Bandwidth, (low-pass -3dB point), typical	<7 Hz	<7 Hz	<7 Hz	<7 Hz
Displayed Noise, typical	$\leq 75 \mu A_{RMS}$ Limit measurement bandwidth to 20 MHz.	$\leq 500 \mu A_{RMS}$ Limit measurement bandwidth to 20 MHz.	$\leq 500 \mu A_{RMS}$ Limit measurement bandwidth to 20 MHz.	$\leq 70 mA_{RMS}$ Limit measurement bandwidth to 20 MHz.
Signal Delay, typical, (includes probe, amplifier, and TEKPROBE- to-TEKPROBE interface cable, or 012-0117-00 BNC cable)	approximately 17 ns	approximately 19 ns	approximately 53 ns	approximately 103 ns
Maximum Bare Wire Voltage	Use with insulated wires only	Use with insulated wires only	600 V RMS CAT I & II 300 VRMS CAT III	600 V RMS CAT I & II 300 VRMS CAT III
Lowest Measurable Current	1 mA	5 mA	5 mA	1 A
Insertion Impedance (see Figure 4-6 for plots)	1 MHz 0.08 Ω 10 MHz 0.15 Ω 50 MHz 0.27 Ω 100 MHz 0.7 Ω	1 MHz 0.035 Ω 10 MHz 0.12 Ω 50 MHz 0.04 Ω	1 MHz 0.01 Ω 5 MHz 0.025 Ω 15 MHz 0.1 Ω	10 kHz 0.1 m Ω 100 kHz 0.6 m Ω 1 MHz 8.0 m Ω 2 MHz 16.0 m Ω
Current Transfer Ratio	1 V/Amp and 100 mV/Amp	200 mV/Amp and 100 mV/Amp	200 mV/Amp and 20 mV/Amp	1 mV/Amp
Maximum Current Ratings at Sensitivity Ranges				
High Current Sensitivity Range	10 A/V Range	10 A/V Range	50 A/V Range	1 A/mV Range
DC (continuous)	30 A	50 A	150 A	500 A
DC (noncontinuous)	N/A	N/A	N/A	750 A
RMS (sinusoidal)	21 A	35 A	150 A	500 A
Peak Pulse	50 A	50 A	500 A	750 A

Table 4-2: Nominal and typical amplifier characteristics (Cont.)

Parameter	Installed probe			
	TCP312	TCP305	TCP303	TCP404XL
Low Current Sensitivity Range	1 A/V Range	5 A/V Range	5 A/V Range	N/A
DC (continuous)	5 A	25 A	25 A	---
DC (noncontinuous)	N/A	N/A	N/A	---
RMS (sinusoidal)	3.5 A	17.7 A	17.7 A	---
Peak Pulse	50 A	50 A	500 A	---
Input Voltage	100-240 VAC ($\pm 10\%$), 47 Hz to 440 Hz, single phase			
Maximum Power	50 Watts maximum			
Fuse Rating	3.15 AH, 250 V (Not operator-replaceable.)			

Mechanical Characteristics

Mechanical characteristics of the amplifiers are listed in Table 4-3.

Table 4-3: TCPA300 and TCPA400 mechanical characteristics

Parameter, nominal	Characteristic
Length	173 mm (6.8 in)
Width	91.4 mm (3.6 in)
Height	167 mm (6.6 in)
Weight	1.14 kg (2.5 lb)

Mechanical characteristics of the probes are listed in Table 4-4.

Table 4-4: Probe mechanical characteristics

	TCP305 and TCP312	TCP303 and TCP404XL
Probe dimensions		
Length:	20 cm (7.77 inches)	268 cm (10.55 inches)
Width:	1.6 cm (0.625 inches)	41 cm (1.60 inches)
Height:	3.2 cm (1.25 inches)	156 cm (6.13 inches)
Cable length	1.5 m (5 feet)	TCP303: 2 m (6.6 feet) TCP404XL: 8 m (26.25 feet)
Weight	0.15 kg (0.33 lb)	TCP303: 0.66 kg (1.45 lb) TCP404XL: 0.88 kg (1.90 lb)

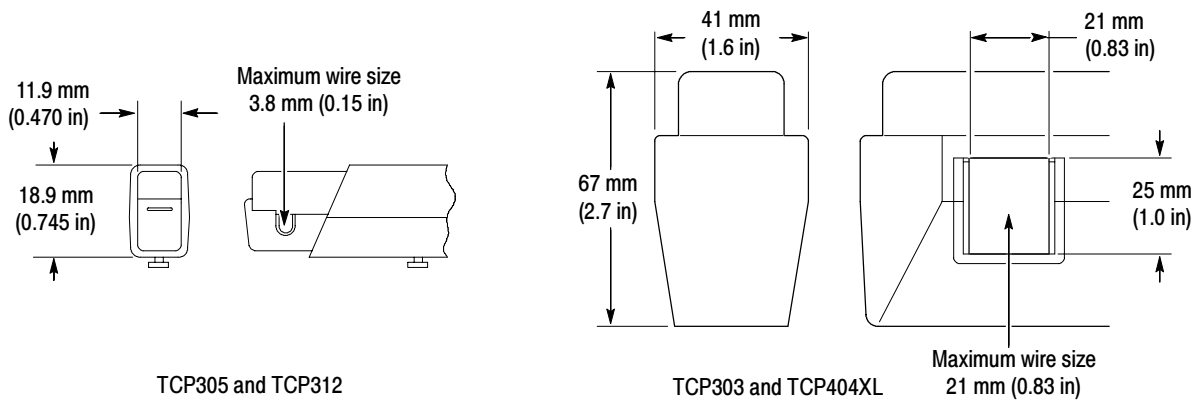


Figure 4-1: Probe jaw dimensions (nominal)

Shipping weights and dimensions are listed in Table 4-5.

Table 4-5: Shipping weights and dimensions

	TCPA300 and TCPA400 Amplifiers	TCP305 and TCP312 Current Probes	TCP303 Current Probe	TCP404XL Current Probe
Dimensions				
Length:	298.5 mm (11.75 inches)	330 mm (13.00 inches)	375 mm (14.75 inches)	375 mm (14.75 inches)
Width:	298.5 mm (11.75 inches)	254 mm (10.00 inches)	318 mm (12.50 inches)	318 mm (12.50 inches)
Height:	254 mm (10.00 inches)	108 mm (4.25 inches)	127 mm (5.00 inches)	127 mm (5.00 inches)
Weight	2.7 kg (6.00 lb)	0.585 kg (1.29 lb)	1.33 kg (2.93 lb)	1.55 kg (3.42 lb)

Environmental Characteristics

The environmental characteristics in Table 4-6 are warranted performance specifications. Unlike the warranted characteristics in Table 4-1, the environmental characteristics are type tested; therefore there are no performance verification procedures provided to test these characteristics. Unless otherwise noted, these characteristics apply to all probes and amplifiers.

Table 4-6: Environmental characteristics

Parameter	Characteristic
Ambient Temperature	
Operating	0 °C to +50 °C (32 °F to 122 °F)
Nonoperating	-40 °C to +75 °C (-40 °F to 167 °F)
Humidity	
Operating	5 to 95% R.H. to +30 °C (86 °F) 5 to 85% R.H. +30 °C to +50 °C (86 °F to 122 °F)
Nonoperating	5 to 95% R.H. to +30 °C (86 °F) 5 to 85% R.H. +30 °C to +75 °C (86 °F to 167 °F)
Altitude	
Operating	2000 m (6800 ft) maximum
Nonoperating	12,192 m (40,000 ft) maximum
Random Vibration, Amplifiers	
Operating	0.31 g _{RMS} , 5 Hz to 500 Hz, 10 minutes each axis
Nonoperating	2.46 g _{RMS} , 5 Hz to 500 Hz, 10 minutes each axis
Random Vibration, Probes	
Operating	2.66 g _{RMS} , 5 Hz to 500 Hz, 10 minutes each axis
Nonoperating	3.48 g _{RMS} , 5 Hz to 500 Hz, 10 minutes each axis
Shock, Amplifiers	50 g, 11 ms duration, half-sine pulses
Electro-Magnetic Compliance	Meets FCC Part 15, Subpart B, Class A

Table 4-7 lists the certifications and compliances for the amplifiers and probes.

Table 4-7: Certifications and compliances

Category	Standards or description
EC Declaration of Conformity - EMC	<p>Meets intent of Directive 89/336/EEC for Electromagnetic Compatibility. Compliance was demonstrated to the following specifications as listed in the Official Journal of the European Communities:</p> <p>EN 61326 EMC requirements for Class A electrical equipment for measurement, control and laboratory use.¹</p> <p>IEC 61000-4-2 Electrostatic discharge immunity (Performance criterion B)</p> <p>IEC 61000-4-3 RF electromagnetic field immunity (Performance criterion A)</p> <p>IEC 61000-4-4 Electrical fast transient / burst immunity (Performance criterion B)</p> <p>IEC 61000-4-5 Power line surge immunity (Performance criterion B)</p> <p>IEC 61000-4-6 Conducted RF immunity (Performance criterion A)</p> <p>IEC 61000-4-11 Voltage dips and interruptions immunity (Performance criterion B)</p> <p>EN 61000-3-2 AC power line harmonic emissions</p>
Australia / New Zealand Declaration of Conformity - EMC	<p>Complies with EMC provision of Radiocommunications Act per the following standard(s):</p> <p>AS/NZS 2064.1/2 Industrial, Scientific, and Medical Equipment: 1992</p>
EMC Compliance	<p>Meets the intent of Directive 89/336/EEC for Electromagnetic Compatibility when it is used with the product(s) stated in the specifications table. Refer to the EMC specification published for the stated products. May not meet the intent of the directive if used with other products.</p>
FCC Compliance	<p>Emissions comply with FCC Code of Federal Regulations 47, Part 15, Subpart B, Class A Limits.</p>
EC Declaration of Conformity - Low Voltage ²	<p>Compliance was demonstrated to the following specification as listed in the Official Journal of the European Communities:</p> <p>Low Voltage Directive 73/23/EEC, amended by 93/68/EEC</p> <p>EN 61010-1/A2:1995 Safety requirements for electrical equipment for measurement control and laboratory use.</p> <p>EN 61010-2-032:1995 Particular requirements for hand-held current clamps for electrical measurement and test equipment.</p>
U.S. Nationally Recognized Testing Laboratory Listing	<p>UL3111-1 Standard for electrical measuring and test equipment.</p> <p>UL3111-2-032 Standard for hand-held current clamps for electrical measurement and test.</p>
Canadian Certification	<p>CAN/CSA C22.2 No. 1010.1 Safety requirements for electrical equipment for measurement, control, and laboratory use.</p> <p>CAN/CSA C22.2 No. 1010.2.032:1996 Particular requirements for hand-held probe assemblies for electrical measurement and test equipment.</p>

¹ Emissions that exceed the levels required by this standard may occur when this equipment is connected to a test object.

² The TCP305 and TCP312 Current Probes are exempt from the Low Voltage Directive and are not third-party listed. However, they have been evaluated to applicable safety standards.

Table 4-7: Certifications and compliances (cont.)

Category	Standards or description	
Additional Compliance	UL 61010B-1	Safety requirements for electrical equipment for measuring, controlling and laboratory use.
	IEC61010-1/A2:1995	Safety requirements for electrical equipment for measurement, control, and laboratory use.
	IEC 61010-2-032:1995	Particular requirements for hand-held current clamps for electrical measurement and test.
	IEC 61010-1:2001	Safety requirements for electrical equipment for measurement control and laboratory use.
Installation (Overvoltage) Category Descriptions	<p>Terminals on this product may have different installation (overvoltage) category designations. The installation categories are:</p> <p>CAT III Distribution-level mains (usually permanently connected). Equipment at this level is typically in a fixed industrial location.</p> <p>CAT II Local-level mains (wall sockets). Equipment at this level includes appliances, portable tools, and similar products. Equipment is usually cord-connected.</p> <p>CAT I Secondary (signal level) or battery operated circuits of electronic equipment.</p>	
Pollution Degree Descriptions	<p>A measure of the contaminates 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.</p> <p>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.</p> <p>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.</p> <p>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.</p> <p>Pollution Degree 4 Pollution that generates persistent conductivity through conductive dust, rain, or snow. Typical outdoor locations.</p>	
Equipment Type	Test and measuring	
Safety Class	Class 1 (as defined in IEC 61010-1, Annex H) - grounded product	
Overvoltage Category	Overvoltage Category II (as defined in IEC 61010-1, Annex J)	
Pollution Degree	Pollution Degree 2 (as defined in IEC 61010-1). Note: Rated for indoor use only.	

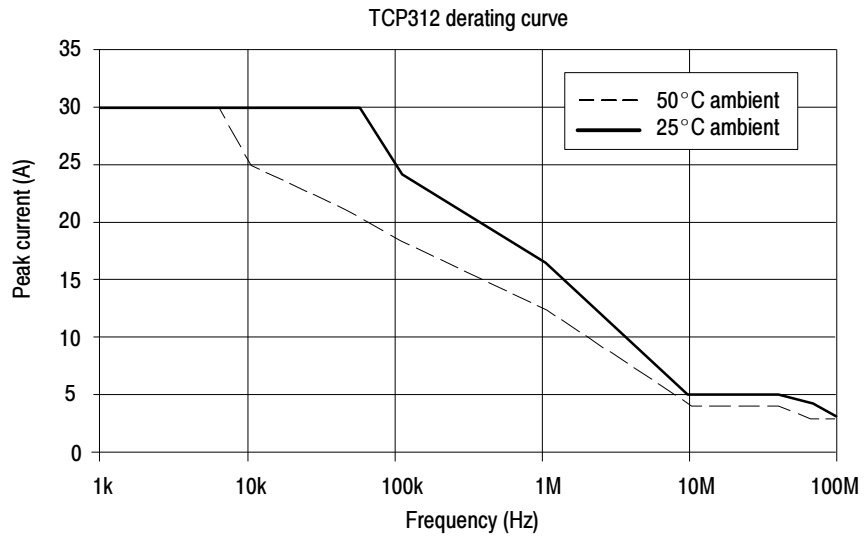


Figure 4-2: Frequency derating- TCP312

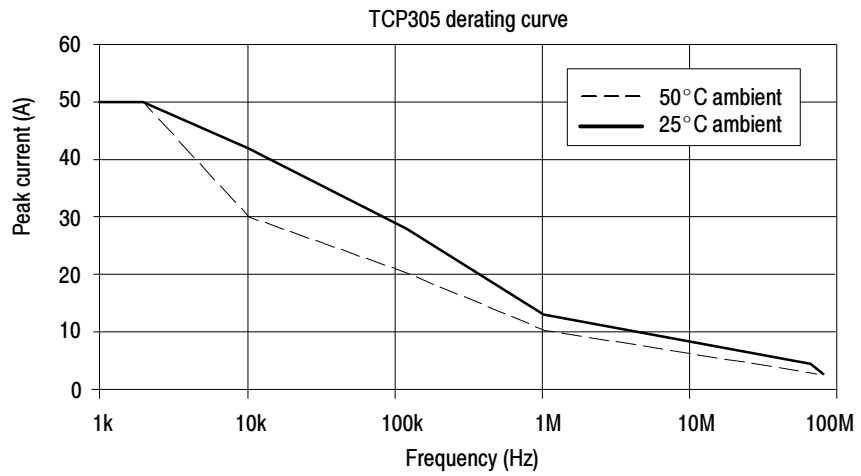


Figure 4-3: Frequency derating- TCP305

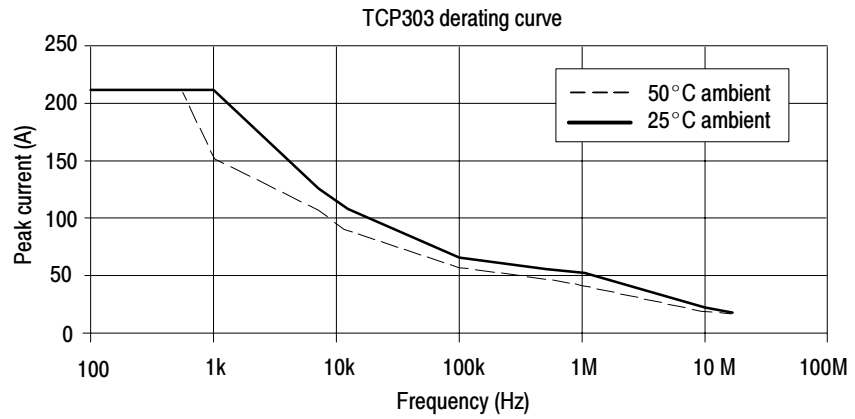


Figure 4-4: Frequency derating- TCP303

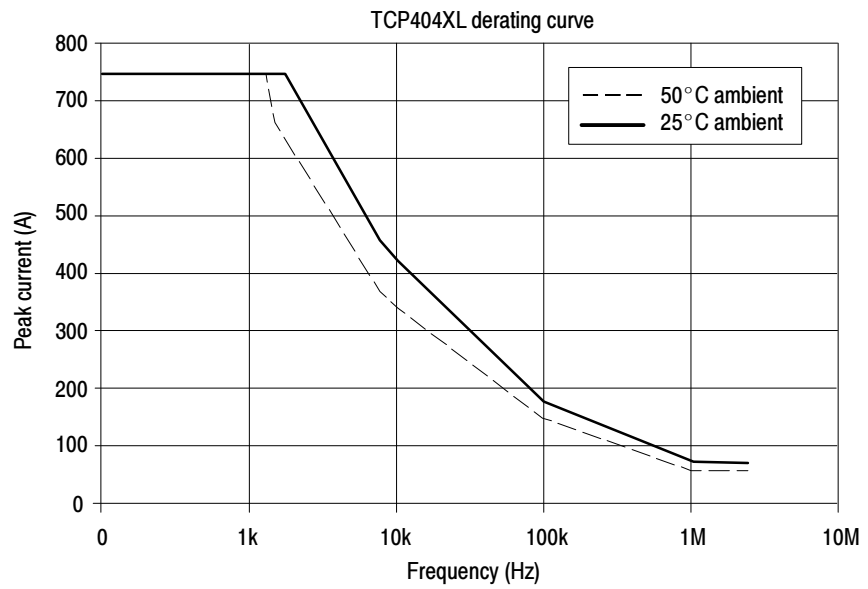


Figure 4-5: Frequency derating- TCP404XL

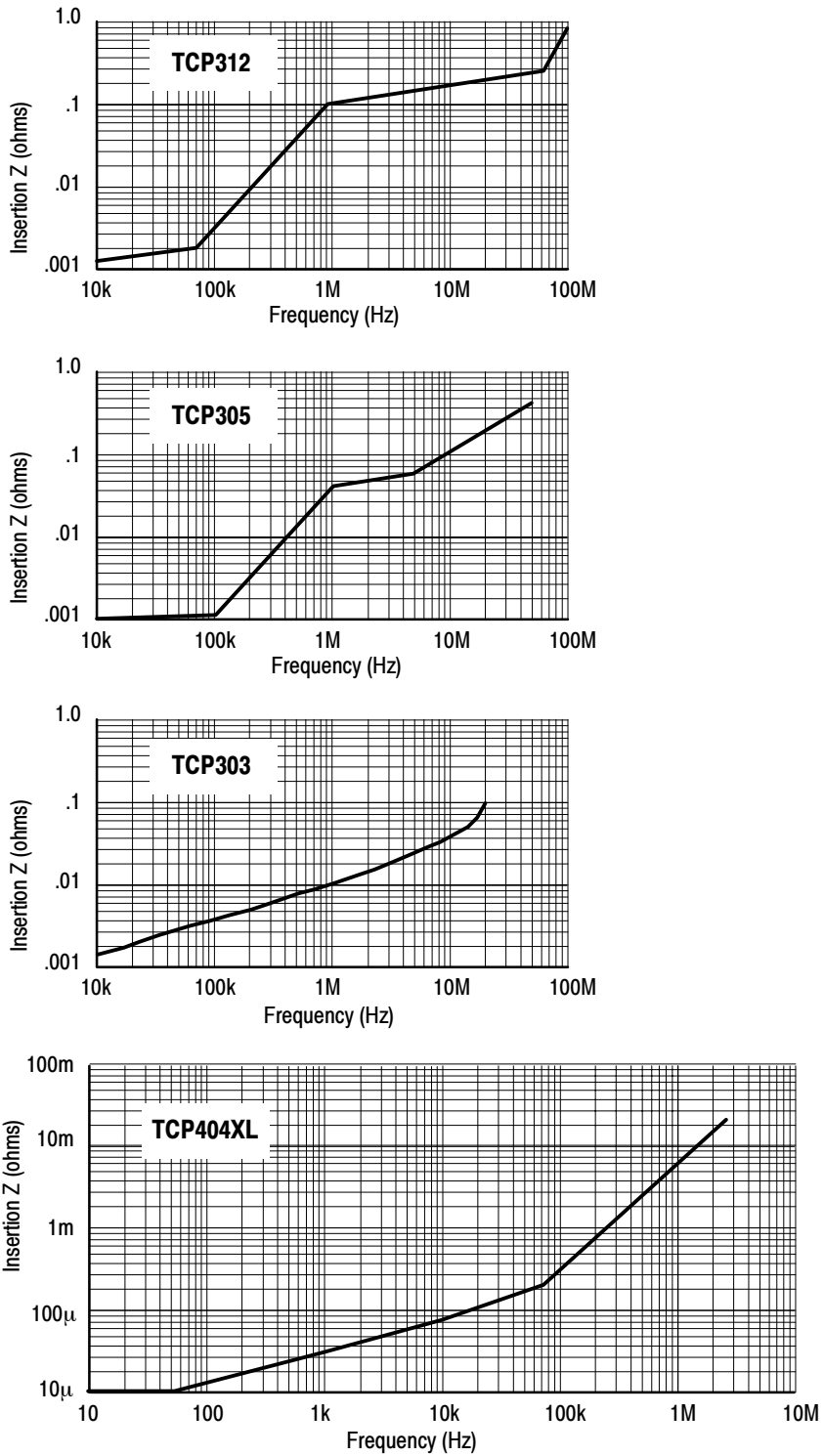


Figure 4- 6: Insertion impedance graphs for the current probes

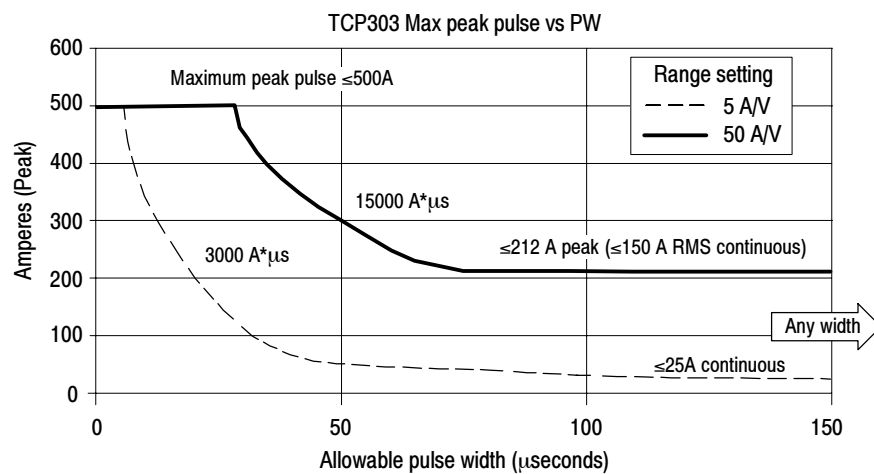
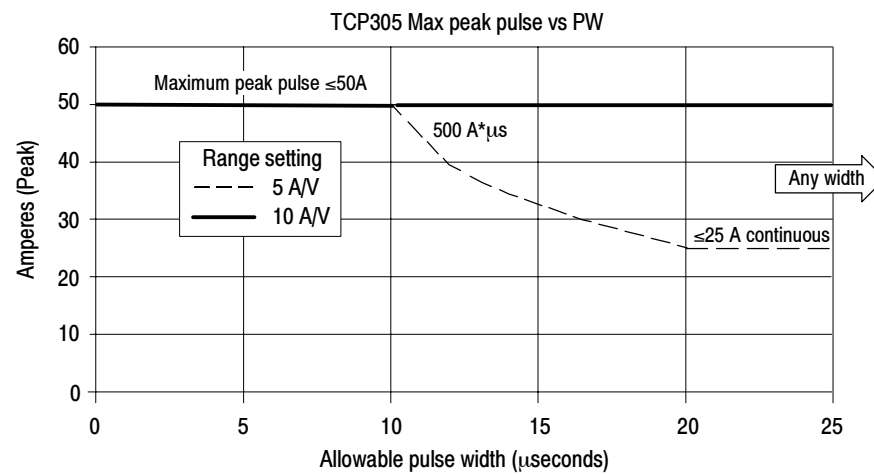
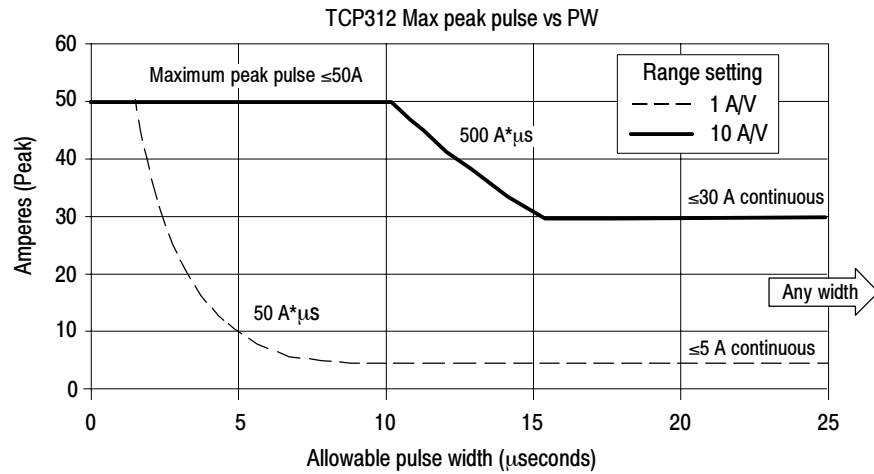


Figure 4-7: Specified operating area of the probes

TCP404XL Maximum Measurement Times

Figures 4-8 through 4-10 show the maximum measurement time for the TCP404XL probe, with varying duty cycles and temperatures. For more detail on the relationship between measurement factors, refer to *Measuring Noncontinuous Current with the TCP404XL Probe* on page 3-6.

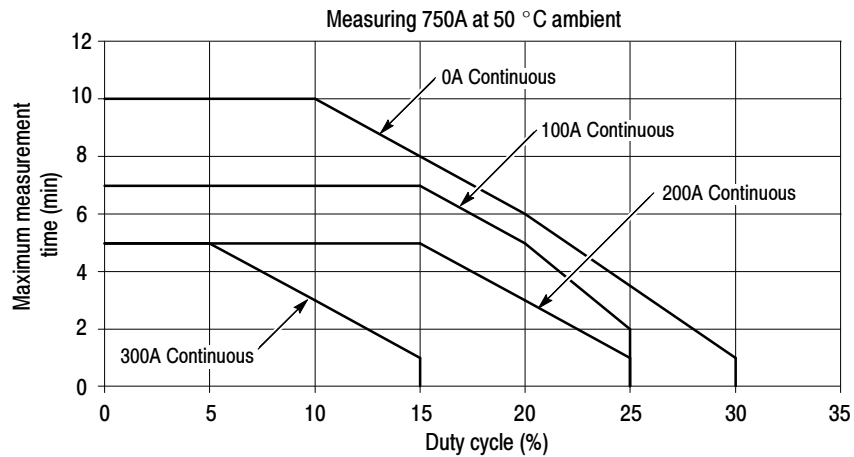


Figure 4-8: Measuring 750A noncontinuous at 50 °C ambient temperature

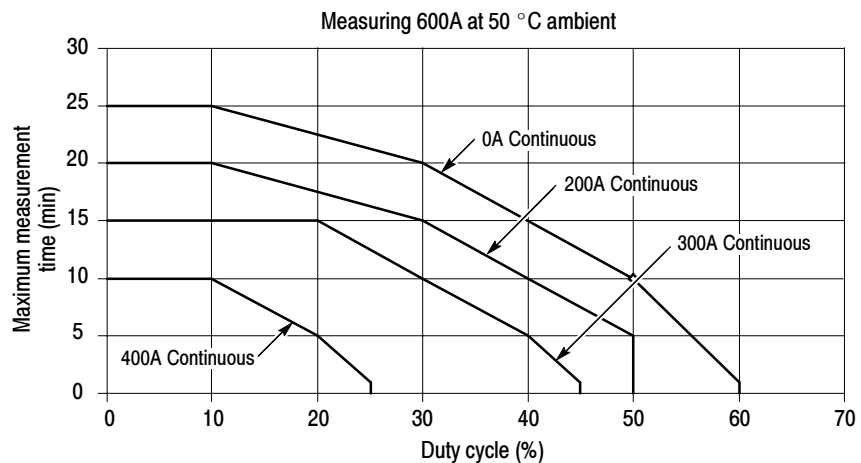


Figure 4-9: Measuring 600A noncontinuous at 50 °C ambient temperature

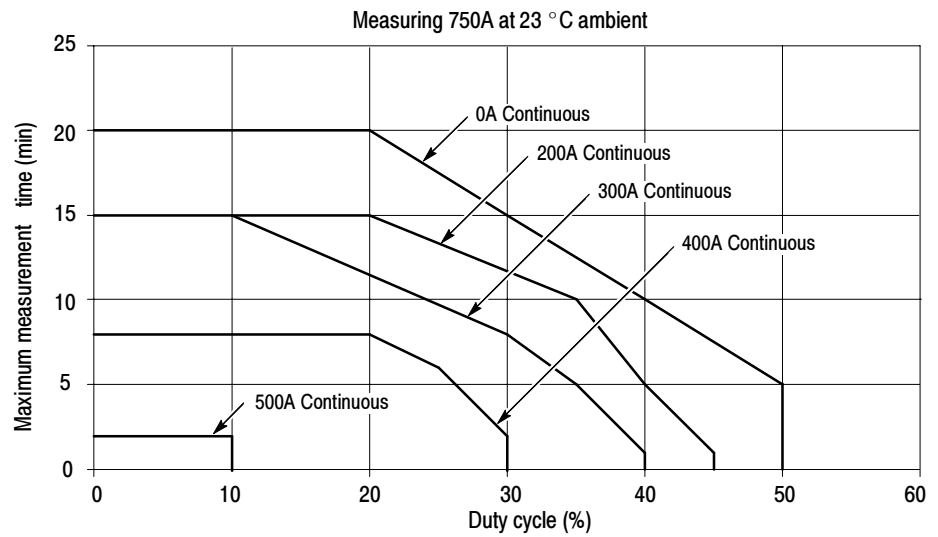


Figure 4-10: Measuring 750A noncontinuous at 23 °C ambient temperature

At 23 degrees ambient temperature, 600 A can be measured continuously with the TCP404XL probe.

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.





Performance Verification

Performance Verification Overview

The Performance Verification tests allow you to demonstrate that the Current Probe Amplifier and Current Probes meet their specified levels of performance. Since the TCPA300 and TCPA400 cannot operate without a current probe, a calibration adapter is used to verify the amplifier(s) separately. The TCPA Calibration Adapter is an optional accessory—see *Replaceable Parts* for part numbers. After you have verified the amplifier performance independent of the current probe(s), you can check the performance of current probes with confidence.

Tolerances that are specified in these procedures apply to the amplifiers and current probes and do not include test equipment error. The recommended calibration interval is one year.

Performance Verification and Functional Checks

The warranted specifications for the amplifiers that are checked in the performance verification procedures are listed in Table 5-1. See Table 4-1 in *Specifications* for warranted values. Functional checks are included for you to verify proper amplifier operation.

Table 5-1: Amplifier checks

Amplifier	Performance verification		Functional checks			
	DC gain accuracy	Bandwidth	Front-panel display	AC coupling	Degauss ¹	Overload ¹
TCPA300	✓	✓	✓	✓	✓	✓
TCPA400	✓	✓	✓	✓	✓	

¹ With probe attached

The warranted specifications for the probes that are checked in the performance verification procedures are listed in Table 5-2. See Table 4-1 in *Specifications* for warranted values.

Table 5-2: Probe performance verification checks

Probe	DC gain accuracy	Bandwidth	Risetime
TCP312	✓	✓	✓
TCP305	✓	✓	✓

Table 5-2: Probe performance verification checks (Cont.)

Probe	DC gain accuracy	Bandwidth	Risetime
TCP303	✓	✓	✓
TCP404XL	✓		✓

Test Procedure Conditions

These procedures are valid only under the following conditions:

- The system has been calibrated at an ambient temperature of $23^{\circ} \pm 5^{\circ} \text{C}$.
- The system is operating in an environment whose limits are described in Table 4-6 on page 4-5.
- The system, including probe, has had a warm-up period of at least 20 minutes.
- The probe degauss/autobalance routine has been performed after the 20-minute warm-up period.

Equipment Preparation

Before performing the verification tests, turn all equipment on and allow the entire system to warm up for a minimum of 20 minutes.

NOTE. Before performing any verification procedure, properly degauss the probe. Remove the probe from any current-carrying conductor, lock the probe, and press the amplifier PROBE DEGAUSS AUTOBALANCE button. The degauss/autobalance routine is complete when the indicator light turns green.

The amplifier front panel will light the NOT TERMINATED INTO 50 Ω LED during the degauss/ autobalance routine if the amplifier is not properly terminated into 50 Ω . Verify that the oscilloscope input is 50 Ω and set to DC coupling. Use a 50 Ω feedthrough termination, attached at the oscilloscope input, if necessary.

TCPA300 and TCPA400 Performance Verification

This section covers the performance verification for the TCPA300 and TCPA400 Current Probe Amplifiers. Refer to the list of equipment required in Table 5-3. Power on the amplifier and test equipment and let them warm up for 20 minutes.

Before starting these procedures, photocopy the appropriate test record beginning on page 5-16 to record the performance test results. The recommended calibration interval is one year.

Equipment Required

The performance verification procedures require the test equipment listed in Table 5-3. The test equipment must meet or exceed the specifications listed. You may need to modify the test procedures if you do not use the recommended equipment.

Table 5-3: Required test equipment

Qty	Item	Description	Recommended equipment
1	Oscilloscope	500 MHz bandwidth	Tektronix TDS5000
1	Leveled Sine Wave Generator	3 MHz to 100 MHz	Wavetek 9100 with >250 MHz Oscilloscope Calibration Option
1	Digital Multimeter	DCV: 0.1% Accuracy, 5 ¹ / ₂ digit resolution	Keithley 2700
1	Current Source	DCA: 0.1% Accuracy, 0 to ±100 mA, floating outputs	Fluke 5100 or HP 6612C
1	Current Source	DCA: 0.1% accuracy, 0 to ±15 A	Wavetek 9100
1	Square Wave Generator	ACV 1.5 Vp-p, 28 Hz square wave	Wavetek 9100
1	HF Current Loop	50 Ω, BNC Connector	Tektronix part number 015-0601-50
1	Precision Termination	50 Ω, ±0.1%, 0.5 W	Tektronix part number 011-0129-00
2	BNC Cables	50 Ω, 0.76 m (30 in) long	Tektronix part number 012-0117-00
1	Cable	TEKPROBE Interface Cable	Tektronix part number 012-1605-00
2	BNC to Dual Banana Adapters		Tektronix part number 103-0090-00
1	DC Current Loop	5 turns 18 AWG coated wire	Refer to page 5-4
1	DC Current Loop	50 turns 13 AWG coated wire	Refer to page 5-4
1	Calibration Adapter	TCPA Calibration Adapter	Tektronix part number 174-4765-00
1	Current Probe ¹	TCPA300/400-compatible probe	Tektronix TCP303, 305, or 312 (TCPA300) or TCP404XL (TCPA400)

¹ Required for functional test only.

Making DC Current Loops

You need to construct simple current loops to complete some tests for the amplifiers. The current loops are also used in the DC gain accuracy tests for the probes.

5-Turn DC Current Loop

Construct the loop using 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.*

The 5-turn DC current loop is also used in the current probe performance verification and adjustment procedures.

50-Turn DC Current Loop

Construct the loop using a cylindrical form approximately 3 inches in diameter:

1. Wind *exactly* 50 turns of #13 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 50 turns. A significant error will result for each turn variance from 50 turns.*

The 50-turn DC current loop is also used in the current probe performance verification procedures.

Front-Panel Display

The status and error LEDs on the front panel are illuminated briefly during the amplifier power-on sequence. Verify that all LEDs are functional by doing the following procedure:

1. Power-cycle the amplifier and check that the LEDs shown in Figure 5-1 light briefly. Note that the PROBE DEGAUSS AUTOBALANCE and OVERLOAD LEDs are multi-color:
 - a. The PROBE DEGAUSS AUTOBALANCE LED lights in an orange→red→green sequence.
 - b. The OVERLOAD LED lights in an orange→red→green sequence.
 - c. The MANUAL BALANCE LED is orange, and lights briefly.
 - d. The RANGE and COUPLING LEDs are green, and light briefly.
2. Record the results (pass/fail) on the test record.

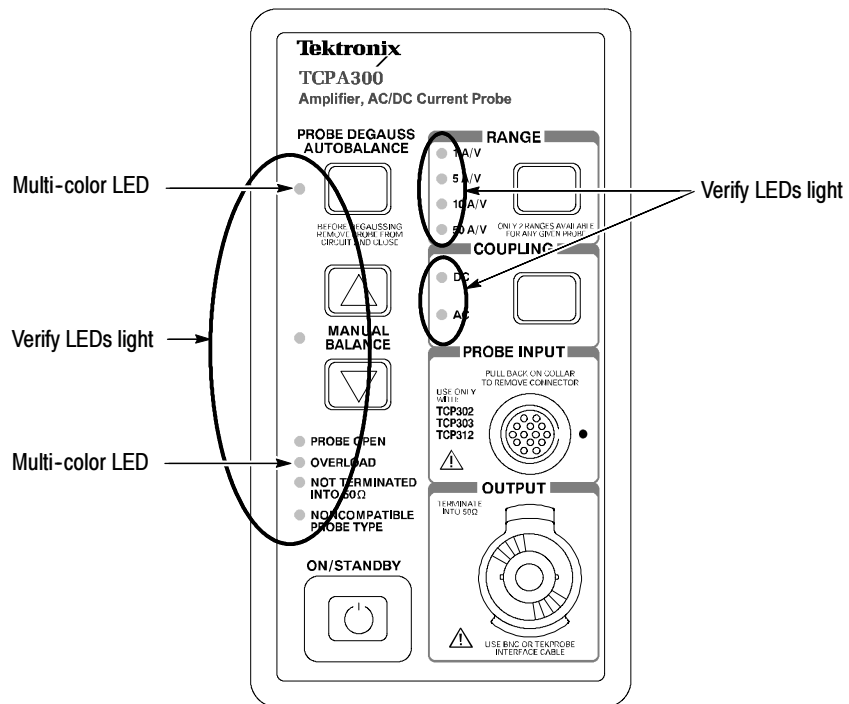


Figure 5-1: Check LED functionality

DC Gain Accuracy

Use the following procedure to verify the DC gain accuracy of the amplifier.

Test Equipment Setup

Refer to Figure 5-2 and set up the test equipment as follows:

1. Connect the output of the amplifier to the DMM:
 - a. Connect a BNC Cable from the amplifier **OUTPUT** to the 50 Ω precision feedthrough termination.
 - b. Attach the termination to a BNC-to-dual banana adapter.
 - c. Observe polarity and insert the dual banana adapter into the digital multimeter DC voltage input.
2. Connect the probe input to the current source:
 - a. Connect the BNC end of the Calibration Adapter to a BNC-to-dual banana adapter.
 - b. Observe polarity and insert the dual banana adapter into the current source DC output. Do not connect the Calibration Adapter to the amplifier at this time.

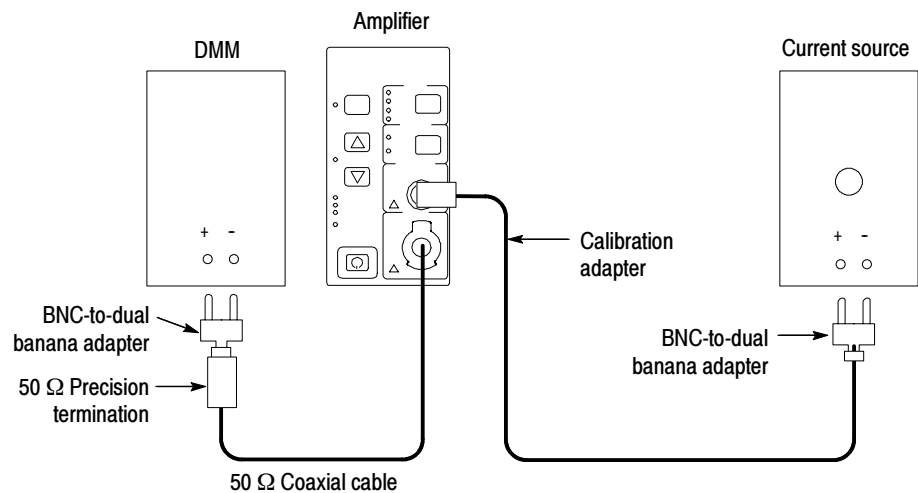


Figure 5-2: Equipment setup for DC gain accuracy test

3. Make or verify the equipment settings in Table 5-4:

Table 5-4: Equipment settings

Digital multimeter	
Measurement Type	DC volts
Range	Autoranging
Current source	
Voltage	6 V
Current	100 mA
Output	Off
TCPA300 and T CPA400 amplifier	
Coupling	DC

Procedure

After the equipment is set up, proceed as follows:

4. Connect the Calibration Adapter to the **PROBE INPUT** of the amplifier.
5. For each of the Range settings in Table 5-5, perform the following steps:
 - a. If you are checking a T CPA300, set the amplifier to the desired Range setting in Table 5-5.
 - b. Enable the output of the current source.
 - c. Record the exact measurement of the digital multimeter as M_I .

Table 5-5: DC gain accuracy test for the T CPA300 and T CPA400

Amplifier	Range, A/V	Current source output	Expected output, V_E (VDC)	Measured output, M_I (VDC)	% Error, calculated
TCPA300	1	100 mA	5.0000		
	5	100 mA	2.5000		
	10	100 mA	1.2375		
	50	100 mA	0.4835		
	50 (COMP) ¹	100 mA	0.4585		
TCPA400	1 A/mV	100 mA	2.5000		

¹ Both 10 A/V and 50 A/V RANGE LEDs light.

- d. Calculate the %Error between the measured output, M_1 , and the expected output (V_E) %Error as follows:

$$\%Error = \frac{M_1 - V_E}{V_E} \times 100$$

For example, using an expected output V_E of 2.5000 V and a measured output M_1 of 2.510, the %Error would be:

$$\%Error = \frac{2.5100 - 2.5000}{2.5000} \times 100 = + 0.4\%$$

NOTE. *It is important that the correct polarity be used to calculate the %Error.*

6. Verify that the measured DC gain accuracy is within the limits specified for all settings in the test record on page 5-16 for the TCPA300 (page 5-17 for the TCPA400). Record the %Error in the test record.

NOTE. *If the %Error on any of the settings is greater than the specified limit, you must perform the adjustment procedure that begins on page 6-3.*

7. Disconnect the DMM cable from the amplifier and the calibration adapter from the current source.

Bandwidth

This procedure tests the bandwidth of the TCPA300 and TCPA400 amplifiers. In this test you measure a signal at a relatively low frequency and again at the upper test frequency. The two measurements are compared to verify that the signal amplitude does not fall below a certain limit. Refer to Figure 5-3 when making equipment connections.

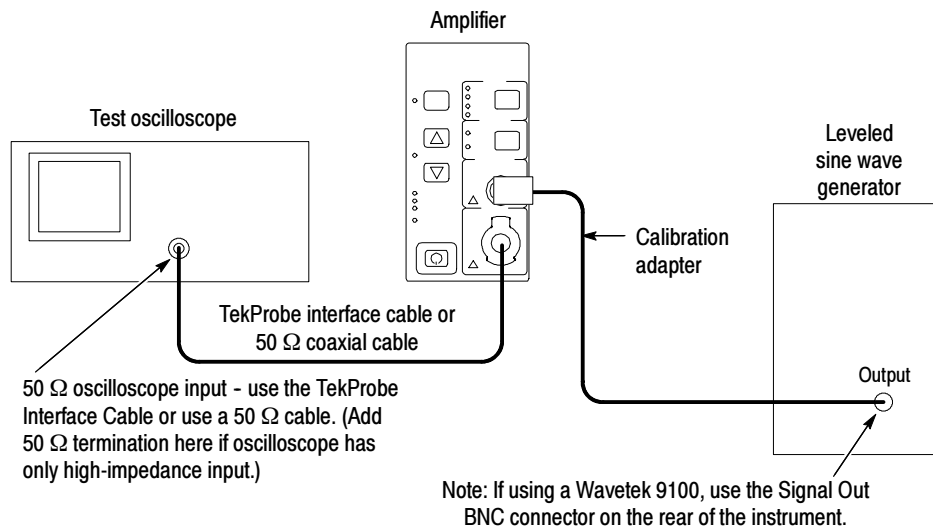


Figure 5-3: Bandwidth test setup

1. If you are using a Tektronix oscilloscope that supports the TekProbe Level 2 Interface, use the TekProbe interface cable to connect the amplifier **OUTPUT** to the oscilloscope input. If you are not using a Tektronix oscilloscope that supports the TekProbe Level 2 Interface, use a 50 Ω BNC cable. If the input impedance of your oscilloscope is 1 MΩ, connect a 50 Ω feedthrough termination at the oscilloscope input. Do not connect the termination at the amplifier output.
2. Connect the Calibration Adapter to the amplifier **PROBE INPUT**.
3. Make or verify the equipment settings in Table 5-6:

Table 5-6: Equipment settings for bandwidth check

Oscilloscope		
Vertical input impedance		50 Ω
Time base	TCPA300	40 ns/division
	TCPA400	80 ns/division
Record length		500

Table 5-6: Equipment settings for bandwidth check (Cont.)

Oscilloscope		
Coupling		DC
Offset		0 V (mid-scale)
Trigger type		Edge
Trigger mode		Auto
Trigger position		50%
Acquisition mode		Average
Number of waveforms to average		16
Measurement type		Peak-to-Peak
Leveled sine wave generator		
Frequency		3 MHz
Amplitude	TCPA300	~3.0 V _{p-p}
	TCPA400	1.0 V _{p-p}
TCPA300 and T CPA400		
Coupling		DC

4. Connect the Calibration Adapter to the output of the leveled sine wave generator.
5. Enable the output of the leveled sinewave generator.
6. Verify the amplifier output is what is listed for the T CPA300 amplifier in Table 5-7 on page 5-11. If you are checking a T CPA400 amplifier, use Table 5-8 on page 5-11.
7. Using the peak-peak measurement capability of the oscilloscope, measure and record the peak-peak reading as M_I in Table 5-7 or Table 5-8 on page 5-11.
8. If you are checking a T CPA300, for each range setting and bandwidth filter in Table 5-7 on page 5-11, perform the following steps. If you are checking a T CPA400, use Table 5-8 on page 5-11.
 - a. Set the oscilloscope time base to 4 or 5 ns/division. Increase the signal generator frequency to 50 or 100 MHz, depending on the range setting and bandwidth.
 - b. When you check the 100 MHz frequency, press either MANUAL BALANCE button until the orange MANUAL BALANCE LED lights. This engages a higher-frequency filter in the amplifier. After you check the bandwidth at 100 MHz, press either MANUAL BALANCE button again to turn off the filter (the LED goes off.)

- c. Using the peak-peak measurement capability of the oscilloscope, measure and record the peak-peak reading as M_2 in Table 5-7 or Table 5-8 on page 5-11.
- 9. The system meets the bandwidth specification if the ratio of the signal amplitude at the warranted bandwidth is at least 70% of the signal amplitude at 3 MHz. Using the following calculation, verify system bandwidth:

$$(\text{correction factor}) \left(\frac{M_2}{M_1} \right) > 0.707$$

- 10. Verify that the calculated system bandwidth is within the limits specified for all settings in the test record on page 5-16 for the TCPA300 (page 5-17 for the TCPA400). Record the calculated system bandwidth in the test record.

Table 5-7: TCPA300 bandwidth measurements

Range	TEKPROBE interface cable		Coaxial cable		Bandwidth filter and generator frequency	Correction factor ¹	M1	M2
	Vertical gain setting	Amplifier output, p-p	Vertical gain setting	Amplifier output, p-p				
1 A/V	500 mA/div	~3 A	500 mV/div	~3 V	50 MHz	1.09		
	500 mA/div	~3 A	500 mV/div	~3 V	100 MHz	1.14		
5 A/V	1 A/div	~7.5 A	200 mV/div	~1.5 V	50 MHz	1.16		
10 A/V	1 A/div	~7.5 A	100 mV/div	~0.75 V	50 MHz	1.11		
50 A/V	2 A/div	~15 A	50 mV/div	~300 mV	50 MHz	1.14		
50 A/V COMP ²	2 A/div	~15 A	50 mV/div	~300 mV	50 MHz	1.00		

¹ The correction factor accounts for impedance differences between the 50 Ω voltage source and the TCPA amplifier at higher frequencies.

² Both 10 A/V and 50 A/V RANGE LEDs light.

Use Table 5-8 to record the measurements for the TCPA400 Amplifier.

Table 5-8: TCPA400 bandwidth measurements

Range	TEKPROBE interface cable		Coaxial cable		Bandwidth filter and generator frequency	Correction factor	M1	M2
	Vertical gain setting	Amplifier output, p-p	Vertical gain setting	Amplifier output, p-p				
1 A/mV	100 A/div	~500 A	100 mV/div	~500 mV	50 MHz	1.09		

AC Coupling

The following test checks that the AC coupling circuit of the amplifier functions properly. First, you measure a square-wave signal in DC coupling mode and record the value, and then switch to AC coupling and measure the signal amplitude.

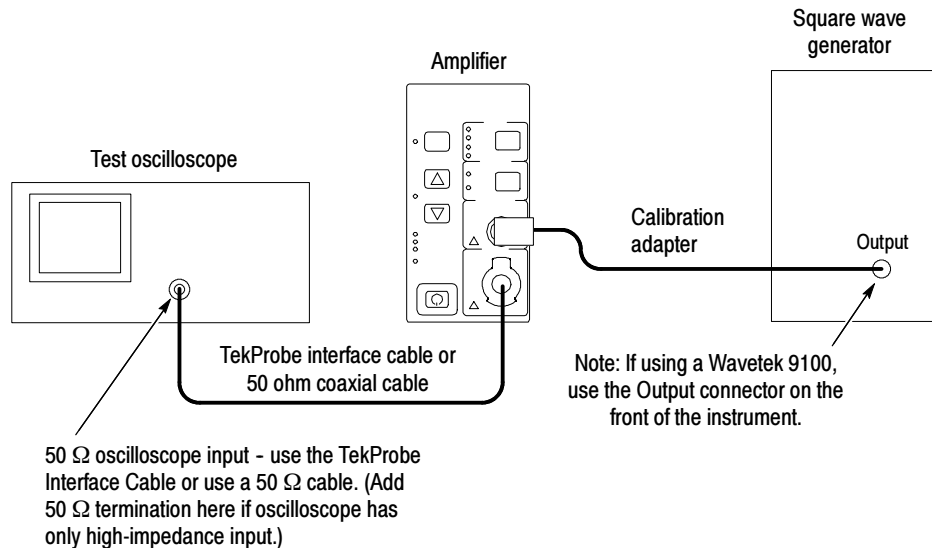


Figure 5- 4: AC coupling test setup

To perform the check, do the following:

1. Connect the circuit as shown in Figure 5-4.
2. Set the amplifier COUPLING to DC.
3. If you are checking a TCPA300, set the RANGE to 1A/V.
4. Set the generator to output a 28 Hz square wave.
5. Set the oscilloscope horizontal scale to 4 or 5 ms/div.
6. Use Table 5-9 on page 5-13 to make further equipment settings.
7. Measure the signal on the oscilloscope and verify that it is 1Vp-p. If necessary, adjust the generator output to achieve 1Vp-p.
8. Set the amplifier COUPLING to AC.
9. Measure the signal on the oscilloscope and verify that the signal is within the limits on the test record.

Table 5-9: TCPA300 and TCPA400 AC coupling measurements

Amplifier	Square wave generator amplitude	TEKPROBE Interface cable				BNC coaxial cable			
		Vertical gain setting	DC coupled amplifier output	Minimum AC coupled amplifier output	Maximum AC coupled amplifier output	Vertical gain setting	DC coupled amplifier output	Minimum AC coupled amplifier output	Maximum AC coupled amplifier output
TCPA300	0.5 Vp	200 mA/div	1.00 Ap-p	1.05 Ap-p	1.50 Ap-p	200 mV/div	1.00 Vp-p	1.05 Vp-p	1.50 Vp-p
TCPA400	0.5 Vp	200 A/div	1000 Ap-p	1050 Ap-p	1500 Ap-p	200 mV/div	1.00 Vp-p	1.05 Vp-p	1.50 Vp-p

10. Disconnect the Calibration Adapter from the amplifier.

Degauss

This is a functional test of the degauss operation. Refer to Figure 5-5.

1. Connect a current probe to the output of the amplifier. Do not clamp the current probe around any conductor, but make sure the jaws are locked shut.
2. Press the amplifier **PROBE DEGAUSS AUTOBALANCE** button. When the indicator turns green, the degauss operation has successfully completed.
3. Verify that there are no error codes. Error codes display on the Probe Status LEDs when the AC and DC COUPLING LEDs alternately flash.
4. Record the results (pass/fail) on the test record.

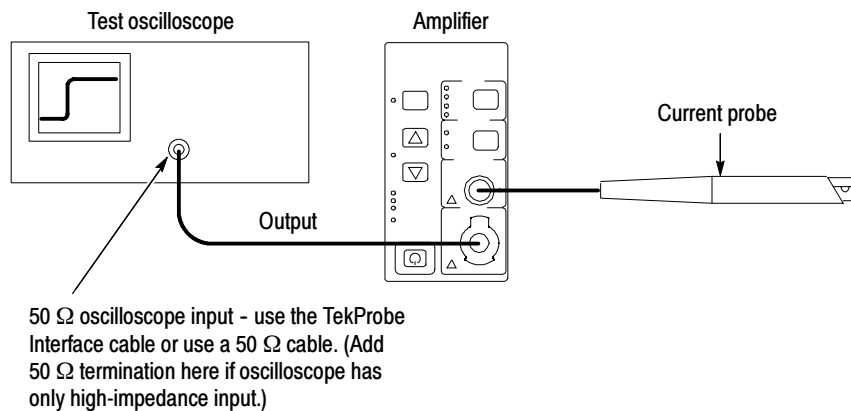


Figure 5-5: Setup for degaussing the current probe

Current Overload Test (TCPA300 Only)

This test checks the functionality of the TCPA300 current overload detection circuit using the setup shown in Figure 5-6. You set the current source to output the maximum rated current for the probe/amplifier you are testing, and then increase the current source to a level that engages the overload circuit (the OVERLOAD LED is on). Then, you repeat the test at the opposite polarity.

This test uses current loops that you make using wire and 3-inch forms. Refer to page 5-4 for instructions on making the current loops.

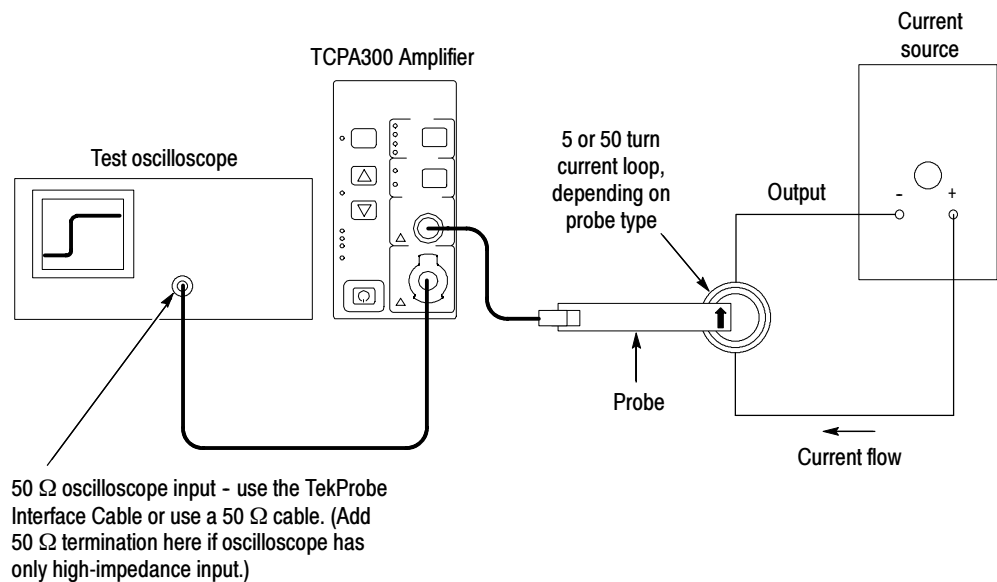


Figure 5-6: Overload test setup

1. Connect the circuit as shown in Figure 5-6. Refer to Table 5-10 for the correct current loop to use for the probe you are testing.
2. Set the RANGE on the amplifier to the highest setting for the probe that is connected to the amplifier.
3. Adjust the current source output to the value listed in Table 5-10 on page 5-15 for the probe you are testing. For example, if you are testing a TCP305, adjust the output to 10 amps.
4. Check that the OVERLOAD LED is off.

Table 5-10: Maximum current ratings for T CPA300-compatible probes

Probe model	Range	Maximum current rating, Amps	Current loop used for test ¹	Current source output, Amps
TCP312	10 A/V	±30	5 T	±6
TCP305	10 A/V	±50	5 T	±10
TCP303	50 A/V	±212 ²	50 T	±4.24

¹ Refer to page 5-4 for instructions on making the current loops.

² The TCP303 is a 150 A RMS probe with a peak current of 212 A. Apply current for only a short amount of time.

5. Slowly increase the output of the current source until the OVERLOAD LED on the amplifier is on.



CAUTION. Do not leave the current turned up longer than necessary – damage to the equipment or personal injury may result.

6. Decrease the output of the current source to zero.
7. Record the results (pass/fail) on the test record.
8. Repeat steps 3 through 7 for the opposite polarity.

This completes the performance verification for the amplifiers.

If the T CPA300 or T CPA400 amplifier fails any of the verification tests, refer to the *Adjustments* section for servicing information.

TCPA300 Amplifier Test Record

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

TCPA300 amplifier test record

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

Performance test	Range, A/V	Minimum	Measured/calculated	Maximum
Front-Panel Display		Pass/Fail		
DC Gain Accuracy (% Error)	1	-1%		+1%
	5	-1%		+1%
	10	-1%		+1%
	50	-1%		+1%
	50 (COMP)	-1%		+1%
Bandwidth	1	.707		-----
	1 (100 MHz)	.707		-----
	5	.707		-----
	10	.707		-----
	50	.707		-----
AC Coupling ¹	TEKPROBE Cable	1	1.05 Ap-p	1.5 Ap-p
	BNC Coax Cable	1	1.05 Vp-p	1.5 Vp-p
Degauss		Pass/Fail		
Current Overload		Pass/Fail		

¹ The AC Coupling test can be performed with either cable, but the units of measure for the results differ between the two.

TCPA400 Test Record

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

TCPA400 amplifier test record

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

Performance test	Minimum	Measured/calculated	Maximum
Front-Panel Display	Pass/Fail		
DC Gain Accuracy (% Error)	-1%		+1%
Bandwidth	.707		-----
AC Coupling ¹	TEKPROBE Cable	1050 Ap-p	1500 Ap-p
	BNC Coax Cable	1.05 Vp-p	1.5 Vp-p
Degauss	Pass/Fail		

¹ The AC Coupling test can be performed with either cable, but the units of measure for the results differ between the two.

TCP305 and TCP312 Performance Verification

The test procedures in this section verify warranted specifications and proper performance of the TCP305 and TCP312 current probes, using the TCPA300 Amplifier. Tolerances that are specified in these procedures apply to the amplifier and current probe and do not include test equipment error.

Before starting these procedures, photocopy the appropriate test record beginning on page 5-29 to record the performance test results. The recommended calibration interval is one year.

NOTE. *If the amplifier is not properly terminated into 50 Ω ., the NOT TERMINATED INTO 50 Ω status LED is on. Verify that the 50 Ω termination is connected at the DMM input when performing the following procedures.*

No probe or amplifier adjustments are required during these test procedures. If any tests fail, refer to *TCP305 and TCP312 Adjustments*, beginning on page 6-7.



WARNING. *Magnetic fields are produced in these procedures that may cause a malfunction in heart pacemakers or damage to sensitive equipment.*

Required Test Equipment

To perform the acceptance tests in this section, you will need the test equipment listed in Table 5-11. The test equipment must meet or exceed the specifications listed. The test procedures may need to be modified if the recommended equipment is not used.

Table 5- 11: Required test equipment

Qty	Item	Description	Recommended equipment
1	Oscilloscope	500 MHz bandwidth	Tektronix TDS5000
1	Current Probe Amplifier		Tektronix TCPA300
1	Leveled Sine Wave Generator	3 MHz to 100 MHz	Wavetek 9100 with Option 250
1	High Amplitude Pulse Generator	Rise time <1 ns, pulse width >100 ns, amplitude >5 V _{p-p} into 50 Ω	Picosecond Labs 2600
1	Digital Multimeter	DCV: 0.1% accuracy 5 ^{1/2} digit resolution	Keithley 2700
1	Current Source	DCA: 0.1% accuracy, 0 to ±10 A	Wavetek 9100
1	HF Current Loop	50 Ω, BNC Connector	Tektronix part number 015-0601-50
1	DC Current Loop	5 turns 18 AWG coated wire	Refer to page 5-4
1	Precision Termination	50 Ω, ±0.1%, 0.5 W	Tektronix part number 011-0129-00
1	BNC Cable	50 Ω, 0.76 m (30 in) long	Tektronix part number 012-0117-00
1	Cable	TEKPROBE Interface Cable	Tektronix part number 012-1605-00
1	Adapter	BNC-to-Dual Banana	Tektronix part number 103-0090-00

DC Gain Accuracy

This procedure tests the DC gain accuracy of the TCP305 and TCP312 Current Probes. In this test you compare the voltage output of the amplifier to a reference input.

This test uses current loops that you make using wire and 3-inch forms. Refer to page 5-4 for instructions on making the current loops.

Equipment Connections

1. Using a BNC cable, connect the amplifier **OUTPUT** to the 50 Ω feed-through termination. Attach the termination to a BNC-to-dual banana adapter. Insert the dual-banana adapter into the digital multimeter DC voltage input, taking care to maintain polarity.
2. Connect the current loop to the current source as shown in Figure 5-7.
3. Connect the current probe to the **PROBE INPUT** connector. Do not connect the probe to the current loop at this time.

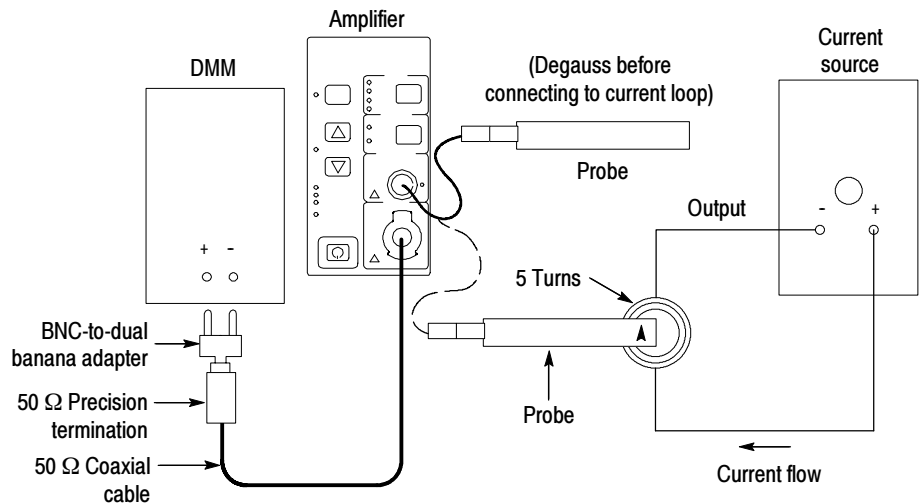


Figure 5-7: DC gain accuracy test setup for TCP305 and TCP312

Equipment Settings

Make or verify the equipment settings in Table 5-12:

Table 5-12: Equipment settings for DC gain accuracy

Digital multimeter	
Measurement Type	DC volts
Range	Autoranging
Current source	
Amplitude	DC Amps

Table 5-12: Equipment settings for DC gain accuracy (Cont.)

Current source	
Output	Off
TCPA300	
Coupling	DC

- Procedure**
1. Do not clamp the current probe around any conductor, but make sure the jaws are locked shut.
 2. Press the amplifier **PROBE DEGAUSS AUTOBALANCE** button. Wait for the degauss/autobalance routine to complete before proceeding. The routine is complete when the indicator light turns green.
 3. Clamp the current probe around the 5 turn current loop, as shown in Figure 5-7 on page 5-21. Observe and maintain proper polarity; the arrow-shaped indicator on the probe points away from the (+) terminal of the current source.
 4. For each of the amplifier range settings in Table 5-13, perform the following steps:
 - a. Set the amplifier range to the first setting in Table 5-13 for the probe you are testing. For example, if you are testing a TCP305, set the range to 5A/V.
 - b. Set the current source output to the first positive (+) setting in Table 5-13 for the probe you are testing. For example, if you are testing a TCP305, set the output to +1.00 A. (Each output level is tested at both polarities; later in the procedure, you will set the output to -1.00A.)
 - c. Enable the output of the current source.
 - d. Record the exact measurement of the digital multimeter as M1.
 - e. Set the current source output to the first negative (-) setting in Table 5-13 for the probe you are testing. For example, if you are testing a TCP305, set the output to -1.00 A.
 - f. Record the exact measurement of the digital multimeter as M2.

Table 5-13: DC gain accuracy test for the TCP305 and TCP312

Probe	Range	Current source output (ADC)	Expected output, V_E (VAC)	M1 (VDC)	M2 (VDC)	M1-M2 (VDC)	% Error, calculated
TCP305	5 A/V	±1.00 A	±1.00 V				
		±3.00 A	±3.00 V				
		±5.00 A	±5.00 V				
	10 A/V	±2.00 A	±1.00 V				
		±6.00 A	±3.00 V				
		±10.00 A	±5.00 V				
TCP312	1 A/V	±0.200 A	±1.00 V				
		±0.600 A	±3.00 V				
		±1.00 A	±5.00 V				
	10 A/V	±1.20 A	±0.60 V				
		±3.60 A	±1.80 V				
		±6.00 A	±3.00 V				

- g. Verify that the measured output (M1-M2) is within the warranted specification listed in Table 4-1 on page 4-1, by computing %Error as follows:

$$\%Error = \frac{(M_1 - M_2) - 2(V_E)}{2(V_E)} \times 100$$

For example, you may measure values of 0.990V for M1 and -0.998V for M2. With an expected V_E of 1.0V, you compute the %Error as follows:

$$\begin{aligned} \%Error &= \frac{(0.990V - -0.998V) - 2(1V)}{2(1V)} \times 100 \\ &= \frac{1.988V - 2V}{2V} \times 100 = -0.6\% \end{aligned}$$

5. Record the results on the test record.
6. Disconnect the DMM cable from the amplifier and the probe from the 5T coil.

Rise Time

This procedure measures the rise time of the TCP305 and TCP312 Current Probes. In this test you directly measure the rise time of a step input. Refer to Figure 5-8 when making equipment connections.

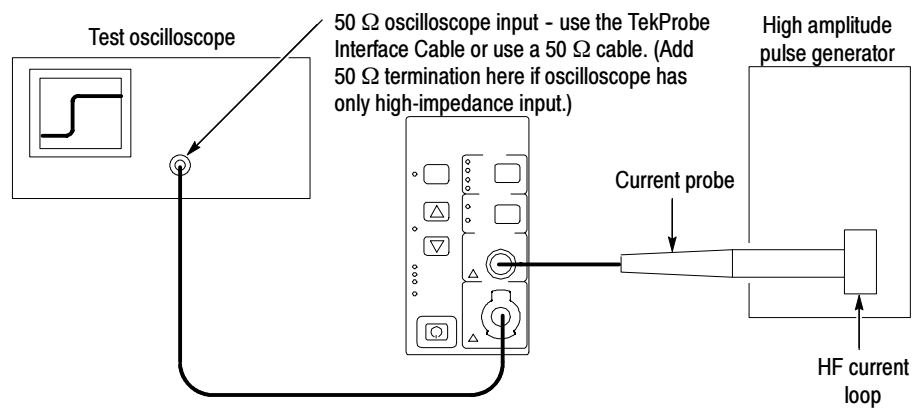


Figure 5-8: Rise time test setup for the TCP305 and TCP312

Equipment Connections

1. If you are using a Tektronix oscilloscope that supports the TekProbe Level 2 Interface, use the TekProbe Interface Cable to connect the amplifier **OUTPUT** to the oscilloscope input. If you are not using a Tektronix oscilloscope that supports the TekProbe Level 2 Interface, use a 50 Ω BNC cable. If the input impedance of your oscilloscope is 1 MΩ, connect a 50 Ω feedthrough termination at the oscilloscope input. Do not connect the termination at the amplifier output.
2. Connect the current probe to the amplifier **PROBE INPUT**.
3. Connect the HF current loop to the high amplitude pulse generator output.

NOTE. If your oscilloscope cannot trigger on the pulse, use another BNC cable to connect the trigger output of the pulse generator to the trigger input of the oscilloscope. Configure the oscilloscope for an external trigger.

Equipment Settings

Make or verify the equipment settings in Table 5-14 on page 5-25:

Table 5-14: Equipment settings for rise time

Oscilloscope	
Vertical input impedance	50 Ω
Vertical scale	200 mA/division
Time base	2 ns/division
Record length	500
Coupling	DC
Offset	0 V (mid-scale)
Trigger type	Edge
Trigger mode	Auto
Trigger position	50%
Acquisition mode	Average
Number of waveforms to average	32
Measurement type	Rise Time
High amplitude pulse generator	
Amplitude	Maximum
TCPA300	
Coupling	DC
Range TCP305	5A/V
TCP312	1A/V

Procedure

1. Do not clamp the current probe around any conductor, but make sure the jaws are locked shut.
2. Press the amplifier **PROBE DEGAUSS AUTOBALANCE** button. Wait for the degauss/autobalance routine to complete before proceeding. The routine is complete when the indicator light turns off.
3. Clamp the current probe around the HF current loop. Verify that the arrow-shaped indicator on the probe points away from the pulse generator.
4. Adjust the vertical gain and vertical position of the oscilloscope so that 5 to 8 divisions are displayed. (You may have to adjust the pulse generator output to achieve this.)
5. Using the measurement capability of the oscilloscope, measure the rise time of the displayed pulse from 10% to 90% amplitude.
6. If the rise time of the pulse generator is greater than 1/4 of the rise time of the probe you are testing, calculate the rise time of the probe (t_r probe) using the formula below:

$$t_r \text{ probe} = \sqrt{t_r \text{ measured}^2 - t_r \text{ system}^2}$$

The measured rise time (t_r measured) is the value calculated in step 5.

The system rise time (t_r system) is the rise time of the displayed signal when output of the pulse generator is connected directly to the oscilloscope input. (The current probe and amplifier are excluded.)

7. Verify that the probe rise time is less than the warranted specification listed in the test record.
8. Record the results on the test record.
9. Disconnect the probe from the pulse generator.

Bandwidth

This procedure tests the bandwidth of the TCP305 and TCP312 Current Probes. In this test you measure a signal at a relatively low frequency and again at the rated bandwidth of the probe. The two measurements are compared to verify that the signal amplitude does not fall below -3 dB at the probe bandwidth. Refer to Figure 5-9 when making equipment connections.

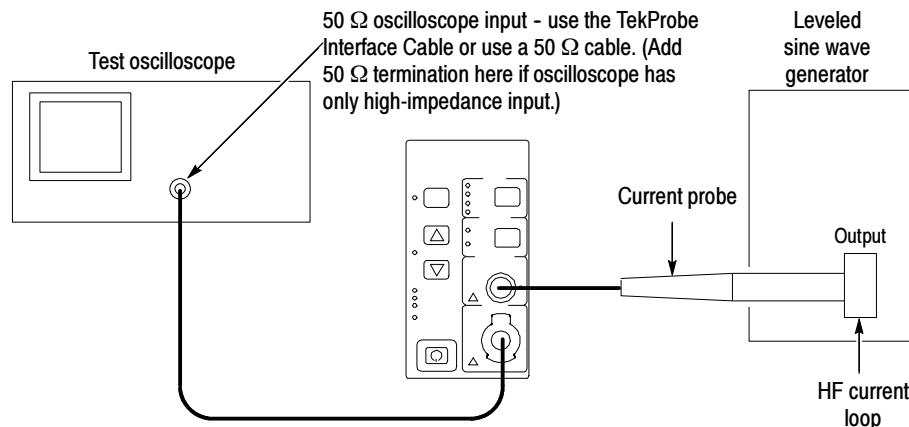


Figure 5-9: Bandwidth test setup for TCP305 and TCP312

Equipment Connections

1. If you are using a Tektronix oscilloscope that supports the TekProbe Level 2 Interface, use the TekProbe Interface Cable to connect the amplifier **OUTPUT** to the oscilloscope input. If you are not using a Tektronix oscilloscope that supports the TekProbe Level 2 Interface, use a 50 Ω BNC cable. If the input impedance of your oscilloscope is 1 MΩ, connect a 50 Ω feedthrough termination at the oscilloscope input. Do not connect the termination at the amplifier output.
2. Connect the current probe to the amplifier **PROBE INPUT**.
3. Connect the HF current loop to the output of the leveled sine wave generator.

Equipment Settings Make or verify the equipment settings in Table 5-15.

Table 5-15: Equipment settings for bandwidth

Oscilloscope	
Vertical input impedance	50 Ω
Time base	200 ns/division
Record length	500
Coupling	DC
Offset	0 V (mid-scale)
Trigger type	Edge
Trigger mode	Auto
Trigger position	50%
Acquisition mode	Average
Number of waveforms to average	8
Measurement type	Peak-to-Peak
Leveled sine wave generator	
Frequency	3 MHz
Amplitude	3 V _{p-p}
TCPA300	
Coupling	DC

- Procedure**
1. Do not clamp the current probe around any conductor, but make sure the jaws are locked shut.
 2. Press the amplifier **PROBE DEGAUSS AUTOBALANCE** button. Wait for the degauss/autobalance routine to complete before proceeding. The routine is complete when the indicator light turns green.
 3. Clamp the current probe around the HF current loop.
 4. Enable the output of the leveled sinewave generator.
 5. Verify the output level is what is listed for the probe in Table 5-16.
 6. Using the peak-peak measurement capability of the oscilloscope, measure the peak-peak reading and record it in Table 5-16 as M_I .

Table 5- 16: Bandwidth test for the TCP305 and TCP312

Probe	Range	Oscilloscope vertical gain		TCPA300 output		M1 @3 MHz ref freq	BW freq	M2 @ warranted BW freq	Calcula- tion ¹
		w/TEK- PROBE cable	w/BNC cable	w/TEK- PROBE cable	w/BNC cable				
TCP305	5 A/V	10 mA/div	2 mV/div	~60 mA p-p	~12 mV p-p		50 MHz		
TCP312	1 A/V	10 mA/div	10 mV/div	~60 mA p-p	~60 mV p-p		100 MHz		

¹ Use the formulas in step 9 on page 5-28.

7. Set the oscilloscope time base to 4 or 5 ns/division. Increase the signal generator frequency to the warranted bandwidth. Refer to Table 4-1 on page 4-1.
8. Using the peak-peak measurement capability of the oscilloscope, measure and record the peak-peak reading as M_2 .
9. The probe meets the bandwidth specification if the ratio of the signal amplitude at the warranted bandwidth is at least 70.7% of the signal amplitude at 3 MHz. Using the following calculation, verify probe bandwidth for the TCP305:

$$\left(\frac{M_2}{M_1}\right) > 0.707$$

NOTE. The impedance of the HF current loop used in this test changes between 3 MHz and 100 MHz. Typically the impedance changes from 50 Ω at 3 MHz to 59 Ω at 100 MHz. Thus you can substitute the following equation to make this test more accurate for the TCP312:

$$(1.18)\left(\frac{M_2}{M_1}\right) > 0.707$$

This completes the performance verification for the TCP305 and TCP312 probes.

If the TCP305 and TCP312 probes fail any of the verification tests, refer to the *Adjustments* section for servicing information.

TCP305 Current Probe Test Record

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

TCP305 test record

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

Performance test	Range, A/V	Test current, A	Minimum	Measured/calculated	Maximum
DC Gain Accuracy (% Error)	5 A/V	1 A	-3%		+3%
		3 A	-3%		+3%
		5 A	-3%		+3%
	10 A/V	2 A	-3%		+3%
		6 A	-3%		+3%
		10 A	-3%		+3%
Rise Time	5 A/V		---		≤7 ns
Bandwidth	5 A/V		.707		-----

TCP312 Current Probe Test Record

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

TCP312 test record

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

Performance test	Range, A/V	Test current, A	Minimum	Measured/calculated	Maximum
DC Gain Accuracy (% Error)	5 A/V	1 A	-3%		+3%
		3 A	-3%		+3%
		5 A	-3%		+3%
	10 A/V	2 A	-3%		+3%
		6 A	-3%		+3%
		10 A	-3%		+3%
Rise Time	1 A/V		---		≤3.5 ns
Bandwidth	1 A/V		.707		-----

TCP303 and TCP404XL Performance Verification

The test procedures in this section verify warranted specifications and proper performance of the TCP303 and TCP404XL Current Probes, using the appropriate amplifier. Tolerances that are specified in these procedures apply to the amplifier and current probe and do not include test equipment error.

Before starting these procedures, photocopy the appropriate test record beginning on page 5-42 to record the performance test results. The recommended calibration interval is one year.

NOTE. *If the amplifier is not properly terminated into 50 Ω , the NOT TERMINATED INTO 50 Ω status LED is on. Verify that the 50 Ω termination is connected at the DMM input when performing the following procedures.*

No probe or amplifier adjustments are required during these test procedures. If any tests fail, refer to *TCP303 and TCP404XL Adjustments*, beginning on page 6-11.



WARNING. *Magnetic fields are produced in these procedures that may cause a malfunction in heart pacemakers or damage to sensitive equipment.*

Equipment Required

To perform the acceptance tests in this section, you will need the test equipment listed in Table 5-17. The test equipment must meet or exceed the specifications listed. The test procedures may need to be modified if the recommended equipment is not used.

Table 5-17: Required test equipment

Qty	Item	Description	Recommended equipment
1	Oscilloscope	100 MHz bandwidth	Tektronix TDS5000
1	High Amplitude Pulse Generator (TCP303 only)	Rise time <5 ns, pulse width >100 ns, amplitude >20 V _{p-p} into 50 Ω	Picosecond Labs 2600
1	High Amplitude Pulse Generator (TCP404XL only)	Square wave with a rise time <35 ns, ≥5 A into 50 Ω	AVTECH AVR-3-PW-C-P-TEK2
1	Leveled Sine Wave Generator (TCP303 only)	3 MHz to 20 MHz	Wavetek 9100 with Option 250
1	Current Source	DCA: 0.1% accuracy, 0 to ±15 A	Wavetek 9100
1	Digital Multimeter	DCV: 0.1% accuracy 5 ^{1/2} digit resolution	Keithley 2700
1	Current Probe Amplifier	Use appropriate amplifier	Tektronix TCPA300 or TCPA400
1	BNC Cable	50 Ω, 0.76 m (30 in) long	Tektronix part number 012-0117-00
1	Cable	TEKPROBE Interface	Tektronix part number 012-1605-00
1	Adapter	BNC-to-Dual Banana	Tektronix part number 103-0090-00
1	HF Current Loop (TCP303 only)	50 Ω, BNC Connector	Tektronix part number 015-0601-50
1	DC Current Loop	50 turns 13 AWG coated wire	Refer to page 5-4
1	Precision Termination	50 Ω, ±0.1%, 0.5 W	Tektronix part number 011-0129-00

DC Gain Accuracy

This procedure tests the DC gain accuracy of the TCP303 and TCP404XL. In this test you compare the voltage output of the amplifier to a reference input.

This test uses a 50-turn current loop that you make using wire and a 3-inch form. Refer to page 5-4 for instructions on making the current loop.

Equipment Connections

1. Using a BNC cable, connect the amplifier **OUTPUT** to the 50 Ω feed-through termination. Attach the termination to a BNC-to-dual banana adapter. Insert the dual-banana adapter into the digital multimeter DC voltage input, taking care to maintain polarity.
2. Connect the current loop to the current source as shown in Figure 5-10.
3. Connect the current probe to the **PROBE INPUT** connector. Do not connect the probe to the current loop at this time.

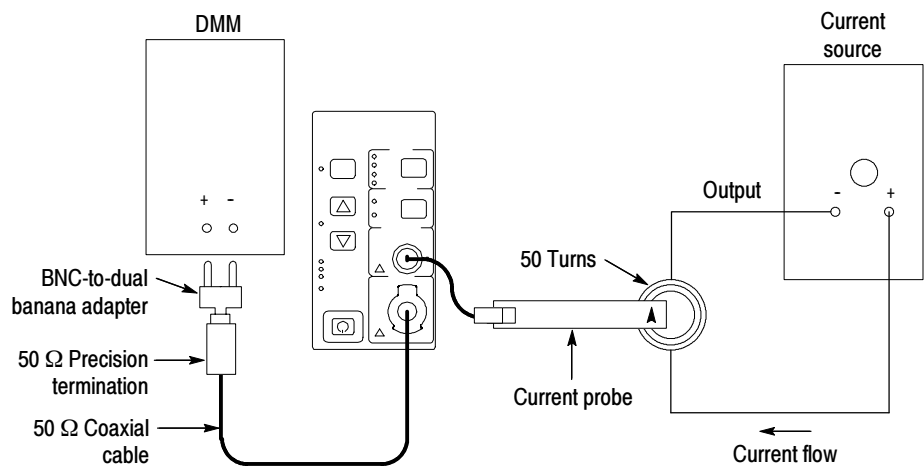


Figure 5-10: DC gain accuracy test setup for the TCP303 and TCP404XL

Equipment Settings

Make or check the equipment settings in Table 5-18.

Table 5-18: Equipment settings for DC gain accuracy

Digital multimeter	
Measurement	DC volts
Range	Autoranging
Current source	
Output	Off
TCPA300 and TCPA400	
Coupling	DC

Procedure

1. Do not clamp the current probe around any conductor, but make sure the jaws are locked shut.
2. Press the amplifier **PROBE DEGAUSS AUTOBALANCE** button. Wait for the degauss/autobalance routine to complete before proceeding. The routine is complete when the indicator light turns green.
3. Clamp the current probe around the 50 turn current loop, as shown in Figure 5-10 on page 5-33. Maintain proper polarity; the arrow-shaped indicator on the probe points away from the (+) terminal of the current source.
4. For each of the amplifier range settings in Table 5-19 on page 5-35, perform the following steps:
 - a. If you are testing a TCP303, set the amplifier range to the first setting in Table 5-19 for that probe. For example, set the range to 5A/V.
 - b. Set the current source output to the first positive (+) setting in Table 5-19 for the probe you are testing. For example, if you are testing a TCP303, set the output to +0.100 A. (Each output level is tested at both polarities; later in the procedure, you will set the output to -0.100A.)
 - c. Enable the output of the current source.
 - d. Record the exact measurement of the digital multimeter as M1.
 - e. Set the current source output to the first negative (-) setting in Table 5-19 for the probe you are testing. For example, if you are testing a TCP303, set the output to -0.100 A.
 - f. Record the exact measurement of the digital multimeter as M2.
 - g. Verify that the measured output (M1-M2) is within the warranted specification listed in Table 4-1 on page 4-1, by computing %Error as follows:

$$\%Error = \frac{(M_1 - M_2) - 2(V_E)}{2(V_E)} \times 100$$

For example, you may measure values of 0.990V for M1 and -0.998V for M2. With an expected V_E of 1.0V, you compute the %Error as follows:

$$\begin{aligned} \%Error &= \frac{(0.990V - -0.998V) - 2(1V)}{2(1V)} \times 100 \\ &= \frac{1.988V - 2V}{2V} \times 100 = -0.6\% \end{aligned}$$

5. Record the results on the test record.

Table 5-19: DC gain accuracy test worksheet for the TCP303 and TCP404XL

Probe	Range	Current source output (ADC)	Expected output, V_E (VAC)	M1 (VDC)	M2 (VDC)	M1- M2 (VDC)	% Error, calculated
TCP303	5 A/V	± 0.100 A	± 1.00 V				
		± 0.300 A	± 3.00 V				
		± 0.500 A	± 5.00 V				
	50 A/V	± 0.600 A	± 0.600 V				
		± 1.80 A	± 1.80 V				
		± 3.00 A	± 3.00 V				
TCP404XL	1 A/mV	± 3.00 A	± 0.150 V				
		± 9.00 A	± 0.450 V				
		± 15.00 A	± 0.750 V				

6. Disconnect the DMM cable from the amplifier and the probe from the 50T coil.

Rise Time

This procedure measures the rise time of the TCP303 and TCP404XL Probes. In this test you directly measure the rise time of a step input. Refer to Figure 5-11 when making equipment connections.

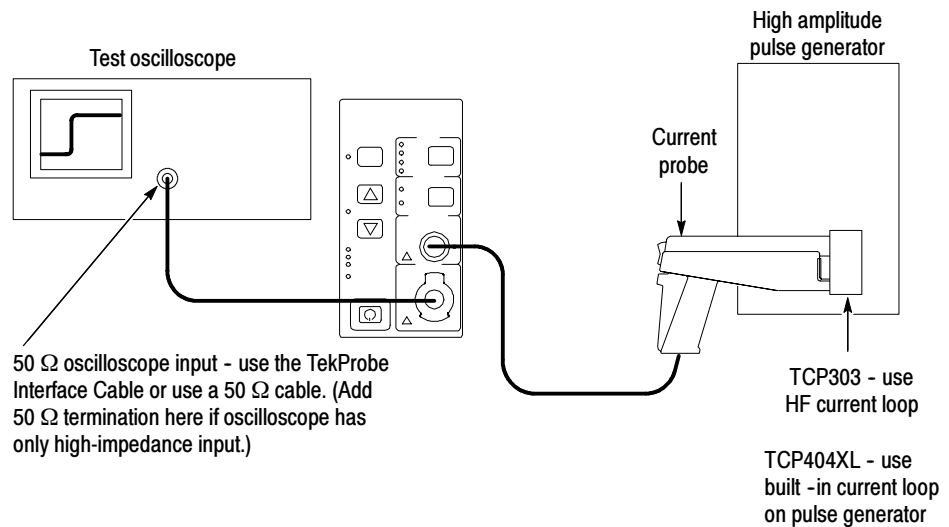


Figure 5- 11: Rise time test setup for the TCP303 and TCP404XL

Equipment Connections

1. If you are using a Tektronix oscilloscope that supports the TekProbe Level 2 Interface, use the TekProbe Interface Cable to connect the amplifier **OUTPUT** to the oscilloscope input. If you are not using a Tektronix oscilloscope that supports the TekProbe Level 2 Interface, use a 50 Ω BNC cable. If the input impedance of your oscilloscope is 1 M Ω , connect a 50 Ω feedthrough termination at the oscilloscope input. Do not connect the termination at the amplifier output.
2. Connect the current probe to the amplifier **PROBE INPUT** connector.
3. If testing a TCP303, connect the HF current loop to the high amplitude pulse generator.

NOTE. If your oscilloscope cannot trigger on the pulse, use another BNC cable to connect the trigger output of the pulse generator to the trigger input of the oscilloscope. Configure the oscilloscope for an external trigger.

Equipment Settings

Make or verify the equipment settings in Table 5-20:

Table 5-20: Equipment settings for rise time

Oscilloscope		
Vertical scale:	TCP303	200 mA/division
	TCP404XL	1 A/division
Vertical input impedance		50 Ω
Time base:	TCP303	10 ns/division
	TCP404XL	80 ns/division
Record length		500
Coupling		DC
20 MHz BW limit:	TCP303	Off
	TCP404XL	On
Offset		0 V (mid-scale)
Trigger type		Edge
Trigger mode		Auto
Trigger position		50%
Acquisition mode		Average
Number of waveforms to average		32
Measurement type		Rise Time
High amplitude pulse generator (TCP303)		
Amplitude		Maximum
High amplitude pulse generator (TCP404XL)		
Pulse width		250 μ s
Pulse repetition frequency		10 Hz
Amplitude		5 A
TCPA300 and TCPA400		
Coupling		DC
Range	TCP303	5 A/V

Procedure

1. Do not clamp the current probe around any conductor, but make sure the jaws are locked shut.
2. Press the amplifier **PROBE DEGAUSS AUTOBALANCE** button. Wait for the degauss/autobalance routine to complete before proceeding. The routine is complete when the indicator light turns green.
3. Make the following connections:
 - a. If you are testing a TCP303, clamp the current probe around the HF current loop. Verify that the arrow-shaped indicator on the probe points away from the pulse generator.

- b.** If you are testing a TCP404XL, clamp the current probe around the built-in current loop on the pulse generator. Verify that the arrow-shaped indicator on the probe points away from the output terminal on the pulse generator.
- 4.** Adjust the vertical gain and set the vertical position of the oscilloscope so that the trace is at the bottom of the screen, and 5 to 8 divisions are displayed. Press LEVEL to trigger the oscilloscope. (You may have to adjust the pulse generator output to achieve this.)
- 5.** Using the measurement capability of the oscilloscope, measure the rise time of the displayed pulse from 10% to 90% amplitude.
- 6.** Check that the rise time is less than the warranted specification listed in the test record.
- 7.** Record the results on the test record.
- 8.** Disconnect the probe from the pulse generator.

Bandwidth (TCP303)

This procedure tests the bandwidth of the TCP303 Current Probe. In this test you measure a signal at a relatively low frequency and again at the rated bandwidth of the probe. The two measurements are compared to verify that the signal amplitude does not fall below -3 dB at the probe bandwidth. Refer to Figure 5-12 when making equipment connections.

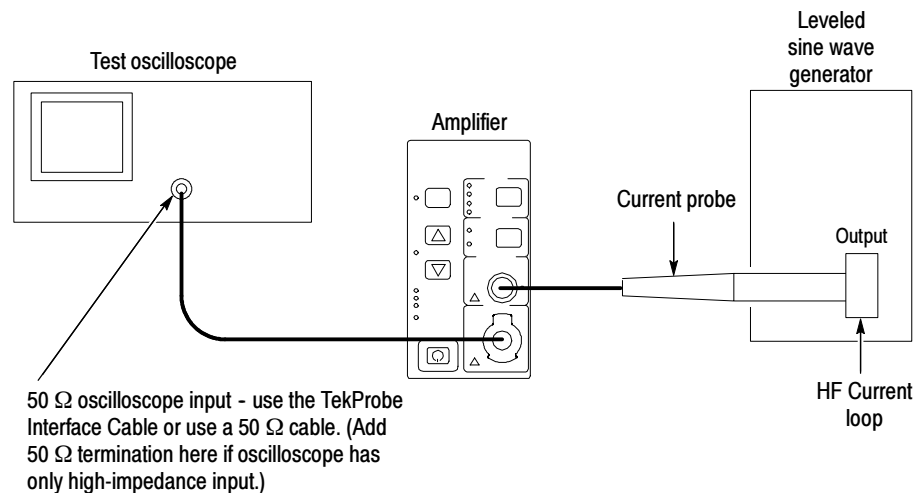


Figure 5-12: Bandwidth test setup for TCP303

Equipment Connections

1. If you are using a Tektronix oscilloscope that supports the TekProbe Level 2 Interface, use the TekProbe Interface Cable to connect the amplifier **OUTPUT** to the oscilloscope input. If you are not using a Tektronix oscilloscope that supports the TekProbe Level 2 Interface, use a 50 Ω BNC cable. If the input impedance of your oscilloscope is 1 M Ω , connect a 50 Ω feedthrough termination at the oscilloscope input. Do not connect the termination at the amplifier output.
2. Connect the current probe to the amplifier **PROBE INPUT**.
3. Connect the HF current loop to the output of the leveled sine wave generator.

Equipment Settings Make or verify the equipment settings in Table 5-21.

Table 5-21: Equipment settings for bandwidth

Oscilloscope	
Vertical input impedance	50 Ω
Time base	200 ns/division
Record length	500
Coupling	DC
Offset	0 V (mid-scale)
Trigger type	Edge
Trigger mode	Auto
Trigger position	50%
Acquisition mode	Average
Number of waveforms to average	8
Measurement type	Peak-to-Peak
Leveled sine wave generator	
Frequency	3 MHz
Amplitude	3 V _{p-p}
TCPA300	
Coupling	DC
Range	5 A/V

- Procedure**
1. Do not clamp the current probe around any conductor, but make sure the jaws are locked shut.
 2. Press the amplifier **PROBE DEGAUSS AUTOBALANCE** button. Wait for the degauss/autobalance routine to complete before proceeding. The routine is complete when the indicator light turns green.
 3. Clamp the current probe around the HF current loop.
 4. Enable the output of the leveled sinewave generator.
 5. Verify the output level is what is listed for the probe in Table 5-22.
 6. Using the peak-peak measurement capability of the oscilloscope, measure and record the peak-peak reading as M_1 in Table 5-22 on page 5-41 .
 7. Set the oscilloscope time base to 40 or 50 ns/division. Increase the signal generator frequency to the warranted bandwidth. Refer to the test record for the warranted bandwidth.
 8. Using the peak-peak measurement capability of the oscilloscope, measure and record the peak-peak reading as M_2 .

Table 5-22: Bandwidth test for the TCP303

Probe	Range	TEKPROBE cable		BNC cable		M1 @ 3 MHz ref freq	M2 @ warranted BW freq (15 MHz)	Calcula- tion ¹
		Oscilloscope vertical Gain	TCPA300 output	Oscilloscope vertical gain	TCPA300 output			
TCP303	5 A/V	10 mA/div	~60 mA p-p	2 mV/div	~12 mV p-p			

¹ Use the formula in step 9 below.

9. The probe meets the bandwidth specification if the ratio of the signal amplitude at the warranted bandwidth is at least 70.7% of the signal amplitude at 3 MHz. Using the following calculation, verify probe bandwidth:

$$\left(\frac{M_2}{M_1}\right) > 0.707$$

10. Record the results on the test record.

Bandwidth (TCP404XL)

The bandwidth of the probe is derived as a function of the probe rise time. The rise time (t_r) is measured in nanoseconds between the 10% and 90% points of the leading edge of the pulse. (Refer to the procedure beginning on page 5-36). To calculate the probe bandwidth, use the following formula:

$$\left(\frac{0.35}{t_r}\right) = \text{Bandwidth}$$

For example, a rise time of 175 ns would result in the following solution:

$$\left(\frac{0.35}{175 \times 10^{-9} \text{ seconds}}\right) = 2.0 \times 10^6 \text{ Hertz}$$

1. Record the results on the test record.

This completes the performance verification for the TCP303 and TCP404XL probes.

If the TCP303 or TCP404XL probes fail any of the verification tests, refer to the *Adjustments* section for servicing information.

TCP303 Current Probe Test Record

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

TCP303 test record

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

Performance test	Range, A/V	Test current, A	Minimum	Measured/calculated	Maximum
DC Gain Accuracy ¹ (% Error)	5 A/V	1	-3%		+3%
		3	-3%		+3%
		5	-3%		+3%
	50 A/V	0.6	-3%		+3%
		1.8	-3%		+3%
		3.0	-3%		+3%
Rise Time	5 A/V	---	---		23 ns
Bandwidth	5 A/V	---	.707		-----

¹ DC Gain Accuracy is tested at the 10 °C to 50 °C specification. If you need to test the probe at 0 °C to 10 °C, refer to the specification limits on page 4-1.

TCP404XL Current Probe Test Record

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

TCP404XL test record

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

Performance test	Range	Test current	Minimum	Measured/calculated	Maximum
DC Gain Accuracy (% Error)	1 A/mV	3.0 A	-3%		+3%
		9.0 A	-3%		+3%
		15.0 A	-3%		+3%
Rise Time	1 A/mV	---	---		175 ns
Bandwidth	1 A/mV	---	2 MHz		-----



Adjustment Procedures

Adjustment Procedures Overview

The following procedures describe adjustments to the current probes and amplifiers. Before performing the adjustment procedures, do the following:

1. If you are adjusting an amplifier, remove the outer case to gain access to the adjustments. Refer to *Disassembly* on page 7-3. Next, attach the calibration adapter to the amplifier.
2. If you are adjusting a probe, attach the current probe to the amplifier.
3. Turn the power on and allow the entire system to warm up for a minimum of 20 minutes. Warm up any test equipment that is listed at the beginning of the procedure used.

The recommended calibration interval is one year.

Table 6-1 lists the adjustments you can make to the amplifiers and probes.

Table 6- 1: Amplifier and probe adjustments

Device	Adjustments		
	DC gain accuracy	Low frequency gain accuracy	High frequency gain accuracy
Amplifiers			
TCPA300	✓ (4 adjustments)		
TCPA400	✓		
Probes			
TCP312	✓		
TCP305	✓		
TCP303	✓	✓	✓
TCP404XL	✓	✓	✓

TCPA300 and TCPA400 Amplifier Adjustments

This section covers the adjustments for the TCPA300 and TCPA400 Current Probe Amplifiers. Refer to the list of equipment required in Table 6-2.

Required Test Equipment

The adjustment procedures require the test equipment listed in Table 6-2. The test equipment must meet or exceed the specifications listed. You may need to modify the test procedures if you do not use the recommended equipment.

Table 6-2: Required test equipment

Qty	Item	Description	Recommended equipment
1	Digital Multimeter	0.20%, 3 ¹ / ₂ digit resolution, range ± 50 mV	Keithley 2700
1	Current Source	0.1%, 0 to ± 100 mA	Fluke 5100A or HP 6612C
1	Termination	50 Ω , $\pm 0.1\%$, 0.5 W	Tektronix part number 011-0129-00
2	BNC Cables	50 Ω , 1.05 m (42 in) long	Tektronix part number 012-0117-00
1	Cables	TEKPROBE Interface	Tektronix part number 012-1605-00
2	Adapters	BNC-to-Dual Banana Adapters	Tektronix part number 103-0090-00
1	Calibration Adapter	TCPA Calibration Adapter	Tektronix part number 174-4765-00
1	Adjustment tool	1/8-inch flat-blade	Tektronix part number 003-0675-01

Accessing the Adjustments

To gain access to the amplifier adjustments, you must remove the outer case. There are access ports in the right-side internal cover, but you can also remove the internal cover to get a better view of the adjustments. Refer to *Disassembly* on page 7-3. After completing the disassembly procedure, power on the amplifier and test equipment and let them warm up for at least 20 minutes.

TCPA300 Amplifier

The T CPA300 has four internal adjustments that affect the gain of the amplifier. (The T CPA400 has one adjustment.) Each range has an individual control, except the 1A/V range, which does not have an adjustment. To make adjustments to the amplifier, do the following:

1. Set up the circuit shown in Figure 6-1.

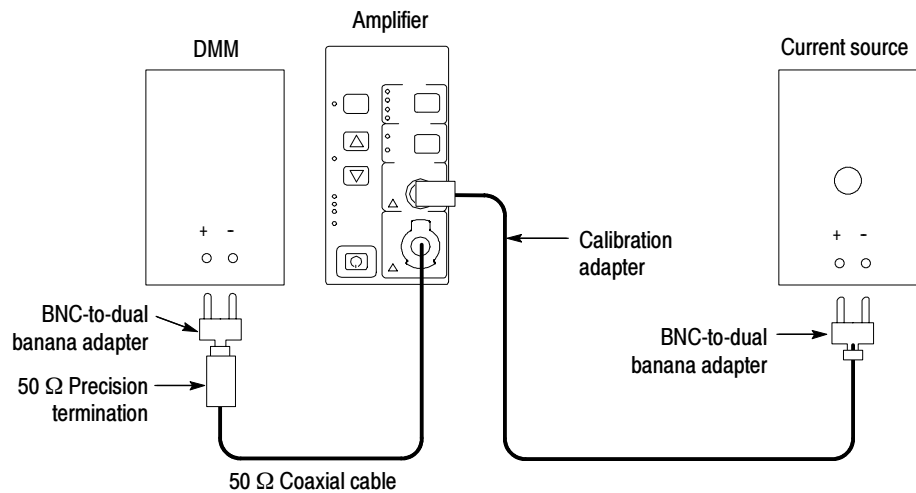


Figure 6- 1: Amplifier adjustments

2. Set the current source to the values shown in Table 6-3 and adjust the corresponding adjustment pot to the target values shown in Table 6-3. Use Figure 6-2 on page 6-5 to locate the adjustments on the amplifier board.

Table 6-3: T CPA300 gain adjustments

Range, A/V	Current source value, ADC	Adjustment	Minimum output, VDC	Expected output, VDC	Maximum output, VDC
1	0.100	No adjustment	4.9900	5.0000	5.0100
5	0.100	25 Ω	2.4950	2.5000	2.5050
10	0.100	12.5 Ω	1.2350	1.2375	1.2400
50	0.100	5 Ω	0.4825	0.4835	0.4845
50 COMP ¹	0.100	5 Ω COMP	0.4576	0.4585	0.4594

¹ Both 10 A/V and 50 A/V LEDs light.

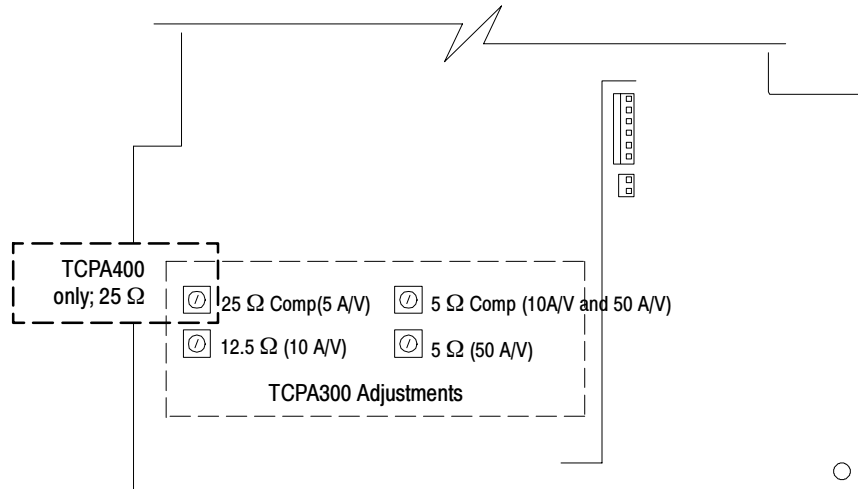


Figure 6-2: Gain adjustment locations

TCPA400 Amplifier

The TCPA400 has one internal gain adjustment in the amplifier. To make adjustments to the amplifier, do the following:

1. Set up the circuit shown in Figure 6-1 on page 6-4.
2. Set the current source to the value shown in Table 6-4 and adjust the corresponding adjustment pot to within the limits shown in Table 6-4. Use Figure 6-2 to locate the adjustment on the amplifier board.

Table 6-4: TCPA400 gain adjustments

Range, A/mV	Current source value, DC Amps	Adjustment	Minimum output, VDC	Expected output, VDC	Maximum output, VDC
1	0.100	25Ω	2.4938	2.5000	2.5063

This completes the adjustments for the amplifiers. Do the appropriate performance verification for the amplifier to verify that it meets the warranted specifications.

TCP305 and TCP312 Adjustments

The TCP305 and TCP312 Current Probes have one characteristic that is adjustable—DC gain. The following text describes the DC gain adjustment procedure. Tolerances that are specified in these procedures apply to the current probes and do not include test equipment error.

Required Test Equipment

To perform the adjustment procedure in this section, you will need the test equipment listed in Table 6-5. The test equipment must meet or exceed the specifications listed. The test procedure may need to be changed if the recommended equipment is not used.

Table 6-5: Required test equipment

Qty	Item	Description	Recommended equipment
1	AC Current Source	ACA: 0.25% accuracy, 0 to ±1.5 A, square wave output	Wavetek 9100
1	Digital Multimeter	ACV: <0.1% accuracy 5 ¹ / ₂ digit resolution	Keithley 2700
1	Termination	50 Ω, 0.1% precision, BNC connector, feedthrough	Tektronix part number 011-0129-00
1	BNC Cable ¹	50 Ω, 0.76 m (30 in) long	Tektronix part number 012-0117-00
1	Adapter	BNC to Dual Banana	Tektronix part number 103-0090-00
1	DC Current Loop	5 turns 18 AWG coated wire	Refer to page 5-4

¹ Provided as a standard accessory with the TCPA300.

Accessing the Adjustments

Figure 6-3 shows the location of the DC gain adjustment in the lower probe half.

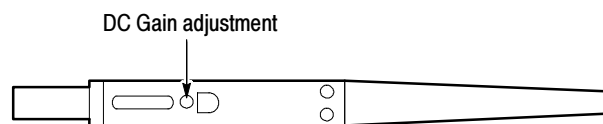


Figure 6-3: TCP305 and TCP312 DC gain adjustment location

TCP305 and TCP312 DC Gain Adjustment

Use the following procedure to adjust the DC Gain of the TCP305 and TCP312 Probes.

Equipment Connections

1. Connect the amplifier **OUTPUT** to the DMM input using a BNC-to-Dual Banana connector, 50 Ω BNC cable, and a 50 Ω precision feedthrough termination. Do not connect the termination at the amplifier output.
2. Connect the current probe to the amplifier **PROBE INPUT** connector.
3. Connect the 5-turn DC current loop to the current source as shown in Figure 6-4 on page 6-9.
4. Do not clamp the current probe around any conductor, but make sure the slide is locked.

Equipment Settings

Make or verify the equipment settings in Table 6-6:

Table 6-6: Settings for DC gain adjustment

Digital multimeter	
Measurement Type	AC volts
Range	Autoranging
Current source	
Output waveshape/frequency	Square wave, 40 Hz
Output	Off
TCPA300	
Coupling	DC
Range: TCP305	5 A/V
TCP312	1 A/V

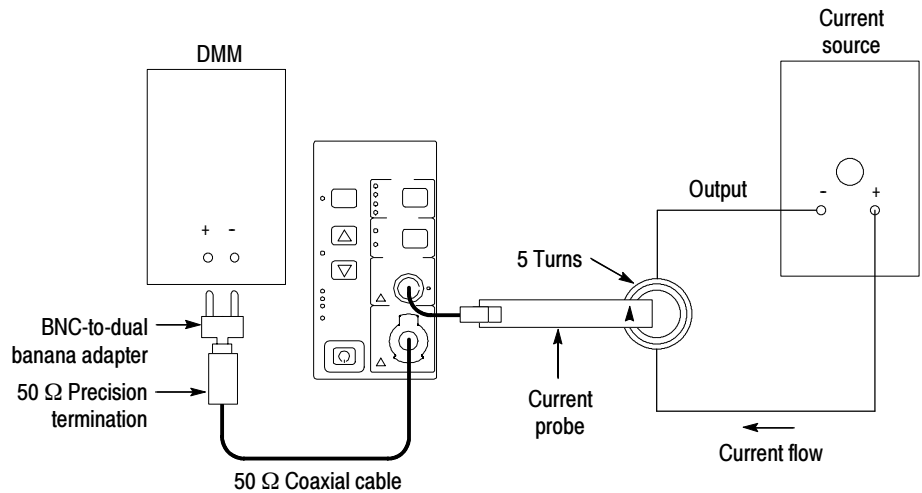


Figure 6-4: DC gain adjustment setup for TCP305 and TCP312

Procedure

1. Press the amplifier **PROBE DEGAUSS AUTOBALANCE** button. Wait for the degauss/autobalance routine to complete before proceeding. The routine is complete when the indicator light turns green.
2. Connect the current probe to the DC current loop.
3. Refer to Table 6-7 and perform the following steps:
 - a. Set the amplifier to the appropriate range setting for the probe you are testing.
 - b. Set the current source output to the correct current level.
 - c. Enable the output of the current source.
 - d. Adjust the DC gain control on the probe to the expected output value shown in Table 6-7.

Table 6-7: DC gain accuracy adjustments for the TCP305 and TCP312

Probe	Range	Current source output (mA pk)	Expected output, V_E (VAC)	Minimum output, VAC	Maximum output, VAC
TCP305	5 A/V	300 mA	0.3000	0.2990	0.3011
TCP312	1A/V	60 mA	0.3008	0.2997	0.3018

This completes the adjustments for the TCP305 and TCP312 Current Probes. Do the appropriate performance verification procedure for the probe you adjusted, using the procedures beginning on page 5-19.

TCP303 and TCP404XL Adjustments

Each of the following adjustment procedures describes how to adjust specific performance characteristics of the TCP303 and TCP404XL. Tolerances that are specified in these procedures apply to the current probe and do not include test equipment error.

Required Test Equipment

To perform the adjustment procedures in this section, you will need the test equipment listed in Table 6-8. The test equipment must meet or exceed the specifications listed. You may need to modify the test procedures if you do not use the recommended equipment.

Perform the steps on page 6-1 before starting these procedures. To ensure proper completion, read each procedure before starting.

Table 6-8: Required test equipment

Qty	Item	Description	Recommended example
1	Oscilloscope	100 MHz bandwidth	Tektronix TDS5000
1	High Amplitude Pulse Generator (TCP404XL only)	Square wave with a rise time <35 ns, ≥ 5 A into 50 Ω	AVTECH AVR-3-PW-C-P-TEK2
1	Current Probe Amplifier		Tektronix TCPA300 (TCP303) or TCPA400 (TCP404XL)
1	AC Current Source	AC A: 0.25% accuracy, 0 to ± 5 A, square wave output, 40 Hz-1 kHz, $t_R < 10$ μ s	Wavetek 9100
1	Digital Multimeter	AC V: $\leq 0.1\%$ accuracy, $5^{1/2}$ digit resolution	Keithley 2700
1	Cable	TEKPROBE Interface	Tektronix part number 012-1605-00
1	BNC Cable (TCP303 only)	50 Ω , 0.76 m (30 in) long	Tektronix part number 012-0117-00
1	Cable	Banana plugs at ends, 18 inches	Tektronix part number 012-0031-00
1	Adapter	BNC to Dual Banana	Tektronix part number 103-0090-00
1	Termination	50 Ω , $\pm 0.1\%$, 0.5 W	Tektronix part number 011-0129-00
1	DC Current Loop (TCP404XL only)	5 turns 18 AWG coated wire	Refer to page 5-4

Adjustment Locations

Refer to Figure 6-5 for the location of the probe adjustments.

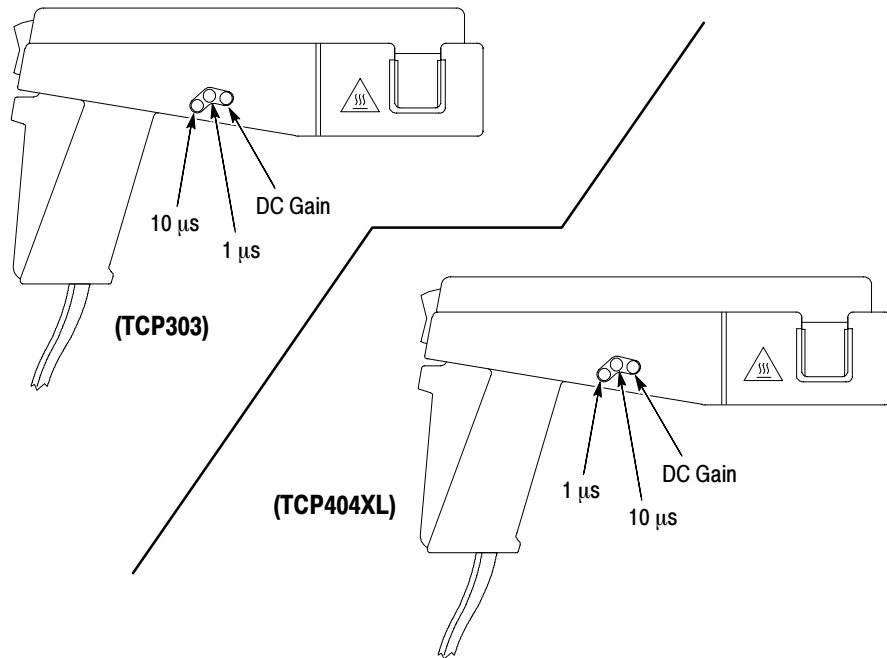


Figure 6- 5: TCP303 and TCP404XL adjustment locations

TCP303 and TCP404XL Transient Response and Coarse Gain Adjustment

These procedures describe how to adjust and optimize the transient response and coarse gain adjustment of the TCP303 and TCP404XL probes, using the 1 μ s, 10 μ s, and DC gain adjustments. The current source and current loop setups are different between the two probes, but the connections are similar. Refer to Figure 6-6 when making equipment connections.

Equipment Connections

1. If you are using a Tektronix oscilloscope that supports the TEKPROBE Level 2 Interface, use the TEKPROBE Interface Cable to connect the amplifier **OUTPUT** to the oscilloscope input. If you are not using a Tektronix oscilloscope that supports the TEKPROBE Level 2 Interface, use a 50 Ω BNC cable. If the input impedance of your oscilloscope is 1 M Ω , connect a 50 Ω feedthrough termination at the oscilloscope input. Do not connect the termination at the amplifier output.
2. Connect the current probe to the amplifier **PROBE INPUT** connector.
3. If you are adjusting a TCP303, form a 1-turn current loop by connecting the banana lead to the output connectors of the AC current source.
4. Do not clamp the current probe around any conductor, but make sure the jaws are locked shut.

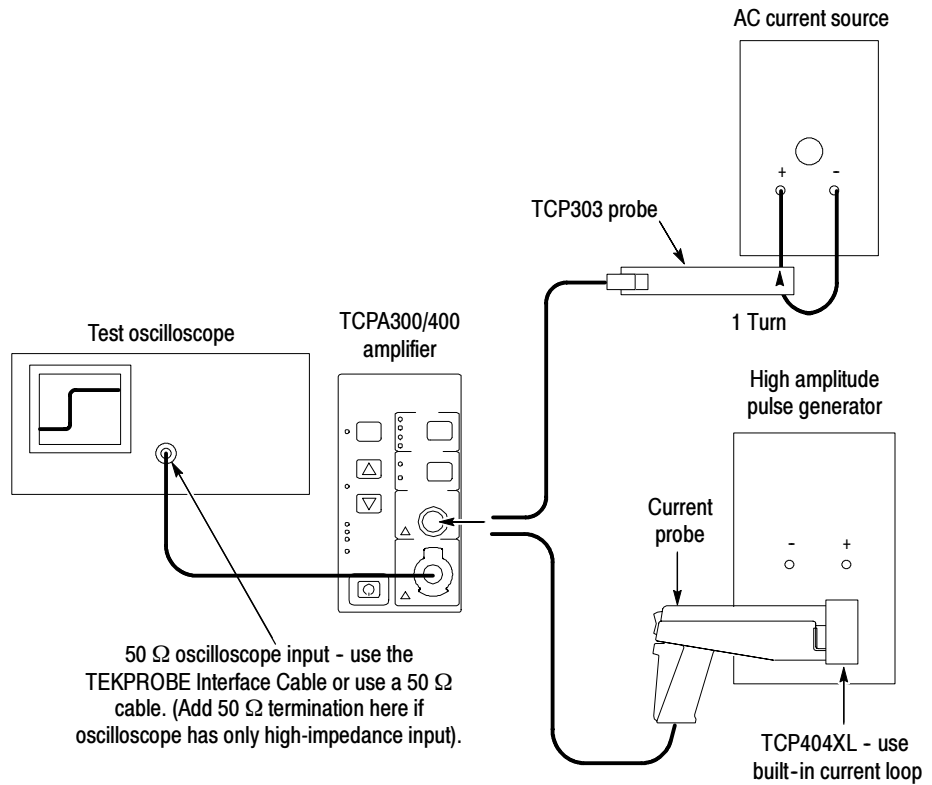


Figure 6-6: TCP303 and TCP404XL transient response and coarse gain adjustment setup

Equipment Settings

Make or verify the equipment settings in Table 6-9:

Table 6-9: Settings for transient response and preliminary gain adjustments

TCPA300 and TCPA400		
Coupling		DC
Range:		
TCPA300		5 A/V
Oscilloscope		
Vertical Gain:		
TCP303	Using TEKPROBE Cable:	100 mA/division
	Using BNC Cable:	20 mV/division
TCP404XL	Using TEKPROBE Cable:	1 A/division
	Using BNC Cable:	1 mV/division

Table 6-9: Settings for transient response and preliminary gain adjustments (Cont.)

Oscilloscope		
Time Base		100 μ s/division, Auto triggered
Vertical Input		50 Ω
Record Length		500
Coupling		DC
Offset		0 V
Trigger		
	Type	Edge
	Mode	Auto
	Position	10%
	Acquisition Mode	Average
Number of Waveforms		8
Measurement Type		Risetime, Amplitude
AC current source (TCP303 only)		
Frequency		1 kHz square wave
Amplitude		0.3 A pk
High amplitude pulse generator (TCP404XL only)		
Pulse Width		250 μ s
Pulse Repetition Frequency		20 Hz
Amplitude		5 A p-p

TCP303 Procedure

1. Remove the access plugs that cover the DC gain, 10 μ s, and 1 μ s adjustments on the probe.
2. Preset the probe adjustments: Refer to Figure 6-5 on page 6-12 for adjustment locations. Do this only at the beginning of the probe adjustment process.
 - a. Set the 1 μ s adjustment fully clockwise.
 - b. Set the 10 μ s adjustment fully counter-clockwise.
3. Do not clamp the current probe around any conductor, but make sure the jaws are locked shut.
4. Press the amplifier **PROBE DEGAUSS AUTOBALANCE** button. Wait for the degauss/autobalance routine to complete before proceeding. The routine is complete when the indicator light turns green.
5. Connect the probe to the 1-turn current loop.
6. Enable the output of the generator.

NOTE. *The DC gain, 10 μ s, and 1 μ s adjustments on the TCP303 interact. Adjusting them can be a repetitive process. You may need to balance between transient response and gain to meet both specifications at once.*

7. Repeat steps 7 and 8 as necessary to achieve optimum response:
 - a. Adjust the DC gain and 10 μ s adjustments to achieve an amplitude of six divisions and a flat waveform (optimum response).
 - b. Adjust the 1 μ s adjustment to achieve a flat waveform (optimum response).
 - c. Repeat step a.
8. Verify the DC gain accuracy of the probe using the procedure on page 5-31. You may have to make some minor adjustments to the DC gain adjustment to achieve the highest accuracy possible.

TCP404XL Procedure

1. Move the oscilloscope trace to one graticule line from the bottom of the screen.
2. Do not clamp the current probe around any conductor, but make sure the jaws are locked shut.
3. Remove the probe access plugs for 1 μ s, 10 μ s, and DC Gain.
4. Preset the probe adjustments: Refer to Figure 6-5 on page 6-12 for adjustment locations. Do this only at the beginning of the probe adjustment process.
 - a. Set the 1 μ s adjustment fully clockwise
 - b. Set the 10 μ s adjustment fully counterclockwise
5. Press the amplifier **PROBE DEGAUSS AUTOBALANCE** button. Wait for the degauss/autobalance routine to complete before proceeding. The routine is complete when the PROBE DEGAUSS AUTOBALANCE LED returns to green.
6. Lock the jaws of the probe around the built-in current loop on the high amplitude pulse generator. Observe proper polarity; the arrow-shaped indicator on the probe points away from the (+) terminal of the current source.
7. Repeat steps a through d to achieve optimum response:
 - a. Adjust the DC Gain adjustment to produce an amplitude of five graticule divisions (5 amps) at the 100 μ s portion of the pulse.
 - b. Adjust the **10 μ s** control for a flat waveform to match the level at the 100 μ s point.
 - c. Adjust the oscilloscope sweep to 1 μ s/div.
 - d. Adjust the **1 μ s** control to flatten the front end of the pulse.

NOTE. *The 10 μ s and 1 μ s adjustments on the TCP404XL interact. Adjusting them can be a repetitive process. You may need to balance between short and long term response to meet both specifications at once.*

8. Verify the DC Gain Accuracy using the procedure on page 6-18. You may have to make some minor adjustments to the DC gain adjustment to achieve the highest accuracy possible.

DC Gain Adjustment

This procedure adjusts the DC gain accuracy of the TCP303 and TCP404XL probes.

Equipment Connections

1. Connect the amplifier **OUTPUT** to the DMM input using a BNC-to-Dual Banana connector, 50 Ω BNC cable, and a 50 Ω precision feedthrough termination. Do not connect the termination at the amplifier output.
2. Connect the current probe to the amplifier **PROBE INPUT** connector.
3. If you are adjusting a TCP303, connect the banana lead cable to the output connectors of the AC current source. If you are adjusting a TCP404XL, connect the 5-turn DC current loop to the current source as shown in Figure 6-7.
4. Do not clamp the current probe around any conductor, but make sure the slide is locked.

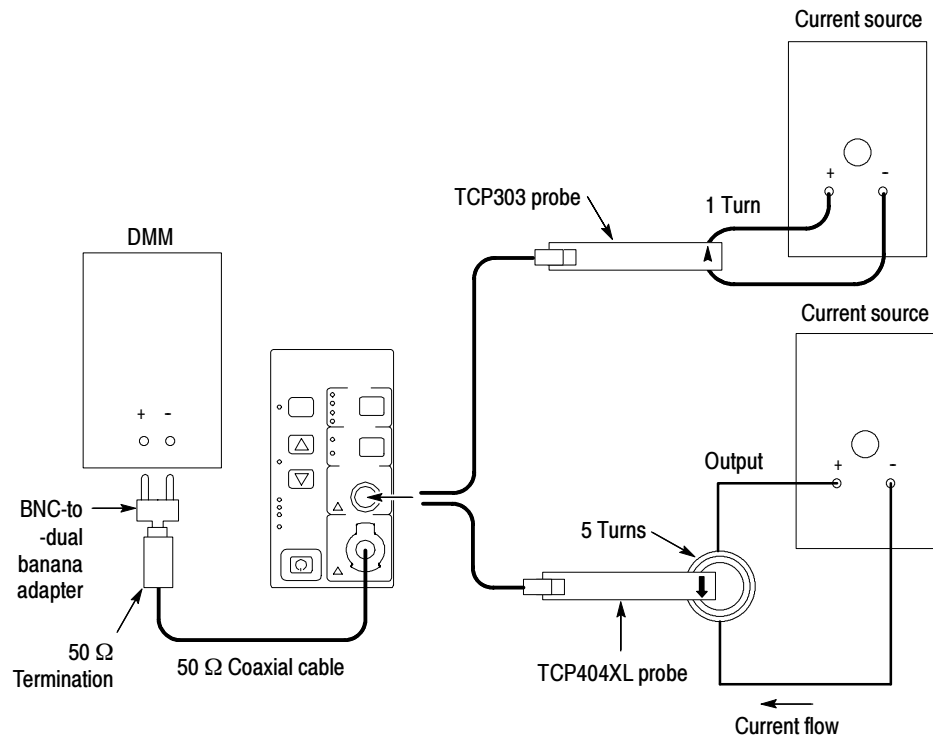


Figure 6-7: DC gain accuracy adjustment setup

Equipment Settings

Make or check the equipment settings in Table 6-10:

Table 6-10: Equipment settings for DC gain accuracy

Digital multimeter	
Measurement Type	AC volts, autorange
Current source	
Output waveshape/frequency	Squarewave, 40 Hz
Output	Off
TCPA300 and TCPA400	
Coupling	DC
Range: TCP303	5 A/V

Procedure

1. Do not clamp the current probe around any conductor, but make sure the jaws are locked shut.
2. Press the amplifier **PROBE DEGAUSS AUTOBALANCE** button. Wait for the degauss/autobalance routine to complete before proceeding. The routine is complete when the indicator light turns green.
3. Connect the current probe to the appropriate current loop. (One-turn for the TCP303 and 5-turn for the TCP404XL.)
4. Refer to Table 6-11 and perform the following steps:
 - a. Set the current source output to the correct current level.
 - b. Enable the output of the current source.
 - c. Adjust the DC gain adjustment on the probe to the expected output value shown in Table 6-11.

Table 6-11: DC gain accuracy adjustments for the TCP303 and TCP404XL

Probe	Range	Current source output (A pk)	Expected output, V_E (mVAC)	Minimum output, mVAC	Maximum output, mVAC
TCP303	5 A/V	1.5 A	300.00	299.00	301.10
TCP404XL	1A/mV	5 A	25.00	24.91	25.09

5. Remove the probe from the current loop.

6. If the DC gain adjustment was adjusted, verify the pulse response by repeating the *TCP303 and TCP404XL Transient Response and Coarse Adjustment* procedure beginning on page 6-13.
7. When the probe adjustments are done, reinstall the probe access plugs for the 1 μ s, 10 μ s, and DC Gain adjustments.



Maintenance

Customer Maintenance

This manual supports maintenance of the amplifiers and probes.

Service Strategy

The amplifiers have some mechanical and electrical parts that may be replaced by the customer. This section describes the preventive maintenance and repair procedures.

The probes can be repaired to component level. Information on troubleshooting and repair begin on page 7-21.

Preventive Maintenance

The TCPA300 and TCPA400 Current Probe Amplifiers and current probes require little maintenance during normal use. The primary maintenance involves cleaning accumulated dirt from the probe body and, if necessary, cleaning the exposed core surfaces in the probe jaw.

General Care

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



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

Cleaning the Exterior

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



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

Disassembly

To access the internal adjustments or to replace internal components of the amplifiers, you need to remove the instrument case and internal covers. This section covers the disassembly of the amplifiers. Current probe procedures are described later in this section.

Amplifiers

Use these procedures when making adjustments or replacing components in the amplifiers.



WARNING. *Amplifier disassembly must be performed by qualified service personnel at an antistatic workstation.*

The following components are replaceable:

- Outer Case
- Front Panel Assembly
- Amplifier Board
- Power Supply
- Fan

Equipment Required

Use the equipment listed in Table 7-1 to replace the internal components.

Table 7-1: Equipment required

Qty	Description
1	#2 Phillips screwdriver
1	T-15 screwdriver
1	Long-nose pliers
1	3/8-inch nutdriver or wrench
1	Torque wrench
1	Antistatic wrist strap

Removing the Outer Case and Internal Covers

To replace internal components, you need to remove the outer case and internal covers. You may also want to remove the case and covers to access the internal adjustments. The following procedures describe the removal process:

1. Disconnect the AC cord and any probes or cables from the amplifier.
2. Remove the 3 screws from the rear of the amplifier and slide the case off the rear side of the amplifier. See Figure 7-1.

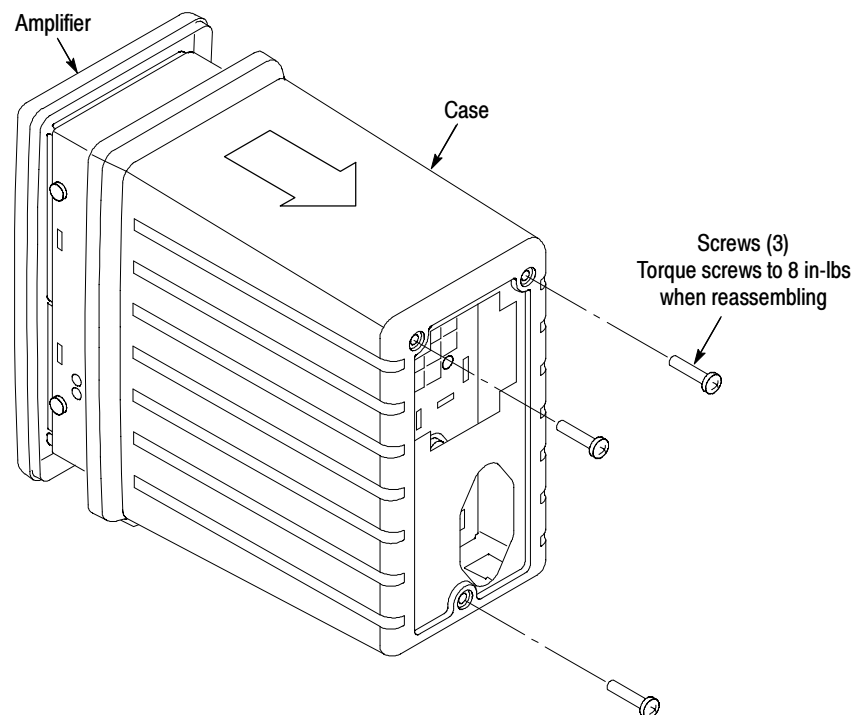


Figure 7- 1: Removing the case from the amplifier

3. Remove the 6 screws that secure the right-side inner panel to the chassis. See Figure 7-2.

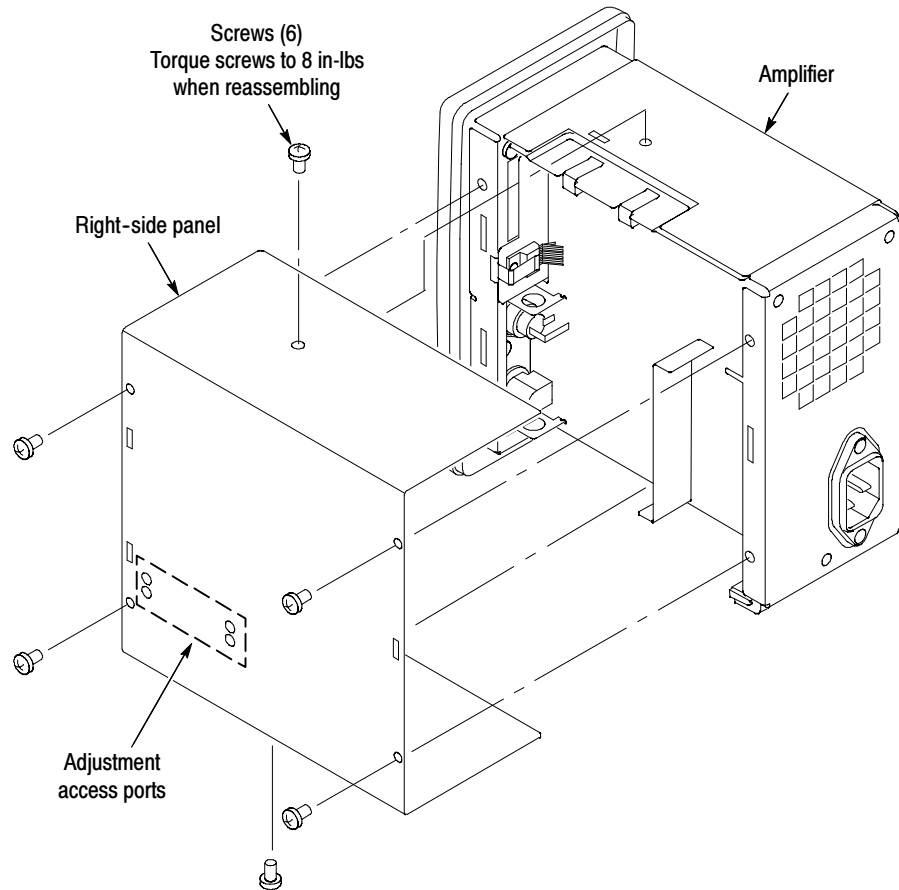


Figure 7-2: Removing the right-side inner panel

4. Remove the 4 screws that secure the left-side inner panel to the chassis. See Figure 7-3.

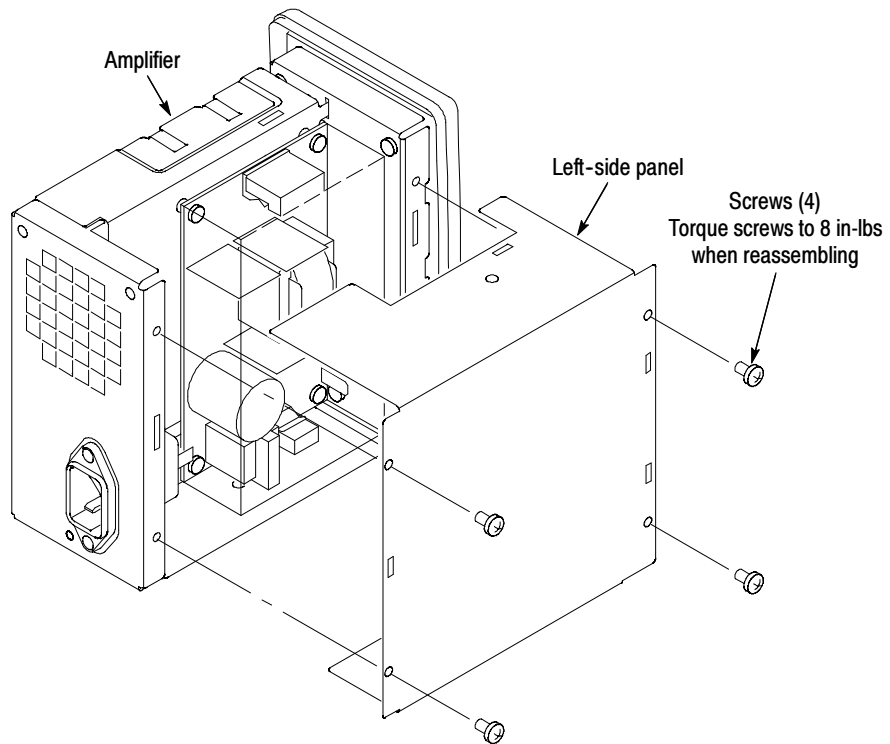


Figure 7-3: Removing the left-side inner panel

You now have exposed access to the amplifier adjustments. If you need to replace any of the internal components, refer to the following instructions.

Replacing the Front Panel Assembly

If you need to replace the Front Panel Assembly, do the following:

1. Wear an antistatic wriststrap when handling the circuit assemblies.
2. Using pliers, remove the heat sink clip from U9. See Figure 7-4.

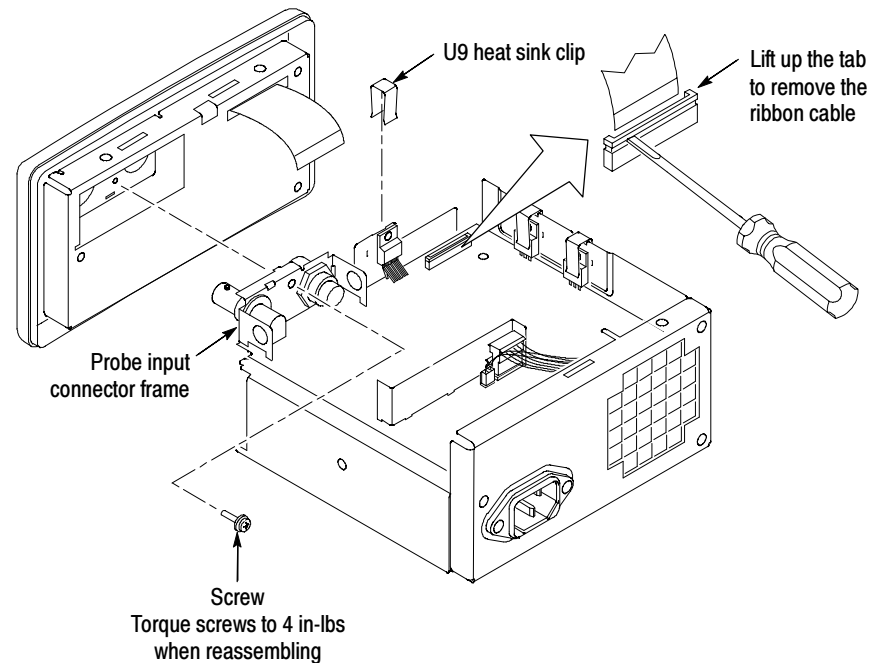


Figure 7-4: Disconnecting the front-panel assembly

3. Disconnect the front-panel ribbon connector from J4 on the amplifier board. Release the tab on the connector by carefully lifting the ends of the tab before removing the ribbon cable from the connector. See Figure 7-4.
4. Remove the screw that attaches the probe input connector frame to the front-panel assembly. Pull the front-panel assembly away from the amplifier.
5. Do in reverse steps 4 through 1 to install a new front-panel assembly.

Replacing the Amplifier Board

If you need to replace the amplifier board, you must detach the rear- and front-panel assemblies of the amplifier from the chassis.

1. Wear an antistatic wriststrap when handling the circuit assemblies.
2. Remove the 2 Phillips screws that attach the AC power connector to the rear panel.
3. Gently pull back the rear panel enough to allow clearance for the amplifier board.
4. Disconnect the DC power supply connector from J3 on the amplifier board.
5. Disconnect the fan connector from J2 on the amplifier board.
6. Using pliers, remove the three heat sink clips from U9, Q18, and Q21. See Figure 7-5.

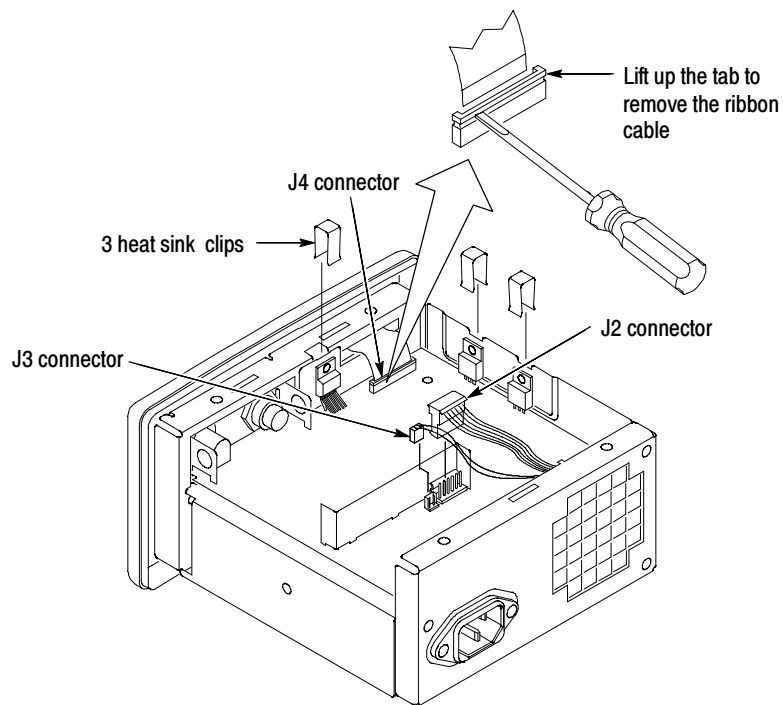


Figure 7-5: Removing the three heat sink clips

7. Disconnect the front-panel ribbon connector from J4 on the amplifier board. Be sure to carefully release the tab on the connector before removing the ribbon cable from the connector. Only lift the ends of the tab to release it from the connector. See Figure 7-5.

8. Remove the screw that attaches the probe input connector to the front panel amplifier board to the chassis. Pull the front panel assembly away from the amplifier and set it aside. See Figure 7-6.
9. Remove the three screws that attach the amplifier board to the chassis.
10. Do in reverse steps 8 through 2 to install a new amplifier board.

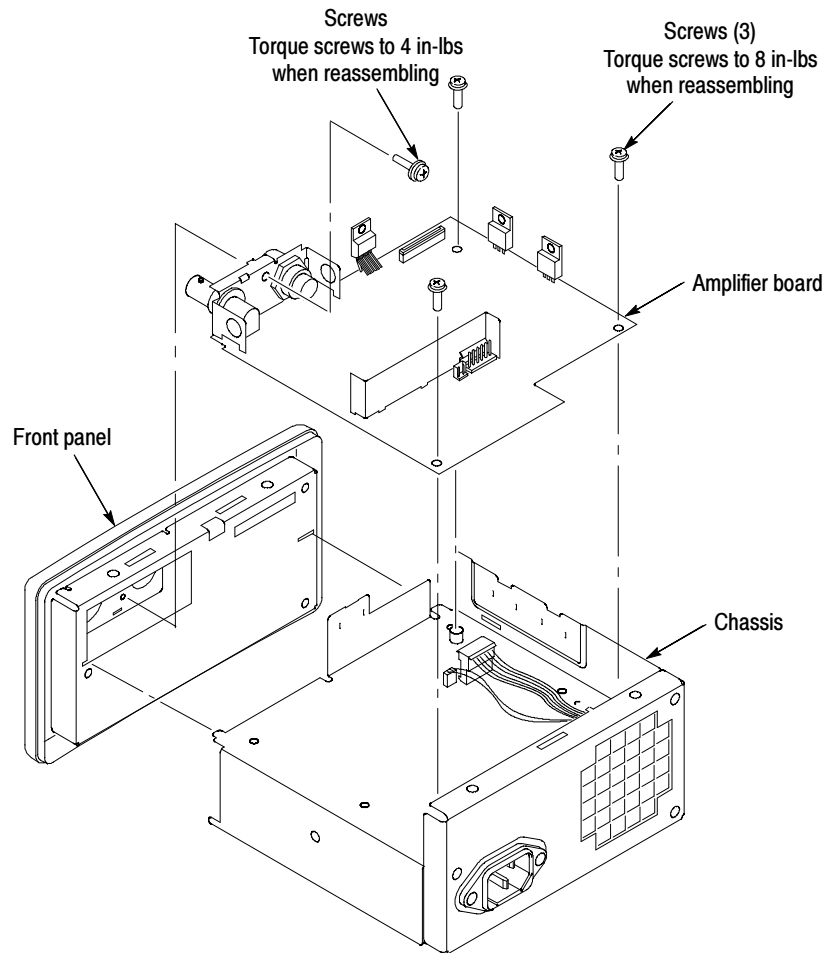


Figure 7-6: Removing the amplifier board

Replacing the Power Supply

To replace the power supply, refer to Figure 7-7 and do the following:

1. Disconnect the AC and DC power connectors from the power supply.
2. Remove the four screws from the power supply.
3. Remove the power supply from the chassis.
4. Do in reverse steps 3 through 1 to install a new power supply.

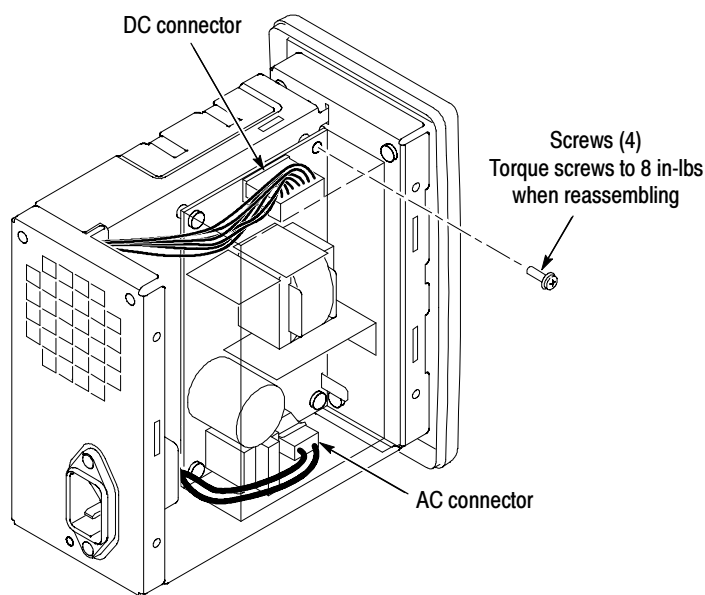


Figure 7-7: Replacing the power supply

2. Disconnect the DC power supply connector from J2 on the amplifier board. See Figure 7-9.
3. Disconnect the fan connector from J3 on the amplifier board.
4. Gently pull back the rear panel enough to allow access to the four nuts that secure the fan to the rear panel.

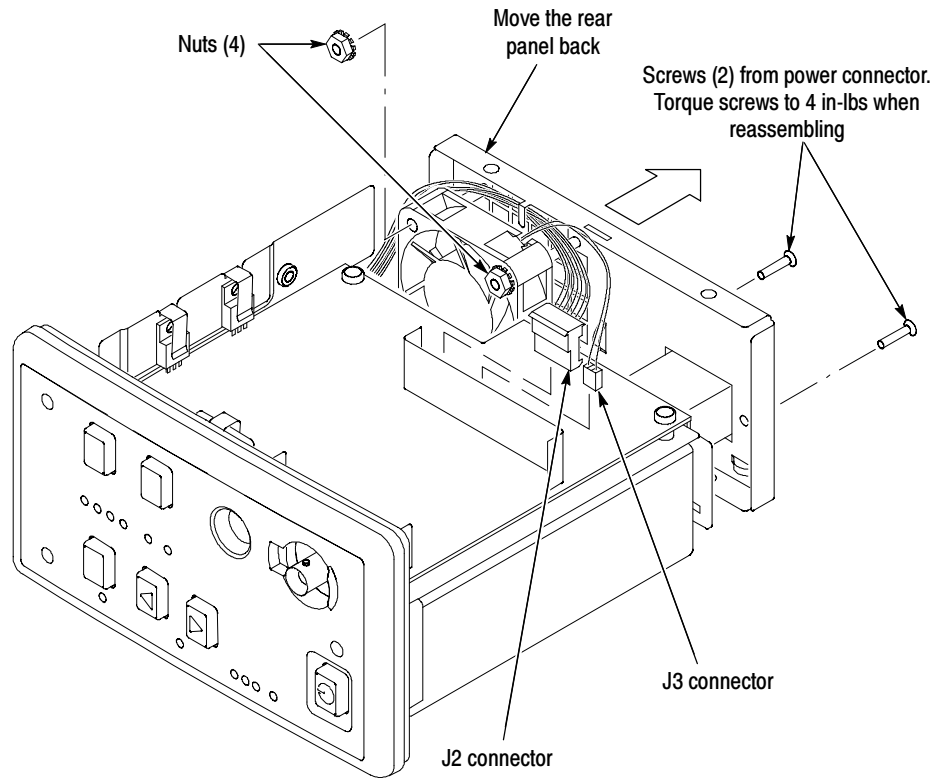


Figure 7-9: Removing the fan

5. Remove the four 3/8-inch nuts that secure the fan to the rear panel.
6. Lift the fan off of the four studs on the rear panel.
7. Do in reverse steps 6 through 1 to install a new fan. Be careful not to pinch the power supply cable wires under the fan.

Probes

Use these procedures when repairing or replacing defective components in the current probes.



WARNING. *Probe disassembly must be performed by qualified service personnel.*

The probes that mate with the TCPA300 and TCPA400 Current Probe Amplifiers have two physical styles. The TCP305 and TCP312 use a slender form factor that contain three replaceable assemblies - the connector/cable, the circuit board, and the current transformer.

The TCP303 and TCP404XL use a pistol-style case with an integral handgrip. These probes contain two replaceable assemblies - the connector/cable/circuit board assembly and the current transformer. Both probes use a few mechanical components that are replaceable, such as springs and plastic parts.

Equipment Required

Table 7-2 lists the equipment required to service the probes.

Table 7-2: Equipment required

Qty	Description
1	#2 Phillips screwdriver
1	Isopropyl alcohol
1	Silicone-based grease
1	25 W soldering iron

TCP305 and TCP312

Disassemble the TCP305 or TCP312 probe body as follows:

1. Remove the two screws from the bottom of the probe and pull the strain relief boot back as shown in Figure 7-10. Note: When reassembling the probe, insert and tighten the two screws. Verify that the slider works smoothly. If it does not, loosen the screws slightly.

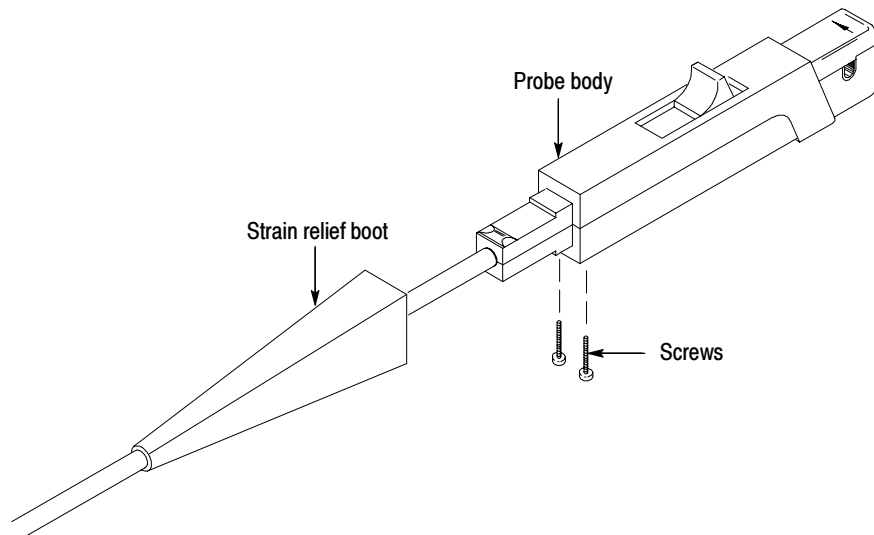


Figure 7-10: Removing the strain relief boot

2. Move the probe slide assembly to the open position.

NOTE. The probe slide contains a tiny metal ball. In step 3, be careful not to lose the ball by accidentally letting it fall out.

3. Hold the probe in a top-up horizontal position and slide the top half of the probe body off as shown in Figure 7-11.
4. Remove the metal ball.
5. Turn the probe upside down, push the slide back slightly, and remove the slide (see Figure 7-12).

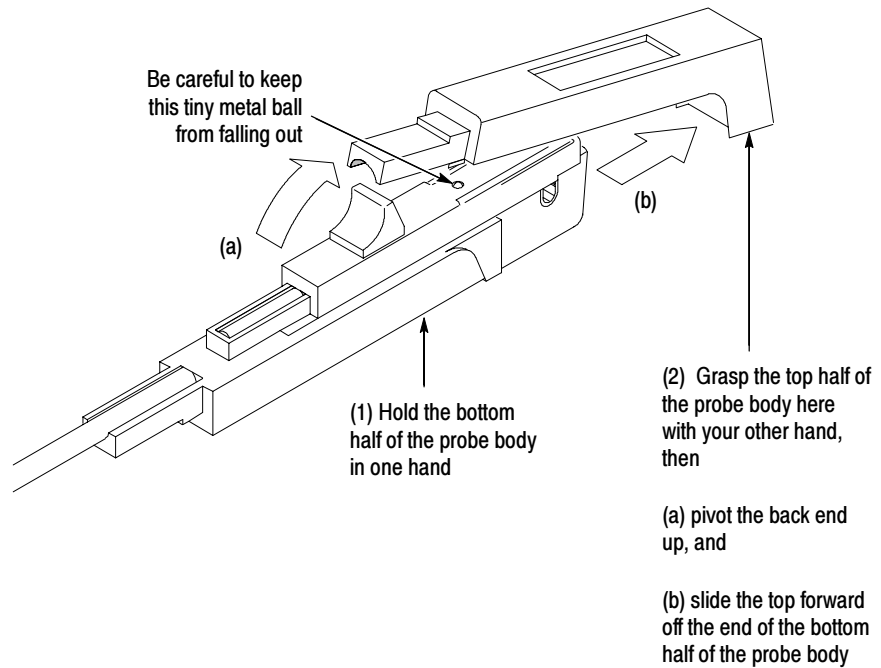


Figure 7-11: Removing the top half of the probe

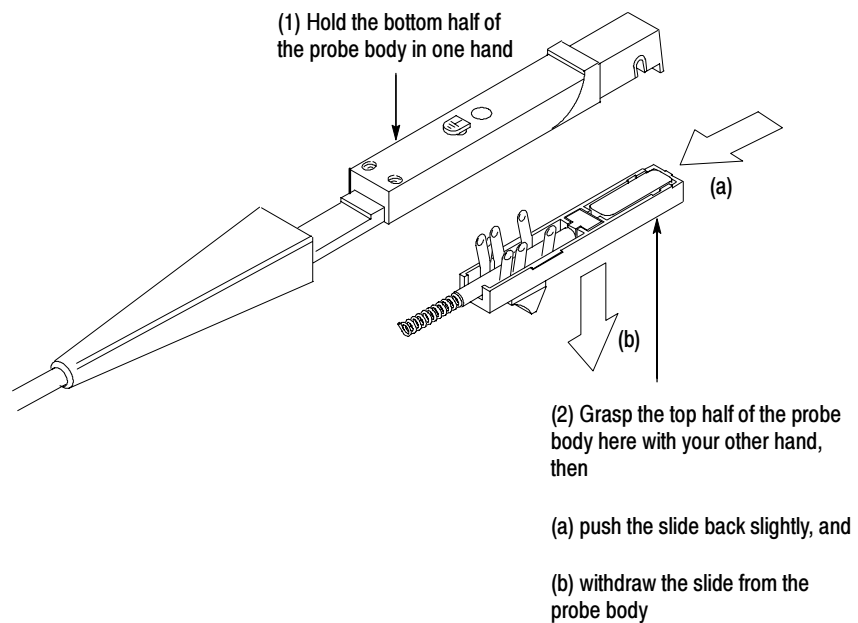


Figure 7-12: Removing the probe slide

Replacing the Current Transformer

Replace the current transformer of the probe as follows:

1. Gently lift the front edge of the circuit board and transformer enough to clear the probe body. Refer to Figure 7-13.
2. Pull the transformer socket straight off the circuit board pins.

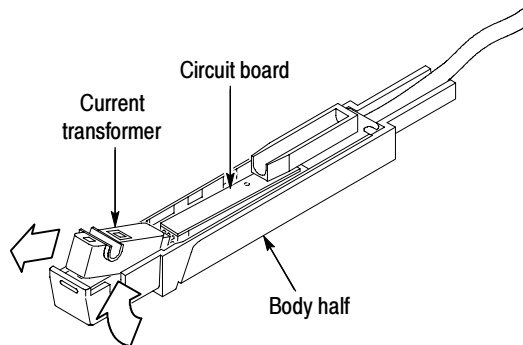


Figure 7-13: Removing the current transformer

3. Before reassembling the probe, be sure that 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. Also, clean the contacts of the slide switch, if necessary. If the plastic slide assembly requires lubrication, sparingly apply silicone-based grease to the parts.
4. Probe reassembly is the reverse of steps 1 through 2 of this procedure and steps 1 through 5 on pages 7-14 through 7-15.

NOTE. Exercise care when fitting the slide back into the probe body; aligning the switch contacts can require patience.

Replacing the Circuit Board or Cable Assembly

Replace the circuit board or cable assembly of the probe as follows:

1. Remove the current transformer using the procedure on page 7-16.
2. Lift the plastic cable housing from the probe body half. See Figure 7-14.
3. Unsolder the probe body connection on the circuit board. Be careful not to damage the circuit board.
4. Lift the cable and the circuit board from the probe body half.

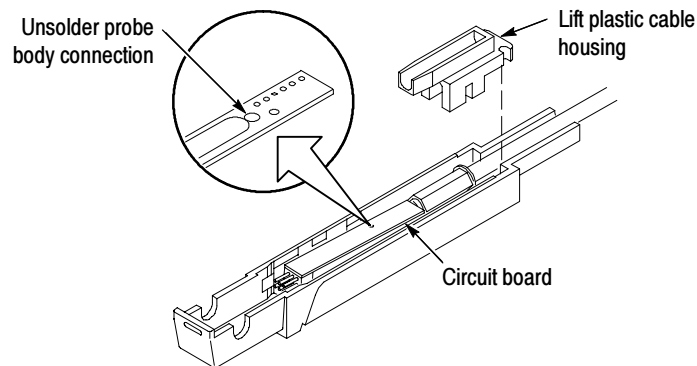


Figure 7-14: Removing the circuit board and cable assembly

5. If you need to replace the cable, separate the cable and circuit board by unsoldering the cable ground wire and disconnecting the cable connector from the circuit board.
6. If you need to replace the circuit board, do step 5, and then unsolder the ground wire from the circuit board to the probe body half.
7. Before reassembling the probe, be sure that 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. Also, clean the contacts of the slide switch, if necessary. Should the plastic slide assembly require lubrication, sparingly apply silicone-based grease to the parts.
8. Probe reassembly is the reverse of steps 1 through 6 of this procedure and steps 1 through 5 on pages 7-14 through 7-15.



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. Exercise care when fitting the slide back into the probe body; aligning the switch contacts can require patience.

TCP303 and TCP404XL

The following procedures explain how to disassemble the probe body and replace the current transformer, the circuit board, and the cable assembly.



WARNING. *Probe disassembly must be performed by qualified service personnel.*

1. Unlock the probe slide.
2. Place the probe on a flat surface with the screw heads facing up.
3. Using a $\frac{3}{32}$ inch Allen wrench, remove the eight retaining screws from the case.
4. While holding the squeeze handle and slide, lift the top part of the probe body off.
5. Remove the slide.



WARNING. *There is a spring in the squeeze handle that can pop out and cause personal injury unless care is exercised when disassembling the probe.*

6. Lift the cable out of the probe handle and insert a pair of pliers in the handle as shown in Figure 7-15.

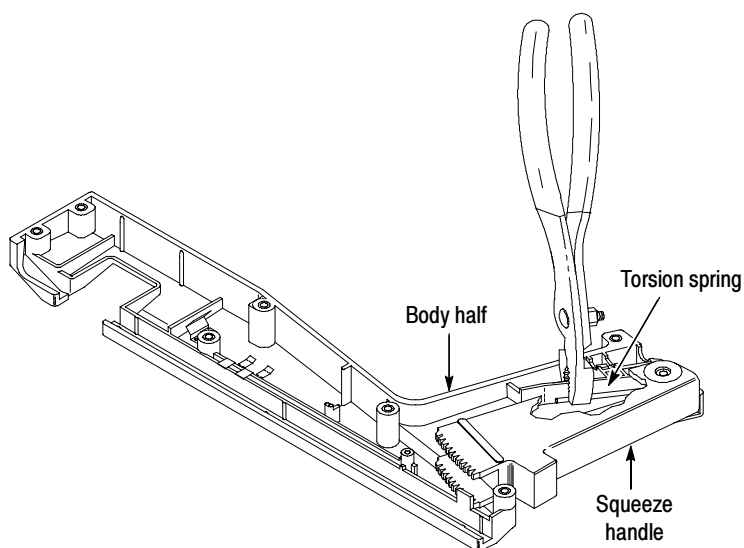


Figure 7-15: Removing the handle

7. While maintaining a firm grip on the pliers, carefully lift the squeeze handle and gear out of the probe. See Figures 7-15 and 7-16.
8. To remove the current transformer, lift the assembly out of the probe as shown in Figure 7-16 and unplug it from the circuit board.

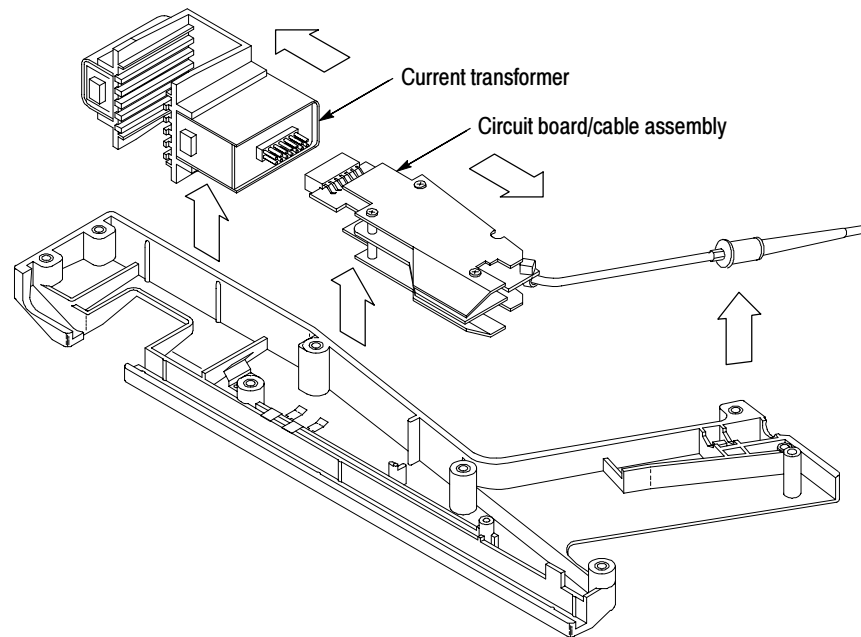


Figure 7-16: Removing the current transformer

9. To remove the circuit board and cable assembly, desolder the two leads to the slide switch and lift the circuit board and cable clear.

NOTE. *Observe the routing of the switch leads through the circuit board shield. It is important that the leads be routed in the same way when the board is replaced.*

10. Before reassembling the probe, be sure that the gap between the stationary and moveable core pieces is clean. If necessary, clean the core pieces using a lint-free cloth and water or isopropyl alcohol (IPA). Also, clean the contacts of the slide switch, if necessary.
11. Should the plastic slide assembly require lubrication, sparingly apply silicone-based grease to the parts.
12. Probe reassembly is the reverse of steps 1 through 9. You may need to squeeze the handle slightly to align the gear teeth with the slide rack.

Isolating Hardware Faults

Use the following procedures to help locate a hardware malfunction.

You can isolate the symptoms to the amplifier or probe by substituting a known good probe or amplifier. If you suspect that you have a defective probe and you don't have another compatible probe, you can use the calibration adapter in place of the probe to verify some of the amplifier functions.

Tables 7-3 and 7-4 list some of the failures that can occur with the amplifiers and probes.

Table 7-3: Amplifier hardware faults

Symptom	Possible cause	Repair action
Amplifier does not power on. LEDs do not turn on and fan does not work.	Internal power supply problem	Check for +15 V on power supply connector J2, pin 1 at main board. If OK, replace amplifier board. If not, replace power supply.
	Connector loose between main board and front panel	Secure ribbon cable from front-panel assembly to main board
	Front panel is defective	Replace front-panel assembly
LEDs do not turn on and fan works.	Internal power supply problem	Check for +15 V on power supply connector J2, pin 1 at main board. If OK, check power supply test points on main board: +5VD, +5VA, -5VA, +10V, -10V. If these voltages check OK, replace the front-panel assembly. If not, replace the main board.
	Connector loose between main board and front panel	Secure ribbon cable from front-panel assembly to main board
	Front panel is defective	Replace front-panel assembly
LEDs turn on and fan does not work.	Defective fan or defective power supply	Check for greater than +7V at fan connector J3, pin 1 at main board. If present, replace fan. If not, check for +15 V input from power supply. If +15 V is present, replace the amplifier board. If not, replace the power supply.
LEDs turn on in a random pattern (different than is documented in this manual)	Front panel is defective	Replace front-panel assembly
One amplifier range does not work, other range is OK. (TCPA300 only)	Defective amplifier circuit	Replace main board assembly

Table 7-4: Probe hardware faults

Symptom	Possible Cause	Repair Action
Probe Open LED stays continuously lit, even with the probe slider closed.	Open coil in probe.	Substitute probe with another probe or the Calibration Adapter - if the Probe Open LED goes out, coil is open - repair bad connection or replace coil

Determining the Amplifier Firmware Version Number

If you are having a problem with your amplifier, it may be helpful to know the version of firmware that is in the amplifier. The firmware version may help the Technical Support Center to isolate the amplifier symptoms to a specific cause.

To determine the amplifier firmware version number, do the following:

1. Turn the amplifier power off.
2. Press and hold the COUPLING button.
3. Turn the amplifier power on.

After the power-on LED sequence, the LEDs on the far-left side of the front panel show a binary representation of the firmware version number. The firmware version number is the sum of the values for the lit LEDs. See Figure 7-17 for the values each LED represent.

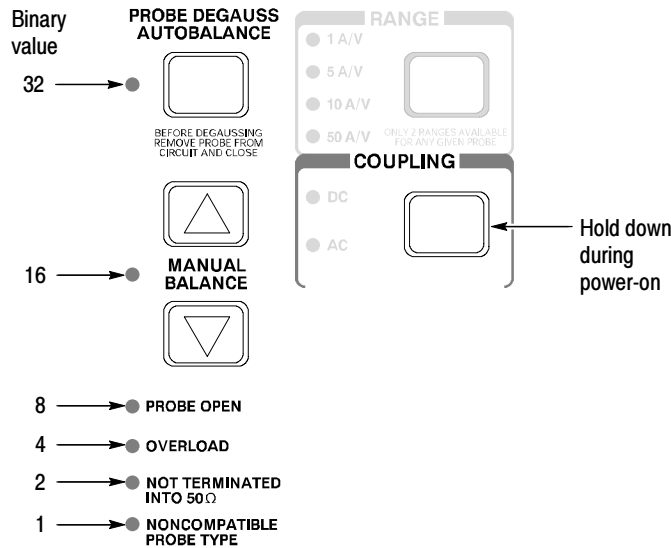


Figure 7-17: Displaying the amplifier firmware version number

For example, if the NONCOMPATIBLE PROBE TYPE LED is lit, the firmware version number is 1.



Replaceable Parts

Replaceable Parts

This section contains a list of the components that are replaceable for the TCPA300 and TCPA400. As described below, use these lists to identify and order replacement parts.

Parts Ordering Information

Replacement parts are available from or through your local Tektronix, Inc., service center 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

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

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 the information you need for ordering replacement parts.

Item Names

In the Replaceable Parts List, an Item Name is separated from the description by a colon (:). Because of space limitations, an Item Name may sometimes appear as incomplete. For further Item Name identification, U.S. Federal Cataloging Handbook H6-1 can be used where possible.

Indentation System

This parts list is indented to show the relationship between items. The following example is of the indentation system used in the Description column:

1	2	3	4	5	Name & Description
					Assembly and/or Component
					Attaching parts for Assembly and/or Component (END ATTACHING PARTS)
					Detail Part of Assembly and/or Component
					Attaching parts for Detail Part (END ATTACHING PARTS)
					Parts of Detail Part
					Attaching parts for Parts of Detail Part (END ATTACHING PARTS)

Attaching parts always appear at the same indentation as the item it mounts, while the detail parts are indented to the right. Indented items are part of, and included with, the next higher indentation. Attaching parts must be purchased separately, unless otherwise specified.

Abbreviations

Abbreviations conform to American National Standards Institute (ANSI) standard Y1.1.

Amplifier Replaceable Parts

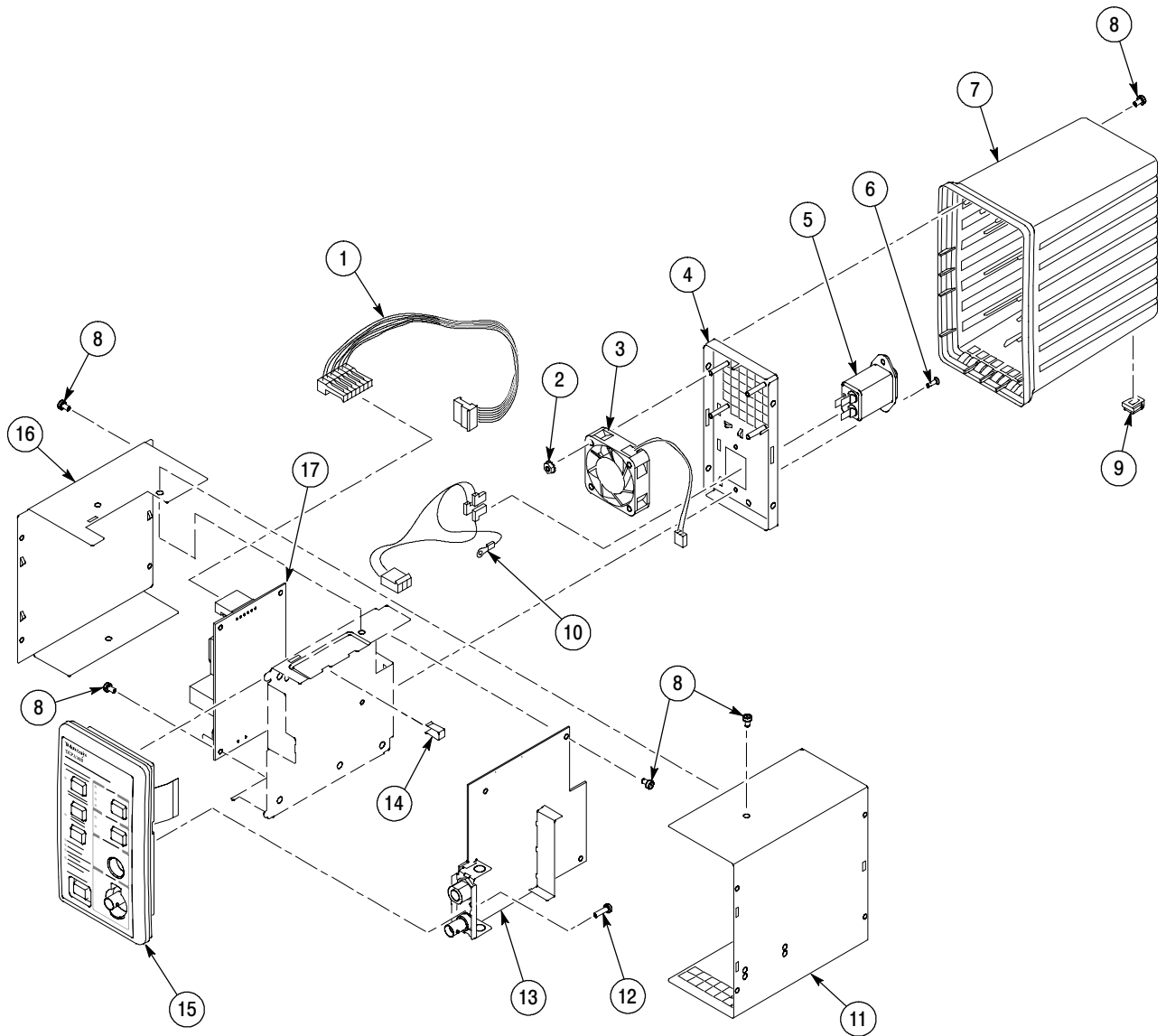
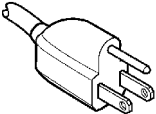
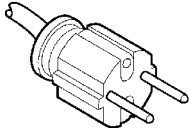
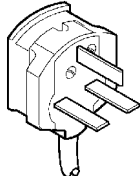
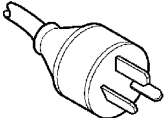
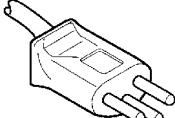
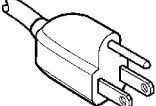
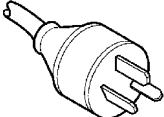


Figure 8-1: TCPA300 and TCPA400 replaceable parts

Replaceable parts list

Fig. & index number	Tektronix part number	Serial no. effective	Serial no. discont'd	Qty	Name & description	Mfr. code	Mfr. part number
8-1-1	174-4676-00			1	CABLE ASSEMBLY,DC, POWER SUPPLY	80009	174-4676-00
-2	210-0457-00			4	NUT,PL,ASSEM WA:6-32 X 0.312,STL CD PL,W/LOCKWASHER	0KB01	ORDER BY DESCRIPTION
-3	119-6721-00			1	FAN,TUBEAXIAL:12VDC,0.10A,1.2W,14CFM,5600RPM,32DBA,50MM X 50MM X 15MM, W/3.5 IN LEADS, 2-PIN C	0ADN8	AFB0512HB
-4	050-3547-00			1	PANEL,REAR:0.046 AL,W/LABEL,TCPA300 /TCPA400	0J9P9	050-3547-00
-5	119-0420-00			1	FILTER,RFI:LINE 6A,250VAC,DC-400HZ,LEAKAGE CURRENT 2UA AT 220V/55HZ,FN223B-6/06	0GV52	FN323B-6/01
-6	211-0038-00			2	SCREW,MACHINE:4-40 X 0.312,FLH,100 DEG,STL CD PL,POZ	93907	ORDER BY DESCRIPTION
-7	380-1157-00			1	HOUSING:MAIN AMPLIFIER,PLASTIC	TK1163	380-1157-00
-8	211-0747-00			20	SCREW,MACHINE:6-32 X 0.188,PNH,STL,CDPL,T-15 TORX DR	0KB01	ORDER BY DESCRIPTION
-9	348-1525-00			2	FOOT:FRONT,SANTOPRENE,BLACK,64 DEROMETER,TEXTURED	TK1163	348-1525-00
-10	174-4721-00			1	CABLE ASSEMBLY,AC, POWER SUPPLY	80009	174-4721-00
-11	390-1213-00			1	CABINET:RIGHT AMPLIFIER AC,0.032 AL	0J9P9	390-1213-00
-12	211-0720-00			1	SCR,ASSEM WSHR:6-32 X 0.500,PNH,STL,CDPL,T-15 TORX DR,MACHINE	0KB01	ORDER BY DESCRIPTION
-13	671-5434-00			1	CIRCUIT BOARD:MAIN,TCPA300	TK6136	671-5434-00
	671-5354-00			1	CIRCUIT BOARD:MAIN,TCPA400	01KV9	671-5354-00
-14	214-5018-00			3	HEAT SINK,MISC:CLIP,TO-220 TRANSISTOR,PHOSPHOR BRONZE CLIP FOR TO-220,0.25 IN W X 0.507 IN L, F		214-5018-00
-15	614-1018-00			1	FRONT PANEL ASSY, TCPA300,W/CABLE ASSY,SP:FLAT FLEX	80009	614-1018-00
	614-1019-00			1	FRONT PANEL ASSY, TCPA400,W/CABLE ASSY,SP:FLAT FLEX	80009	614-1019-00
-16	390-1209-00			1	CABINET:LEFT AMPLIFIER DC,0.032 AL	0J9P9	390-1209-00
-17	119-6823-00			1	POWER SUPPLY:40W,AC-DC,90-264 VAC IN,15V 2.6A OR 3.3A (W/20 CFM AIRFLOW) OUT,SAFETY CONTROLLED	TK1955	NAN40-7615 (REV F)

Table 8-1: Power cord identification

Plug configuration	Normal usage	Option number/ part number
	North America 120 V	Standard 161-0066-00
	Universal Euro	A1 161-0066-09
	United Kingdom	A2 161-0066-10
	Australia	A3 161-0066-11
	Switzerland	A5 161-0154-00
	Japan	A6 161-A005-00
	China	AC 161-0306-00
	No power cord supplied.	A99

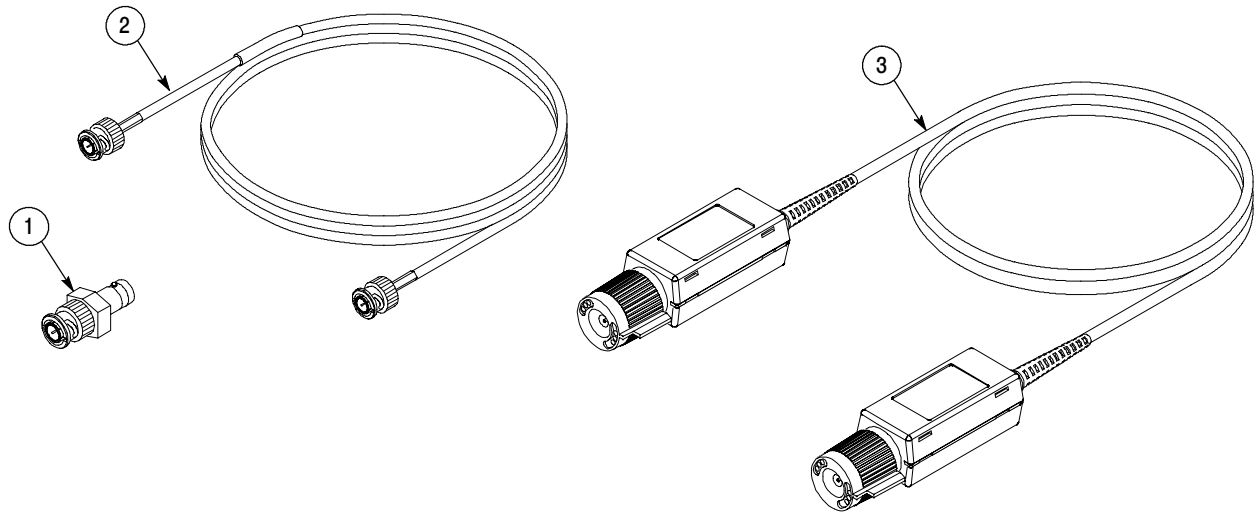


Figure 8-2: TPCA300 and TPCA400 standard accessories

TCPA300 and TPCA400 standard accessories

Fig. & index number	Tektronix part number	Serial no. effective	Serial no. discount'd	Qty	Name & description	Mfr. code	Mfr. part number
8-2-1	011-0049-02			1	TERMINATOR,BNC:COAXIAL,50 OHMS,2W,BNC	61162	50L-012 BNC
-2	012-0117-00			1	CABLE ASSY:COAX,RFD,50 OHM,30.0L,MALE,BNC X MALE,BNC	060D9	012-0117-00
-3	012-1605-00			1	CABLE ASSY RF:TEKPROBE INTERFACE	060D9	012-1605-00
	071-1183-00			1	MANUAL, INSTRUCTION,ENGLISH,TCPA300/400 AMPLIFIERS AND TCP300/400 SERIES CURRENT PROBES	80009	071-1183-00
	071-1184-00			1	MANUAL, INSTRUCTION,JAPANESE,TCPA300/400 AMPLIFIERS AND TCP300/400 SERIES CURRENT PROBES,OPTION L5	80009	071-1184-00

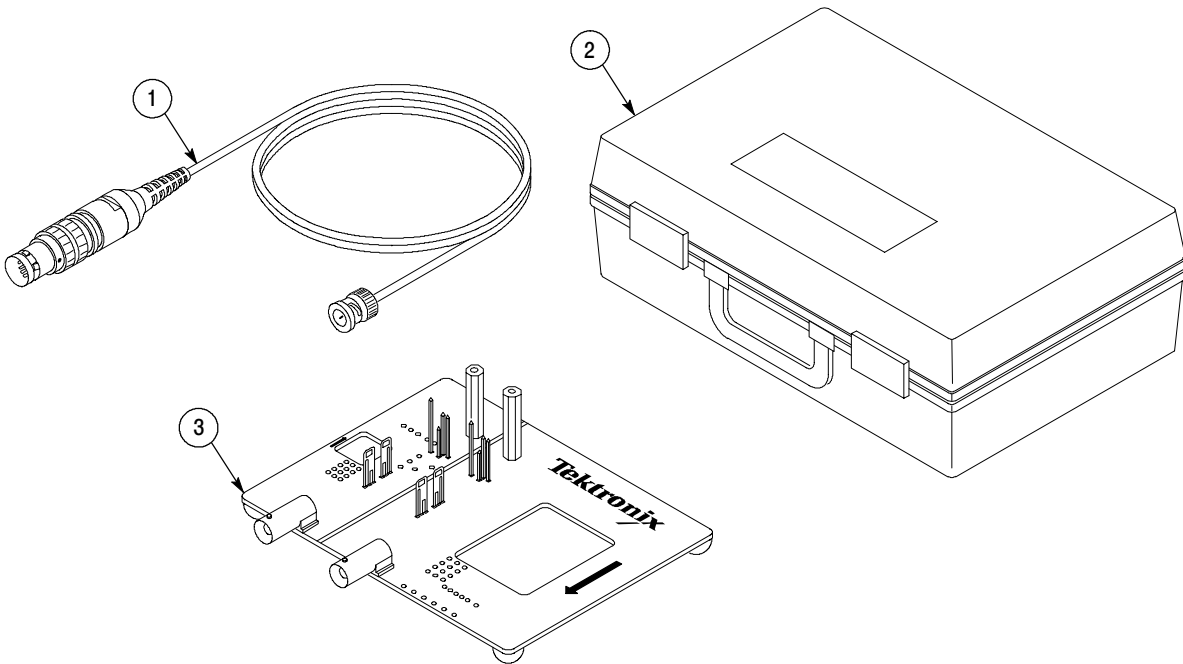


Figure 8-3: TPCA300 and TPCA400 optional accessories

TCPA300 and TPCA400 optional accessories

Fig. & index number	Tektronix part number	Serial no. effective	Serial no. discont'd	Qty	Name & description	Mfr. code	Mfr. part number
8-3-1	174-4765-00			1	CABLE ASSY, CALIBRATION ADAPTER	80009	174-4765-00
-2	016-1922-00			1	CASE, TRANSIT, CURRENT MEASUREMENT SYSTEM	80009	016-1922-00
-3	067-1478-00			1	POWER MEASUREMENTS DESKEW FIXTURE, TCP200, TCP300, A6300 SERIES PROBES	80009	067-1478-00
	TDSPWR2			1	TDSPWR2 POWER MEASUREMENT AND ANALYSIS SOFTWARE	80009	TDSPWR2

Current Probes Replaceable Parts

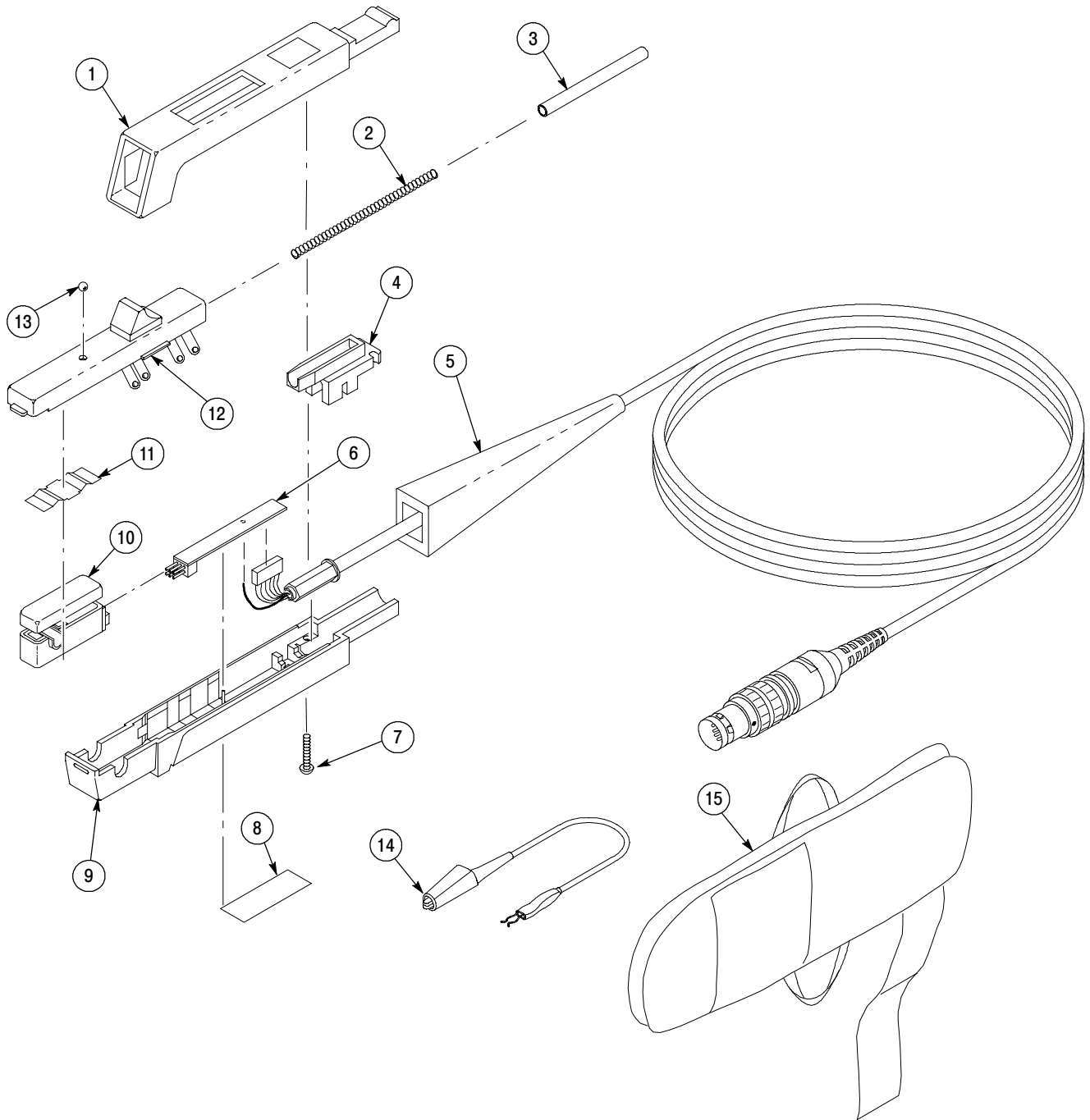


Figure 8-4: TCP305 and TCP312 replaceable parts

TCP305 and TCP312 Replaceable parts list

Fig. & Index Number	Tektronix Part Number	Serial No. Effective	Serial No. Discont'd	Qty	Name & Description	Mfr. Code	Mfr. Part Number
8-4-1	204-0288-03			1	BODY HALF,PROBE:UPPER BODY HALF,BLACK,POLY	80009	204-0288-03
-2	214-0835-00			1	SPRING,HLCPS:0.127 OD X 2.65 L,SST	91260	ORDER BY DESCR
-3	214-0849-00			1	RTNR RETURN SPR:BRS CD PL	80009	214-0849-00
-4	352-0106-00			1	HOLDER,SPR RTNR:DELTRIN	TK2565	352-0106-00
-5	174-4690-00			1	CABLE ASSY,RF COAX,60.0 L	80009	174-4690-00
-6	671-5427-00			1	CKT BD ASSY, TCP305	80009	671-5427-00
	671-5433-00			1	CKT BD ASSY, TCP312	80009	671-5433-00
-7	213-0087-00			2	SCREW,TPG,TC:2-32 X 0.5,TYPE BT,PANHEAD,STEEL,CADIUM PLATED,POZIDRIVE	3M099	ORDER BY DESCR
-8	335-0906-00			1	MARKER,IDENT:PROBE IDENT LABEL,TCP305	80009	335-0906-00
	335-0907-00			1	MARKER,IDENT:PROBE IDENT LABEL,TCP312	80009	335-0907-00
-9	204-0714-06			1	BODY,HALF:LOWER BODY HALF W/CONTACTS	80009	204-0714-06
-10	120-1984-00			1	XFMR SUBASSY:UPPER & LOWER TRANSFORMER SUBASSY, TCP305	80009	120-1984-00
	120-2029-00			1	XFMR SUBASSY:UPPER & LOWER TRANSFORMER SUBASSY, TCP312	80009	120-2029-00
-11	214-0854-00			1	CONTACT,ELEC:UPPER SHELF,CU BE	TK1947	214-0854-00
-12	351-0121-03			1	CONT ASSY,ELEC:PROBE SLIDE ASSY	80009	351-0121-03
-13	214-0997-00			1	BALL,BEARING:0.094,SST	05469	ORDER BY DESCR
					Standard Accessories		
-14	196-3120-01			1	LEAD,ELECTRICAL:23 AWG,6.0 L,GROUND	80009	196-3120-01
-15	016-1923-00			1	COVER,PROBE,SMALL	80009	016-1923-00
	071-1185-00			1	INSTRUCTION SHEET,TCP300/400 SERIES CURRENT PROBES	80009	071-1185-00

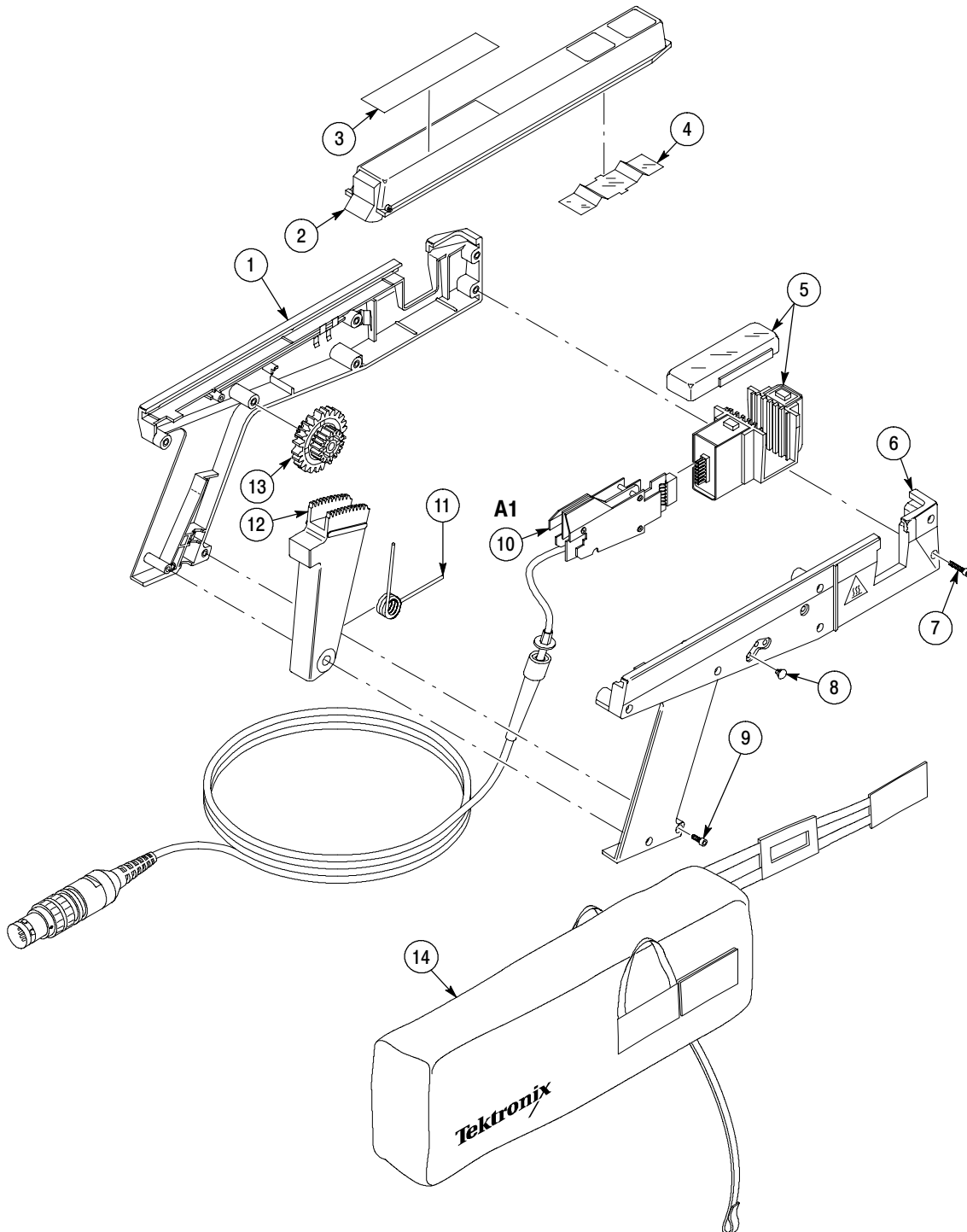


Figure 8-5: TCP303 and TCP404XL replaceable parts

TCP303 and TCP404XL Replaceable Parts List

Fig. & Index Number	Tektronix Part Number	Serial No. Effective	Serial No. Discont'd	Qty	Name & Description	Mfr. Code	Mfr. Part Number
8-5-1	204-0713-02			1	BODY HALF,PROBE:LEFT W/CONTACTS	TK1163	ORDER BY DESCRIPTION
-2	351-0955-01			1	SLIDE ASSEMBLY:WITH WARNING LABEL	80009	351-0955-01
-3	335-0912-00			1	MARKER,IDENT:PROBE ID LABEL,TCP303	0KB05	335-0912-00
	335-0913-00			1	MARKER,IDENT:PROBE ID LABEL,TCP404XL	0KB05	335-0913-00
-4	214-2422-00			1	SPRING,FLAT:UPPER CAN	TK1326	214-2422-00
-5	120-2028-00			1	TRANSFORMER:SUBASSEMBLY, TOP AND BOTTOM, TCP303	80009	120-2028-00
	120-1962-01			1	TRANSFORMER:SUBASSEMBLY, TOP AND BOTTOM, TCP404XL	80009	120-1962-01
-6	204-0712-02			1	BODY HALF,PROBE:RIGHT W/CONTACTS	TK1163	ORDER BY DESCRIPTION
-7	211-0093-00			6	SCREW,CAP:4-40 X 0.75,SCH,STL,CD PL,HEX REC	0KB01	ORDER BY DESCRIPTION
-8	348-0023-00			4	PLUG,HOLE:U/W0.14 DIA HOLE,WHT PLSTC	02768	207-090201-00-0101
-9	211-0183-00			2	SCREW,CAP:4-40 X 0.5,SCH,STL,CD PL,HEX REC	93907	ORDER BY DESCRIPTION
-10	174-4815-00			1	PROBE SUBASSY, TESTED BOARD AND CABLE, TCP303	80009	174-4815-00
	174-4816-00			1	PROBE SUBASSY, TESTED BOARD AND CABLE, TCP404XL	80009	174-4816-00
-11	214-2446-00			1	SPR,HLCL,TRSN:0.1 OD X 0.5 L,MUSIC WIRE	8X345	ORDER BY DESCRIPTION
-12	367-0218-00			1	HANDLE,SQUEEZE:PROBE P6301	TK2565	367-0218-00
-13	401-0352-00			1	GR CLUSTER,SPUR:(2)18 AND (1) 24 T,PLASTIC	TK2565	401-0352-00
					Standard Accessories		
-14	016-1924-00			1	COVER,PROBE,LARGE	80009	016-1924-00
	071-1185-00			1	INSTRUCTION SHEET,TCP300/400 SERIES CURRENT PROBES	80009	071-1185-00

Manufacturers Cross Index

Mfr. Code	Manufacturer	Address	City, State, Zip Code
02768	ILLINOIS TOOL WORKS INC	195 ALGONQUIN RD	DES PLAINES, IL 60016-6103
0KB01	STAUFFER SUPPLY CO	810 SE SHERMAN	PORTLAND, OR 97214-4657
0KB05	NORTH STAR NAMEPLATE INC	5750 NE MOORE COURT	HILLSBORO, OR 97124-6474
80009	TEKTRONIX INC	14150 SW KARL BRAUN DR PO BOX 500	BEAVERTON, OR 97077-0001
8X345	NORTHWEST SPRING MFG CO	5858 SW WILLOW LANE	LAKE OSWEGO, OR 97035
93907	CAMCAR DIV OF TEXTRON INC	ATTN: ALICIA SANFORD 516 18TH AVE	ROCKFORD, IL 611045181
TK1163	POLYCAST INC	9898 SW TIGARD ST	TIGARD, OR 97223
TK1326	NORTHWEST FOURSLIDE INC	18500 SW TETON AVENUE	TUALATIN, OR 97062
TK2548	XEROX CORPORATION	DIV OF XEROX CORPORATION 14181 SW MILLIKAN WAY	BEAVERTON, OR 97005
TK2565	VISION PLASTICS INC	26000 SW PARKWAY CENTER DRIVE	WILSONVILLE, OR 97070
05469	BEARINGS INC	3634 EUCLID PO BOX 6925	CLEVELAND, OH 44101
3M099	PORTLAND SCREW COMPANY	6520 N BASIN AVE	PORTLAND, OR 97217
91260	CONNOR FORMED METAL PRODUCTS	1729 JUNCTION AVENUE	SAN JOSE, CA 95112
TK1947	NORTHWEST ETCH TECHNOLOGY	2601 S HOOD ST PO BOX 110610	TACOMA, WA 98411-0610
060D9	TENSOLITE COMPANY	PRECISION HARNESS AND ASSEMBLY 3000 COLUMBIA HOUSE BLVD #120	VANCOUVER, WA 98661
0ADN8	DELTA PRODUCTS CORP-DPZ	4405 CUSHING PARKWAY	FREMONT, CA 94538
0B445	ELECTRI-CORD MFG CO INC	312 EAST MAIN STREET	WESTFIELD, PA 16950
0GV52	SCHAFFNER EMC INC	9-B FADEM ROAD	SPRINGFIELD, NJ 07081
0J9P9	GEROME MFG CO INC	PO BOX 737 403 NORTH MAIN	NEWBERG, OR 97132
1DM20	PARLEX CORP	7 INDUSTRIAL WAY	SALEM, NH 03079
61162	JFW INDUSTRIES INC	5134 COMMERCE SQUARE DRIVE	INDIANAPOLIS, IN 46237-9738
TK1163	POLYCAST INC	14140 SW 72ND AVE SUITE 100	TIGARD, OR 97224
TK1955	ARTESYN TECHNOLOG.	47173 BENICIA ST	FREMONT, CA 945380-7331



Glossary and Index

Glossary

amp-second product

The unit of measure defining the maximum amount of pulsed current that can be measured before the probe core becomes saturated. The amp-second rating applies only to measurement values between the maximum continuous and maximum pulse current ratings of the probe. The amp-second rating is equal to the peak current multiplied by the pulse width at the 50% point.

auto-balance

A process that removes unwanted DC offsets from the TCPA300 and TCPA400 circuitry to ensure maximum measurement accuracy. This process is performed during the probe degauss routine.

bucking current

Current fed back by the TCPA300 and TCPA400 to the current probe during DC and low-frequency AC measurements. Bucking current nulls most of the magnetic field in the probe core, allowing linear DC and AC measurements simultaneously.

conventional current flow

The flow of the positive charge in a conductor. Conventional current flow is from positive to negative. The arrows on current probes point in the direction of conventional current flow. Conventional current flow is in the opposite direction of *electron current flow*.

degauss

A process of eliminating residual magnetism from the probe core by feeding a decaying sine wave into the core. The degaussing process should be performed before clamping the probe around a conductor, whenever the probe becomes saturated by current overloads, or whenever the probe is exposed to a magnetic field. The term is derived from one of the units of magnetic flux density.

electron current flow

The flow of the electrons in a conductor. Electron current flow is from negative to positive. The arrows on current probes point in the opposite direction of electron current flow. Electron current flow is in the opposite direction of *conventional current flow*.

flux

The density of a magnetic field. As the number of flux lines increases, the magnetic field strength increases. Current in the conductor under test generates flux lines in the probe core by inducing a voltage in the core.

Hall device

A thin, rectangular piece of semiconductor material located in the core of the current probe. The Hall device uses the Hall effect for DC and low-frequency AC measurements.

Hall effect

The effect that produces a voltage potential in the Hall device when magnetic lines of force pass through the device. The voltage potential is directly proportional to the the magnetic field strength. The voltage polarity is determined by the magnetic field polarity. A bias supply is required to produce the Hall effect. The TCP300 and TCP400 Series current probes use the Hall effect for DC and low-frequency AC measurements.

insertion impedance

The equivalent series impedance introduced to a test circuit when the current probe is clamped around a test conductor.

magnetic susceptibility

A figure expressing the amount of current induced into the probe by an external magnetic field of known intensity. The lower the figure is, the less the probe is influenced by external magnetic fields.

saturation

A condition that occurs when the magnetic field strength in the probe core exceeds the maximum level that the core can absorb. When saturation occurs the probe no longer responds linearly to an increase in magnetic field strength, resulting in measurement inaccuracies. A current overload condition will cause core saturation. After saturation occurs, the probe core usually retains residual magnetism, which continues to produce inaccuracies until the probe is degaussed. The probe should be degaussed after saturation occurs.

Index

A

- AC coupling, 1-14, 2-4, 3-3
- Address, Tektronix, xvi
- Adjustments
 - overview, 6-1
 - TCP303 & TCP404XL, 6-11
 - TCP305 & TCP312, 6-7
 - TCPA300 & TCPA400, 6-3
- Amp-second product, 3-4
- Applications, 3-11
- Autobalance function, 2-2

B

- Bucking current, 3-8
- Button
 - COUPLING, 2-4
 - MANUAL BALANCE, 2-3
 - ON/STANDBY, 2-4
 - PROBE DEGAUSS/AUTOBALANCE, 2-2
 - RANGE, 2-4

C

- Cleaning, 7-1
- Connecting
 - a current probe to the amplifier, 1-9
 - a probe to a circuit under test, 1-13
 - the amplifier to an oscilloscope, 1-8
- Connector
 - OUTPUT, 2-5
 - PROBE INPUT, 2-4
- Contacting Tektronix, xvi
- Continuity measurements, 3-16
- Control summary, 2-1
- COUPLING button and indicator, 2-4
- Coupling modes, 3-3
- CT-4 high-current adapter, 1-5, 3-9
- Current limitations
 - amp-second product, 3-4
 - maximum continuous, 3-4
 - maximum pulsed, 3-4

D

- DC coupling, 2-4, 3-3
- DC gain adjust, optimizing, 2-5
- DC LEVEL control, 3-3
- Degauss function, 1-11, 2-2, 3-1
 - functional check, 5-13
- Differential current, 3-2

E

- Error Codes
 - correcting, 3-24
 - displaying, 3-22
 - shutdown error, 3-24
- Extending the current range of the probes, 3-8

F

- Frequency derating, 3-4
- Front panel controls, 2-1

G

- GPIB Operation, 2-5

H

- Hardware faults, isolating, 7-21

I

- Increasing bucking current, 3-8
- Increasing probe sensitivity, 3-10
- Indicator
 - MANUAL BALANCE, 2-3
 - NONCOMPATIBLE PROBE TYPE, 2-4
 - NOT TERMINATED INTO 50 OHMS, 2-4
 - OVERLOAD, 2-3
 - PROBE DEGAUSS/AUTOBALANCE, 2-2
 - PROBE OPEN, 2-3
 - RANGE, 2-4
- Inductance measurements, 3-13

M

- Maintenance, 7-1
- MANUAL BALANCE buttons and indicator, 2-3
- Maximum continuous current rating, 3-4
- Maximum measurement times, 3-6
- Maximum pulsed current rating, 3-4
- Measuring continuity, 3-16
- Measuring current
 - AC, 1-14
 - current nulls, 3-2
 - DC, 1-12
 - differential current, 3-2
- Measuring inductance, 3-13

N

- NONCOMPATIBLE PROBE TYPE, indicator, 2-4
- NOT TERMINATED INTO 50 OHMS indicator, 2-4
- Null current, 3-2

O

- ON/STANDBY button, 2-4
- Optional Accessories, 1-5, 8-7
- Options, 1-3
- OUTPUT connector, 2-5
- OVERLOAD indicator, 2-3

P

- Performance Verification
 - overview, 5-1
 - TCP303 & TCP404XL, 5-31
 - TCP305 & TCP312, 5-19
 - TCPA300 & TCPA400, 5-3
- Test Record
 - TCP303, 5-42
 - TCP305, 5-29
 - TCP312, 5-30
 - TCP404XL, 5-43
 - TCPA300, 5-16
 - TCPA400, 5-17
- Phone number, Tektronix, xvi
- Power on the amplifier, 1-8
- PROBE DEGAUSS/AUTOBALANCE button, 1-11
- PROBE DEGAUSS/AUTOBALANCE button and indicator, 2-2
- PROBE DEGAUSS/AUTOBALANCE indicator, 2-2
- Probe Holders, 1-6
- PROBE INPUT connector, 2-4

- PROBE OPEN indicator, 2-3
- Probes
 - coupling, 3-3
 - degaussing (demagnetizing), 1-11, 2-2
 - description, 1-2
 - disassembly, 7-13
 - extending the current range, 3-8
 - increasing the current limit, 3-8
 - maintenance, 7-1
 - maximum current limits, 3-4
 - operating the probe slide, 1-10
 - saturation, 3-4
- Product support, contact information, xvi

R

- RANGE button and indicator, 2-4
- Replaceable Parts
 - overview, 8-1
 - TCP303 & TCP404XL, 8-11
 - TCP305 & TCP312, 8-9
 - TCPA300 & TCPA400, 8-3
- Replacing
 - Amplifier Board, 7-8
 - Fan, 7-11
 - Front Panel Assembly, 7-7
 - Instrument Case & Internal Covers, 7-4
 - Power Supply, 7-10
 - Probe Circuit Board or Cable Assembly, 7-17, 7-18
 - Probe Current Transformer, 7-16, 7-18

S

- Service support, contact information, xvi
- Shutdown error, 3-24
- Specifications, 4-1
- Standard Accessories, 1-4, 8-6

T

- TCP303, bandwidth check, 5-39
- TCP303 & TCP404XL
 - DC accuracy adjustment, 6-18
 - DC accuracy check, 5-33
 - rise time check, 5-36
 - transient response & gain adjustment, 6-13
- TCP305 & TCP312
 - bandwidth check, 5-26
 - DC accuracy check, 5-21
 - rise time check, 5-24

- TCP404XL
 - bandwidth check, 5-41
 - maximum measurement times, 3-6, 4-12
 - TCPA300 & TCPA400
 - bandwidth check, 5-9
 - DC coupling check, 5-12
 - DC gain accuracy check, 5-6
 - disassembly, 7-3
 - front panel display check, 5-5
 - Technical support, contact information, xvi
 - TEKPROBE-to-TEKPROBE interface cable, 1-8
 - Tektronix, contacting, xvi
 - Termination, 50-ohm feedthrough, 1-8
 - Test Record, Performance Verification
 - TCP303, 5-42
 - TCP305, 5-29
 - TCP312, 5-30
 - TCP404XL, 5-43
 - TCPA300, 5-16
 - TCPA400, 5-17
 - Travel Case, 1-7
 - Troubleshooting, 3-19
- U**
- URL, Tektronix, xvi
- W**
- Web site address, Tektronix, xvi

