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

## User Manual

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Tektronix

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

# User Manual

This document applies for firmware version 1.0 and above.

www.tektronix.com

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## Contacting Tektronix

Tektronix, Inc.
14200 SW Karl Braun Drive
P.O. Box 500
Beaverton, OR 97077
USA

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

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

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

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# General Safety Summary

Review the following safety precautions to avoid injury and prevent damage to this product or any products connected to it.

To avoid potential hazards, use this product only as specified.

*Only qualified personnel should perform service procedures.*

While using this product, you may need to access other parts of a larger system. Read the safety sections of the other component manuals for warnings and cautions related to operating the system.

## To Avoid Fire or Personal Injury

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

**Ground the Product.** This product is grounded through the grounding conductor of the power cord. To avoid electric shock, the grounding conductor must be connected to earth ground. Before making connections to the input or output terminals of the product, ensure that the product is properly grounded.

**Observe All Terminal Ratings.** To avoid fire or shock hazard, observe all ratings and markings on the product. Consult the product manual for further ratings information before making connections to the product.

Connect the probe reference lead to earth ground only.

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

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

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

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

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

**Do Not Operate in Wet/Damp Conditions.**

**Do Not Operate in an Explosive Atmosphere.**

**Keep Product Surfaces Clean and Dry.**

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

## Terms in this Manual

These terms may appear in this manual:

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

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

## Symbols and Terms on the Product

These terms may appear on the product:

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

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

# Compliance Information

This section lists the EMC (electromagnetic compliance) and environmental standards with which the instrument complies.

## EMC Compliance

### EC Declaration of Conformity – EMC

Meets intent of Directive 2004/108/EC for Electromagnetic Compatibility. Compliance was demonstrated to the following specifications as listed in the Official Journal of the European Communities:

**EN 61326-1:2006, EN 61326-2-1:2006.** EMC requirements for electrical equipment for measurement, control, and laboratory use. [1] [2] [3]

- CISPR 11:2003. Radiated and conducted emissions, Group 1, Class A
- IEC 61000-4-2:2001. Electrostatic discharge immunity
- IEC 61000-4-3:2002. RF electromagnetic field immunity
- IEC 61000-4-4:2004. Electrical fast transient/burst immunity
- IEC 61000-4-5:2001. Power line surge immunity
- IEC 61000-4-6:2003. Conducted RF immunity
- IEC 61000-4-11:2004. Voltage dips and interruptions immunity [4]

**EN 61000-3-2:2006.** AC power line harmonic emissions

**EN 61000-3-3:1995.** Voltage changes, fluctuations, and flicker

**European Contact.**

Tektronix UK, Ltd.
Western Peninsula
Western Road
Bracknell, RG12 1RF
United Kingdom

1 This product is intended for use in nonresidential areas only. Use in residential areas may cause electromagnetic interference.

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

3 To ensure compliance with the EMC standards listed here, high quality shielded interface cables should be used.

4 Performance Criterion C applied at the 70%/25 cycle Voltage-Dip and the 0%/250 cycle Voltage-Interruption test levels (IEC 61000-4-11).

### Australia / New Zealand Declaration of Conformity – EMC

Complies with the EMC provision of the Radiocommunications Act per the following standard.

- CISPR 11:2003. Radiated and Conducted Emissions, Group 1, Class A, in accordance with EN 61326-1:2006 and EN 61326-2-1:2006.

### FCC – EMC

Emissions are within the limits of FCC 47 CFR, Part 15, Subpart B for Class A equipment.

# Environmental Considerations

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

## Product End-of-Life Handling

Observe the following guidelines when recycling an instrument or component:

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

This symbol indicates that this product complies with the applicable European Union requirements according to Directives 2002/96/EC and 2006/66/EC on waste electrical and electronic equipment (WEEE) and batteries. For information about recycling options, check the Support/Service section of the Tektronix Web site (www.tektronix.com).

## Restriction of Hazardous Substances

This product has been classified as Monitoring and Control equipment, and is outside the scope of the 2002/95/EC RoHS Directive.

# Preface

This User 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 A, 100 MHz, compatible with TCPA300)
- TCP305 (50 A, 50 MHz, compatible with TCPA300)
- TCP303 (150 A, 15 MHz, compatible with TCPA300)
- TCP404XL (500 A*, 2 MHz, compatible with TCPA400) *750 A 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 *Glossary* and *Index* are provided as quick reference locators for important information.

### Service Manual

The *Performance Verification and Adjustment* procedures are located in the Service Manual and support the qualification and calibration of the probes when used with either amplifier.

The *Maintenance* section is also located in the Service Manual and supports the routine maintenance and repair of mechanical parts associated with the amplifiers.

## 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.

# 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. (See Figure 1.)

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

1. 50 Ω oscilloscope input — use the TEKPROBE Interface Cable or use a 50 Ω cable. (Add a 50 Ω termination here if the oscilloscope only has a high-impedance input).

## 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 A, 100 MHz)
- TCP305 (50 A, 50 MHz)
- TCP303 (150 A, 15 MHz)

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

- TCP404XL (750 A [1], 2 MHz)

[1] 500 A continuous, 750 A 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 peakA.

## 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: 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 |

Tektronix service options that you can order for your amplifiers and probes are listed in this section. (See Table 2.) 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 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.

### 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
- User 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.

- 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 2.)

**Figure 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 3.)

**Figure 3: Equipment locations in the travel case**

1. Large current probe
2. Probe holders
3. Small current probe
4. Amplifier
5. Cables and terminations

## 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 1 V/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 on page 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, do the following and refer to the illustration. (See Figure 4.)

1. To connect the probe, align the red dots.
2. Push the probe connector in. Do not twist the connector.
3. To disconnect the probe, pull back the collar.
4. Pull out the connector.

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

***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.

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.

Each current probe is calibrated before it is shipped, and should not require further adjustment. If a probe requires adjustment, information is available in the service manual. The adjustment procedure must be performed only by qualified service personnel. Contact your nearest Tektronix Service Center if you need more assistance.

## 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.

The slide operation of the TCP305 and TCP312 current probes is shown in the following illustration. (See Figure 5.) 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 5: TCP312 and TCP305 slide operation**

The slide operation of the TCP303 and TCP404XL current probes is shown in the following illustrations. To open the probe:

1. Press the bottom of the lock button.
2. Squeeze the handle until the core is open.
3. Place the probe core around the conductor.

**Figure 6: Unlock and open the TCP303 and TCP404XL**

4. To lock the probe, release the squeeze handle.
5. Press the top of the lock button.

**Figure 7: Close and lock the TCP303 and TCP404XL**

## 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 Figure 5.) (See Figure 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. (See page 16, *PROBE DEGAUSS AUTOBALANCE Button and Indicator*.)

---

***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, first degauss the probe:

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.*

The current probe is shown connected to a power supply line. (See Figure 8.)

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 (-). To measure DC current, perform these steps:

1. Open the probe slide, place the probe around the conductor under test, and then lock the slide.
2. 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.
3. Adjust the oscilloscope time base, trigger, and gain as needed.

**Figure 8: 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.

# Control Summary

This section describes the function of each TCPA300 and TCPA400 front panel control and connector. The overview shows most functions and is followed by a detailed description. (See Figure 9.)

Some seldom-used functions do not appear in the illustration. These functions are completely discussed in the detailed descriptions that follow this illustration.

**Figure 9: The TCPA300 front panel**

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.
2. 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.
3. The four probe error lights indicate the following faults: PROBE OPEN, OVERLOAD (current or temperature), NOT TERMINATED INTO 50 Ω and NONCOMPATIBLE PROBE TYPE.
4. The ON/STANDBY button turns on power to the amplifier.
5. The TCPA300 and TCPA400 output appears at the OUTPUT connector. Connect this to a 50 Ω input of your oscilloscope.

6. The current probes connect to the TCPA300 and TCPA400 at the PROBE INPUT connector.
7. The COUPLING button selects AC or DC probe coupling, as indicated by the LEDs.
8. The RANGE button toggles between the two scale factors that are available for the attached probe (TCPA300 only). LEDs indicate the selected range.

## TCPA300 and TCPA400 Controls

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

### PROBE DEGAUSS AUTOBALANCE Button and Indicator

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, reenergize 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.

(See page 43, *Displaying Error Codes with the Probe Degauss Autobalance Button*.)

***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. Proper cabling is shown. (See Figure 1 on page 1.)*

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*.

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**

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 Ω 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**

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 TCPA300 Amplifier, and the TCP404XL probe only works with the TCPA400 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**

Press the RANGE button to toggle between the scale factors (sensitivity settings) of the probe attached to the TCPA300. 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 TCPA300/TCPA400 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. (See page 43, *Displaying Error Codes with the Probe Degauss Autobalance Button*.)

**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. Information

about connecting a probe is available. (See page 8, *Connecting a Current Probe to the Amplifier*.)

## 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. The proper cabling is shown. (See Figure 1 on page 1.)*

*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. See the service manual for adjustment procedures and 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 1 A/V range is 1%. If you want to measure a 3 Ap-p, 1 kHz square wave and need increased accuracy (better than 0.25% is attainable), first adjust the TCP312 on the 1 A/V range setting using a calibrated 3 Ap-p, 1 kHz 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 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, the degauss procedure succeeds because the amplifier is able to saturate the probe core. (See Figure 11 on page 23.) While degauss occurs, the probe induces a voltage in the unpowered circuit as shown. (See Figure 11 on page 23.) 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: Unpowered circuit degauss limits**

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

## Measuring Differential Current

You can place two conductors in a current probe to provide differential or null current measurement. (See Figure 10.) This avoids the necessity of using two current measurement systems with a differential oscilloscope.

**Figure 10: Measuring two conductors**

***WARNING.*** *To avoid injury or loss of life from shock or fire, 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.
2. Clamp the current probe around the two conductors as shown. Be careful not to pinch a conductor in the probe jaws.

**Figure 11: Measuring differential current and nulls**

3. Measure the current. A waveform above the baseline indicates the conductor with the conventional current flow ($I_1$, in the direction of the probe arrow), is carrying the greater current. Conventional current flows from positive to negative.

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

## 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. (See Figure 12.)

1. A low-frequency square wave using AC coupling. The signal exhibits low-frequency rolloff.
2. By changing the amplifier coupling to DC, the pulse is displayed as truly square, as shown.

**Figure 12: 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.

- Maximum Continuous Current refers to the maximum current that can be continuously measured at DC or at a specified AC frequency. (See page 47, *Specifications*.) 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.

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***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.*

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To determine if your measurement exceeds the Ampere-second product, perform either Procedure A (Maximum Allowable Pulse Width), or Procedure B (Maximum Allowable Pulse Amplitude).

## Procedure A: Maximum Allowable Pulse Width

To determine the maximum allowable pulse width do the following:

1. Measure the peak current of the pulse.
2. Divide the Ampere-second (or Ampere-microsecond) specification for the range setting of the probe by the measured peak current of the pulse. The quotient is the maximum allowable pulse width ($PW_{max}$).

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

   For example, the TCP312 Current Probe has a maximum Ampere-second product of 500 Arms 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 Arms divided by 40 A, or 12.5 µs.

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

**Figure 13: Applying the amp-second product rule**

## Procedure B: Maximum Allowable Pulse Amplitude

To determine the maximum allowable pulse amplitude do the following:

1. Measure the pulse width at the 50% points.
2. Divide the Ampere-second (or Ampere-microsecond) specification for the range setting of the probe by the pulse width. The quotient is the maximum allowable pulse amplitude; the peak amplitude of the measured pulse must be less than this value.

   For example, the TCP312 Current Probe has a maximum Ampere-second product of 500 Arms in the 10 A/V range setting. If a pulse measured with a TCP312 probe has a width of 15 µs, the maximum allowable peak current would be 500 Arms divided by 15 µs, 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 as measurement time) and the measurement period. A continuous and noncontinuous current is shown and how to calculate the duty cycle. (See Figure 14.)

**Figure 14: 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. (See Figure 34 on page 56.) (See Figure 36 on page 57.)

You can see how duty cycle affects the measurement time by looking at any of the three graphs. (See Figure 34 on page 56.) (See Figure 36 on page 57.) As the duty cycle increases on the x-axis, the measurement time (of the noncontinuous current) on the y-axis decreases.

The effect of measuring two different noncontinuous current amplitudes, 750 A and 600 A respectively, with varying duty cycles and levels of continuous current is illustrated. (See Figure 34 on page 56.) (See Figure 35 on page 56.) The ambient temperature in these two examples is kept constant at 50 °C.

***WARNING.*** *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. Because 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 see how noncontinuous current amplitude affects measurement time, look at the curves for measurements of 200 A continuous between the two graphs. (See Figure 34 on page 56.) (See Figure 35 on page 56.) Compare the maximum measurement time allowed for a duty cycle of 20%: At 750 A, you have 3 minutes of safe measurement time, versus 17 minutes for a smaller noncontinuous-current amplitude of 600 A.

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. (See Figure 34 on page 56.) (See Figure 36 on page 57.) 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 loss of life due to shock or fire, 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.*** *To avoid injury or loss of life from shock or fire, 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, do the following and refer to the illustration. (See Figure 15.)

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

**Figure 15: Adding a second conductor**

***NOTE.*** *Adding a second conductor to the probe increases the insertion impedance and reduces the upper bandwidth limit of the probe.*

You can increase the value of the bucking current by winding multiple turns of the second conductor around the probe, as shown in the illustration. (See Figure 16.)

**Figure 16: Adding multiple turns**

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.*** *Winding multiple turns to the probe increases the insertion impedance and reduces the upper bandwidth limit of the probe.*

## 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. The signal is multiplied by the number of turns around the probe.

***WARNING.*** *To avoid injury or loss of life, 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 17: 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. (See Figure 19 on page 34.)

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. (See Figure 18.) 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 4: 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 TEKPROBE interface cable) | 10 A/Div (200 mV/Div) |
| | Zero-Current Reference | Center graticule line |
| | Time Base | 200 ms/division |

**Figure 18: Setup for measuring charging current**

The waveform (a) shows the three-phase ripple frequency. (See Figure 19.) 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, waveform (b). (See Figure 19.)

**Figure 19: 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

This figure shows a constant-voltage pulse generator of extremely low output impedance connected to an inductor that has low resistance. (See Figure 20.)

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

**Figure 20: 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.*

4. Measure the current ramp. The inductance is effectively defined by the slope of the current ramp shown here.

**Figure 21: Linear current vs. time ramp**

5. Calculate the inductance using the following formula:

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

where:

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

### High-Impedance Pulse Sources

If the pulse source has a higher impedance of known resistance, such that the output voltage drops as the current increases, the inductance of a coil can be calculated by the time constant of the charge curve. The current ramp shows how the values for the inductance formula are obtained. (See Figure 22 on page 37.)

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

$$L = tR$$

where $L$ is the inductance in henries, t 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 22: 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, do the following. (See Figure 23.)

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

**Figure 23: Measuring the number of turns in a coil**

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.

1. Repeat steps 1 and 2 above and make the following changes:
2. Insert the reference coil into the current probe.
3. Insert the test coil into the current probe so that the currents oppose each other as shown. (See Figure 24.)

**Figure 24: Turns measurement using reference coil**

You must observe the polarity of coil current to determine whether the test coil has greater or fewer turns than the reference coil. The turns are calculated by using the formula:

$$N_2 = N_1 \times \frac{I_m}{I_1}$$

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

## 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

Possible problems that you may encounter when measuring current with the TCPA300 and TCPA400 are available. (See Table 5.) Use this as a quick troubleshooting reference.

### Table 5: Troubleshooting

| Problem | Remedy |
|---|---|
| Amplifier will not power on | Check that the amplifier is plugged into a working AC outlet.<br>Defective amplifier. Refer the instrument to qualified service personnel for repair. To help determine which module is defective, a troubleshooting section is available in the service manual. |
| Front panel displays an error status. Error Status LEDs are on the lower-left section of the amplifier front panel | 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. |
| The AC and DC COUPLING LEDs are flashing alternately | The Error Status LEDs are displaying an error code. Error codes descriptions are available. (See Table 6 on page 44.) 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.<br>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.<br>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. |
| All LEDs are flashing | 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. |
| OVERLOAD LED remains lit red after removing probe from circuit | Probe transformer or amplifier main board is defective. |
| OVERLOAD LED remains lit orange | 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. |
| Probe does not degauss successfully and LEDs are lighted in an unfamiliar pattern | Amplifier is displaying an error code or is out of calibration or defective. (See Table 6 on page 44.) If another amplifier is available, try to degauss the probe on the other amplifier, to help isolate the cause.<br>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. |
| Cannot degauss the probe | Current Probe is not locked. Lock the current probe.<br>Current Probe is improperly connected to the amplifier input connector.<br>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, *not* at the amplifier output.<br>Current Probe is defective or not compatible with the amplifier type. |

**Table 5: Troubleshooting (cont.)**

| Problem | Remedy |
|---|---|
| Degauss takes longer than 10 seconds | Probe is attached to an energized circuit. Disconnect probe from circuit and retry.<br>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.<br>Defective main board - If the probe is not the cause, then it is most likely a defective main board in the amplifier. |
| Cannot make a current measurement - no measurement output from amplifier | Current Probe is not locked. Lock the current probe.<br>Current Probe is improperly connected to the amplifier input connector.<br>Amplifier COUPLING is set to AC. Set the COUPLING to DC.<br>A Degauss/Autobalance routine has not been completed successfully on the system. Degauss the probe.<br>Oscilloscope/Amplifier is not set to an appropriate sensitivity setting.<br>Defective interface cable (between oscilloscope and amplifier). |
| MANUAL BALANCE will not adjust | Oscilloscope or amplifier input coupling not set to DC. MANUAL BALANCE buttons only function when the amplifier is in the DC coupling mode.<br>Oscilloscope/Amplifier is not set to an appropriate sensitivity setting. |
| Stray DC component in measurement | Degauss the probe using the PROBE DEGAUSS AUTOBALANCE button. (The Current Probe has been overloaded, dropped, or exposed to magnetic field.)<br>You can use the MANUAL BALANCE buttons to null out any residual DC offset after performing a Probe Degauss Autobalance routine. |
| Measurements are inaccurate | Degauss the probe.<br>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.<br>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.<br>Amplifier or current probe out of calibration. (See the service manual for performance verification procedures.)<br>The jaw mechanism is dirty - disassemble probe, clean and lubricate. Probe disassembly procedures are available. (See the service manual.)<br>Defective current probe transformer. |
| Measurements roll off at high frequencies | The oscilloscope bandwidth limit is turned on. Verify that the bandwidth limit switch on the oscilloscope is set to the desired bandwidth position.<br>(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.) |
| Measurements exhibit excessive noise | Current Probe is not locked. Lock the current probe.<br>Current Probe is improperly connected to the amplifier input.<br>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, *not* at the amplifier output.<br>Defective current probe transformer. |

**Table 5: Troubleshooting (cont.)**

| Problem | Remedy |
|---|---|
| Measurement aberrations exceed the specified limit | 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 at the oscilloscope input. Do not attach the termination to amplifier output.<br>The measurement exceeds the maximum continuous current or Ampere-second product ratings of the Current Probe. (Current limits are available) (See page 25, *Maximum Current Limits*.) If possible, upgrade to a probe with a higher current rating or use a CT-4 transformer. |
| Excessive low frequency droop in pulse response or low DC gain accuracy | Check that the probe slider is fully closed and locked.<br>Check and clean the probe transformer and lid.<br>Degauss the probe.<br>The amplifier or the oscilloscope may be AC coupled. Set the COUPLING to DC. |
| Measurements exhibit excessive delay or slowed pulse response | 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 at the oscilloscope input. Do not attach the termination to the amplifier output.<br>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.<br>The oscilloscope bandwidth limit is turned on. Verify that the bandwidth limit switch on the oscilloscope is set to the desired bandwidth position. |
| Probe jaw not opening and closing freely | The jaw mechanism is dirty - disassemble probe, clean and lubricate. Probe disassembly procedures are available. (See the service manual.) |

## 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. To display the error codes, do the following. (See Figure 25.)

1. Press the PROBE DEGAUSS AUTOBALANCE button.
2. The AC and DC Coupling LEDs will flash alternately to indicate that error codes are being displayed instead of normal conditions.
3. The four fault indicator LEDs above the ON/STANDBY switch are used to form a four-bit binary error code. (See Figure 26 on page 44.) The error codes are defined in the table. (See Table 6 on page 44.)

   The PROBE OPEN LED indicates the most significant bit (MSB), and the NONCOMPATIBLE PROBE TYPE LED indicates the least significant bit (LSB).
4. 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 25: Error code display

For example, after you press the PROBE DEGAUSS AUTOBALANCE button, if the AC and DC Coupling LEDs are flashing, then an error code is being displayed:

1. In this example, the NOT TERMINATED INTO 50 Ω LED is illuminated.
2. This four-bit binary code (0010) indicates an Error Code 2: a null error in the DC offset circuit occurred. (See Figure 26.)

**Figure 26: Interpreting the error code display**

A complete list of error codes for the amplifier is listed in the table. (See Table 6.)

**Table 6: 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<br>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<br>5 | TCPA300 ONLY - An error occurred while 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:<br>1) Remove the probe from the circuit.<br>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<br>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<br>9 | Unused | |

**Table 6: Amplifier error codes (cont.)**

| Code | Description of error | Action to take |
|---|---|---|
| 10<br>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<br>13<br>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).<br>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

These specifications are valid only under the following conditions:

- The probe and amplifier have been calibrated at an ambient temperature of 23 ° ±5 °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 °C to +50 °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 Ω.

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 7: Warranted TCPA300 and TCPA400 specifications**

| **Amplifier** | **TCPA300** | | | **TCPA400** |
|---|---|---|---|---|
| DC Gain Accuracy | ≤1% | | | ≤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% | ≤3.5 ns | ≤7 ns | ≤23 ns | ≤175 ns |
| DC Gain Accuracy: | | | | |
| Warranted | ≤3% | ≤3% | ≤3% [1] | ≤3% |
| Typical [2] | ≤1% | ≤1% | ≤1% | ≤1% |

1 Warranted from 10 °C to 50 °C. For temperature range of 0 °C to <10 °C, spec is +3%/-6%.

2 23 °C ±5 °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 8: Nominal and typical amplifier characteristics

| | Installed probe | | | |
|---|---|---|---|---|
| **Parameter** | **TCP312** | **TCP305** | **TCP303** | **TCP404XL** |
| Ranges, nominal | 1 A/V,<br>10 A/V | 5 A/V,<br>10 A/V | 5 A/V,<br>50 A/V | 1 A/mV |
| Maximum Amp-Second Product – Frequency deratings shown. (See page 52, *Performance Graphs*.) | 1 A/V - 50 A · µs<br>10 A/V - 500 A · µs | 5 A/V - 500 A · µs<br>10 A/V - NA | 5 A/V - 3000 A · µs<br>50 A/V -<br>15000 A · ms | NA |
| Input Coupling, nominal | AC, DC | AC, DC | AC, DC | AC, DC |
| AC Coupling Low- Frequency Bandwidth, (low-pass -3 dB point), typical | <7 Hz | <7 Hz | <7 Hz | <7 Hz |
| Displayed Noise, typical | ≤75 $mA_{RMS}$ Limit measurement bandwidth to 20 MHz. | ≤500 $mA_{RMS}$ Limit measurement bandwidth to 20 MHz. | ≤500 $mA_{RMS}$ Limit measurement bandwidth to 20 MHz. | ≤70 $mA_{RMS}$ Limit measurement bandwidth to 20 MHz. |
| Signal Delay, typical [1] | 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 – For plots (See Figure 32.) | 1 MHz: 0.08 Ω | 1 MHz: 0.035 Ω | 1 MHz: 0.01Ω | 10 kHz: 0.1 mΩ |
| | 10 MHz: 0.15 Ω | 10 MHz: 0.12 Ω | 5 MHz: 0.025 Ω | 100 kHz: 0.6 m Ω |
| | 50 MHz: 0.27 Ω | 50 MHz: 0.04 Ω | 15 MHz: 0.1 Ω | 1 MHz: 8.0 m Ω |
| | 100 MHz: 0.7 Ω | | | 2 MHz: 16.0 mW |
| 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 8: Nominal and typical amplifier characteristics (cont.)

| | Installed probe | | | |
|---|---|---|---|---|
| **Parameter** | **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 (±10%), 47 Hz to 440 Hz, single phase | | | |
| Maximum Power | 50 Watts maximum | | | |
| Fuse Rating | 3.15 AH, 250 V (Not operator-replaceable.) | | | |

[1] Includes probe, amplifier, and TEKPROBE-to-TEKPROBE interface cable or 012-0117-xx BNC cable.

## Mechanical Characteristics

### Table 9: 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) |

### Table 10: Probe mechanical characteristics

| | TCP305 and TCP312 | TCP303 and TCP404XL |
|---|---|---|
| Probe dimensions | | |
| Length: | 20 cm (7.77 inches) | 268 mm (10.55 inches) |
| Width: | 1.6 cm (0.625 inches) | 41 mm (1.60 inches) |
| Height: | 3.2 cm (1.25 inches) | 68 mm (2.7 inches) |
| Cable length | 1.5 m (5 feet) | TCP303: 2 m (6.6 feet)<br>TCP404XL: 8 m (26.25 feet) |
| Weight | 0.15 kg (0.33 lb) | TCP303: 0.66 kg (1.45 lb)<br>TCP404XL: 0.88 kg (1.90 lb) |

### Figure 27: Probe jaw dimensions (nominal)

### Table 11: Shipping weights and dimensions

| | TCPA300 and TCPA400 Amplifiers | TCP305 and TCP312 | TCP303 | TCP404XL |
|---|---|---|---|---|
| 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 are warranted performance specifications. (See Table 12.)

Unlike the warranted characteristics, 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. (See page 47, *Warranted Specifications*.)

### Table 12: 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)<br>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)<br>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 |

## Performance Graphs

**Figure 28: Frequency derating-TCP312**

**Figure 29: Frequency derating-TCP305**

**Figure 30: Frequency derating-TCP303**

**Figure 31: Frequency derating-TCP404XL**

**Figure 32: Insertion impedance versus frequency**

**Figure 33: Specified operating area of the probes**

## TCP404XL Maximum Measurement Times

The maximum measurement time for the TCP404XL probe with varying duty cycles and temperatures are shown in the following three graphs. Details about the relationship between measurement factors are available. (See page 28, *Measuring Noncontinuous Current with the TCP404XL Probe*.)

**Figure 34: Measuring 750A noncontinuous at 50 °C ambient temperature**

**Figure 35: Measuring 600A noncontinuous at 50 °C ambient temperature**

**Figure 36: Measuring 750A noncontinuous at 23 °C ambient temperature**

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

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

## Safety Compliance Information

**Table 13: Safety compliance information**

| Category | Standards or description |
|---|---|
| EC Declaration of Conformity – Low Voltage [1] | Compliance was demonstrated to the following specification as listed in the Official Journal of the European Communities:<br>Low Voltage Directive 73/23/EEC, amended by 93/68/EEC.<br>EN 61010-1/A2:1995. Safety requirements for electrical equipment for measurement control and laboratory use.<br>EN 61010-2-032:1995. Particular requirements for hand-held current clamps for electrical measurement and test equipment. |
| U.S. Nationally Recognized Testing Laboratory Listing | UL3111-1. Standard for electrical measuring and test equipment.<br>UL3111–2–032. Standard for hand-held current clamps for electrical measurement and test. |
| Canadian Certification | CAN/CSA C22.2 No. 1010.1. Safety requirements for electrical equipment for measurement, control, and laboratory use.<br>CAN/CSA C22.2 No. 1010.2.032:1996. Particular requirements for hand-held probe assemblies for electrical measurement and test equipment. |

### Table 13: Safety compliance information (cont.)

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

1 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.

# 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 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.

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