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## Specifications

The following specifications are valid for model AP015 current probes after the probe has reached operating temperature, which is 20 minutes with power applied in a environment with stable ambient temperature. The probe must be operating within the environmental conditions listed in the General Characteristics section, and has been calibrated within the past 12 months in a ambient temperature of  $23 \pm 5$  °C.

### Nominal Characteristics

Nominal characteristics describe parameters and attributes which are guaranteed by design, but do not have associated tolerances.

Interface:	ProBus
Coupling:	AC, GND, DC
Maximum Current, DC	$\pm 30$ A (continuous) $\pm 50$ A maximum (<10s)
Sensitivity:	10 mA/div – 20 A/div
Offset Range	$\pm 100$ A maximum
Maximum Conductor Size	5 mm
Maximum Voltage, Bare Conductor	300 V CAT I 150 V CAT II
Cable Length	2 m
Weight, probe only	300 g (10.6 oz.)

### Warranted Electrical Characteristics

Warranted characteristics describe parameters which have guaranteed performance. Unless otherwise noted, tests are provided in the Performance Verification Procedure for all warranted specifications.

DC Accuracy:	$\pm 1\%$ of reading to 15A (at 25° C, after degauss) $\pm 2\%$ of reading to 30A (at 25° C, after degauss)
Bandwidth	DC to 50MHz

### Typical Electrical Characteristics

Typical characteristics describe parameters which do not have guaranteed performance, however are representative of the average performance from a sample of several probes. Tests for typical characteristics are not provided in the Performance Verification Procedure.

Rise Time:	< 7 ns
Slew Rate	> 1.6 A/ns ( Sensitivity $\geq 1$ A/div)
Insertion Impedance	< 0.06 $\Omega$ at 5 MHz

**General Characteristics**

Temperature:	0 – 40 °C Operating
Relative Humidity	80% Maximum up to 31° C
Usage Environment	Indoor
Altitude	2000 m maximum
Power Requirements:	Powered from oscilloscope through ProBus interface. No restriction on number of probes used with oscilloscope.

## Performance Verification

This procedure can be used to verify the warranted characteristics of the AP015 Current Probe.

The recommended calibration interval for the model AP015 Current Probe is one year. The complete performance verification procedure should be performed as the first step of annual calibration. Test results can be recorded on a photocopy of the Test Record provided at the end of this manual.

Performance verification can be completed without removing the instrument covers or exposing the user to hazardous voltages. Adjustment should only be attempted if a parameter measured in the Performance Verification Procedure is outside of the specification limits.

Adjustment should only be performed by qualified personnel.

### Test Equipment Required

The following table lists the test equipment and accessories, or their equivalents, which are required for performance verification of the AP015 Current Probe.

Because the input and output connector types may vary on different brands and models of test instruments, additional adapters or cables may be required.

**TABLE 1**  
**List of Required Equipment**

Description	Minimum Requirements	Test Equipment Examples
Wide Band oscilloscope <sup>1</sup>	Minimum 200 MHz bandwidth ProBus interface equipped Software Version 7.6.0 or greater	LeCroy LT322
Digital Multimeter (2 required)	DC: 0.1 % accuracy 5½ digit resolution with Null capability (referenced measurements)	Agilent Technologies 34401A, Fluke 8842A-09, Keithley 2001
Leveled Sine Wave Generator.	Relative output level accurate to $\pm 0.3$ dB into 50 $\Omega$ 1 – 100 MHz frequency range Output adjustable to 18 dBm	Tegam SG503 with TM series mainframe and matching output cable. A semiautomatic software leveled signal source calibrated with a power meter may be substituted.
DC Power Supply	Output adjustable to >6 V at 1 A	Agilent Technologies E3610A
Calibration Fixture, 50 Turn Loop	50 Turn loop in series with 0.5 $\Omega$ $\pm 0.2\%$ resistor with sense terminals	LeCroy AP015-CF01
Calibration Fixture, High Speed Shunt	50 $\Omega$ Termination into single turn loop. VSWR < 1.25:1 DC – 50 MHz	LeCroy AP015-CF02
Calibration Fixture	ProBus Extension Cable	LeCroy PROBUS-CF01
BNC Adapter, T	Male to dual Female	Pomona 3285

**TABLE 1**  
**List of Required Equipment**

Description	Minimum Requirements	Test Equipment Examples
BNC coaxial cable	Male-male BNC, 50 $\Omega$ , 36"	Pomona 5697-36
Banana Plug adapter	BNC female to banana plug.	Pomona 1269
Patch Cables (4 reequired)	Male Banana – Male Banana, 12"	Pomona B-12-0 (black) B-12-2 (red)

### Preliminary Procedure

1. Connect the AP015 to the channel 1 input of the oscilloscope, and completely close the probe slider.
2. Turn the oscilloscope on and allow at least 30 minutes warm-up time for the AP015 and test equipment before performing the Verification Procedure.
3. Turn on the other test equipment and allow these to warm up for the time recommended by the manufacturer.
4. While the instruments are reaching operating temperature, make a photocopy of the Performance Verification Test Record (located at the end of this manual), and fill in the necessary data.

### Functional Check

The functional check will verify the basic operation of all probe functions. It is recommend that the Fucntional Check be performed prior the Performance Verification Procedure.

1. Select Channel 1 and enter the **coupling** menu and verify that the Global BWL is set to OFF.
2. Verify that **Probe sensed (AP015)** is displayed on the right hand menu.
3. Unlock the slider on the probe by pushing the lever towards the probe cable. Release the lever so the input slider remains closed, but unlocked.
4. Verify that the message: **Warning: AP015 Probe Unlocked...** is displayed on the top of the screen.
5. Lock the probe slider by pushing fully away from the probe cable.
6. Verify that the warning message disappears.
7. Degauss the probe by pressing the **DEGAUSS** button, (located on the coupling menu), twice.
8. Verify that no error message remains displayed on the top of the screen.

## Performance Verification Procedure

The warranted characteristics of the AP015 Current Probe are valid at any temperature within the Environmental Characteristics listed in the Specifications. However, some of the other test equipment used to verify the performance may have environmental limitations required to meet the accuracy needed for the procedure. Make sure that the ambient conditions meet the requirements of all the test instruments used in this procedure.

### *Note:*

*The correct operation of the controls of the AP015 requires oscilloscope software version 7.6.0 or higher. The use of earlier versions is not recommended. The software version in the test oscilloscope can be verified by pushing **SHOW STATUS**, then selecting the **System** menu option. Contact your local LeCroy representative if the software in your oscilloscope requires updating.*

### A. Check Bandwidth:

1. Set Leveled Sine Wave Generator frequency to 50kHz, the output level to approximately 5Vp-p (+18dBm), and turn the RF ON.
2. Connect the output to the BNC connection of the high speed shunt calibration fixture, AP015-CF02, using the matched BNC coaxial cable specified for use with the leveled sine wave generator.
3. Open the slider and connect the AP015 to the high speed shunt calibration fixture. Close and lock the probe slider by pushing it fully away from the probe cable.
4. Push the **AUTO SETUP** button on the oscilloscope. Press **MEASURE TOOLS**, set the mode to **Std Voltage**, on trace **1**, from **0.00 div** to **10.00 div**.
5. Adjust the generator level until the current is 100 mA peak to peak, as measured using the peak to peak function on the oscilloscope.
6. Set the sine wave generator frequency to 25 MHz. Be careful not to alter the signal amplitude.
7. Slowly increase the output frequency until the displayed amplitude of the current sine wave decreases to 71mA peak to peak (a 3dB reduction in amplitude).
8. Check that this frequency is greater than 50MHz, and record the frequency on the test record.

### B. Check DC Accuracy.

1. Set the DC Power Supply output voltage to approximately 0 V.
2. Remove the AP015 from the oscilloscope, and reconnect using the ProBus extension cable. Install a BNC T connector, BNC cable, and BNC to dual banana plug adapter as shown in the figure on the following page. Connect the dual banana plug adapter into one of the digital multimeters.
3. Using banana patch cords, connect the 'V Source' terminal of the 50 Turn Calibration Loop, AP015-CF01, to the positive output of the power supply. Connect the 'V Return' terminal to the power supply negative terminal. (Refer to Figure 1 on the following page.)
4. Connect the Current Sense terminals of the 50 Turn Calibration Loop to the voltage inputs of the second digital multimeter.

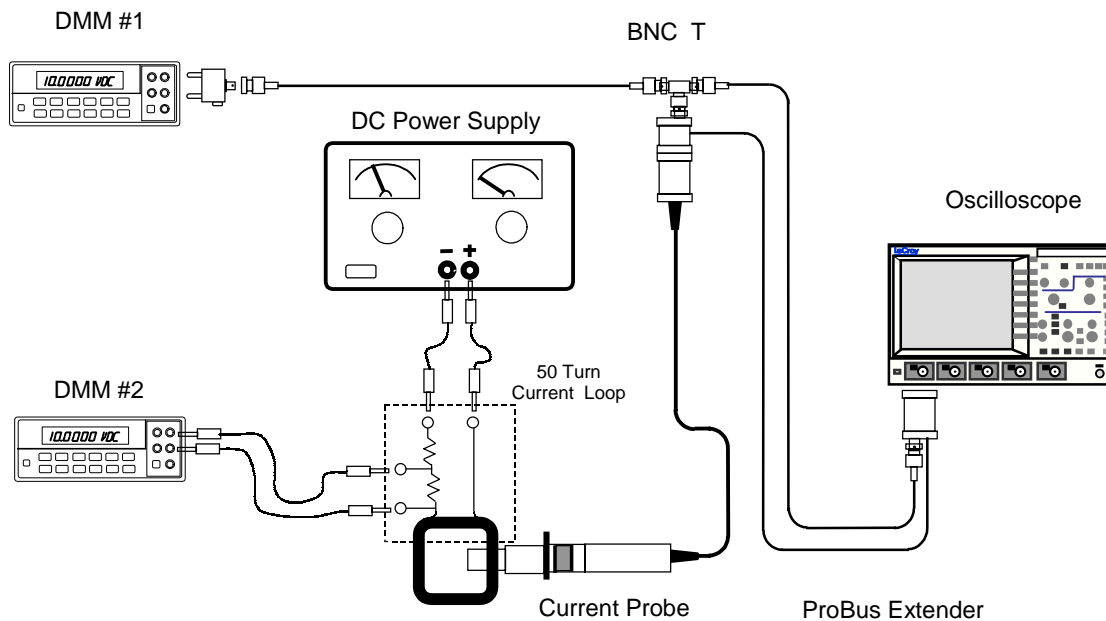


Figure 1. DC Accuracy Test Set Up

5. With the AP015 removed from any signal and the slider returned to the LOCKED position, degauss the probe by pressing the **DEGAUSS** button, (located on the coupling menu), twice.
6. Open the AP015 slider and position the probe input around the 50 Turn loop. Close and LOCK the slider.
7. Set the oscilloscope channel vertical scale to 20A/div.
8. With the power supply set to 0V, press the 'Null' button of the multimeter measuring the probe voltage to subtract the probe's offset voltage from the measurement. (If the multimeter being used does not have this capability, the offset value can be manually subtracted from the probe output values recorded below).
9. Increase the power supply voltage until the voltage measured at the 'Current Sense' terminals (DMM #2) is approximately 150mV. (This corresponds to 15A at the probe head).
10. Record the exact value (a) of the current sense voltage measured with DMM #2 on the test record line marked '15A Current Sense', and (b) the probe output voltage measured with DMM #1 on the line marked '15A Probe Output'.
11. Multiply the value recorded for '15A Current Sense' by 10, and record this value on the line labeled '15A Current'.
12. Calculate the percentage difference between the probe output voltage and the actual current using the equation  $100 * (b - c)/c$ . Record this value on the line marked '15A Accuracy'.
13. Verify that the 15A Accuracy is  $\leq 1\%$
14. Increase the power supply voltage until the voltage measured at the 'Current Sense' terminals is approximately 300mV. (This corresponds to 30A at the probe head).
15. Record the exact value (a) of the current sense voltage on the test record line marked '30A Current Sense', and (b) the probe output voltage on the line marked '30A Probe Output'.
16. Multiply the value recorded for '30A Current Sense' by 10, and record this value on the line labeled '30A Current'.

17. Calculate the percentage difference between the probe output voltage and the actual current using the equation  $100 * (e - f)/f$ . Record this value on the line marked '30A Accuracy'.
18. Verify that the 30A Accuracy is  $\leq 2\%$
19. Leave the connection set up for the remaining test.

### C. Check Peak Current

**Caution:**

*This test increases the power dissipated inside the probe. Do not leave the increased current turned on for extended periods of time longer than needed to complete the test (10 seconds).*

1. Increase the power supply voltage until the voltage measured at the 'Current Sense' terminals is  $>500\text{mV}$ . (This corresponds to  $>50\text{A}$  at the probe head).
2. Note the probe output voltage. Verify that the voltage remains stable without significant decrease for 10 seconds before shutting the current off. Record '>10sec' on the test record.

This completes the Performance Verification of the AP015. Complete and file the results recorded in the AP015 Performance Verification Test Record as required by your quality procedures. Apply suitable calibration label to the AP015 housing as required.



## Adjustment Procedure

### Introduction

This procedure can be used to adjust the AP015 Current Probe in order to meet the warranted gain specification. The other parameters verified in the Performance Verification procedure do not have adjustments associated with them. This procedure should only be performed if the instrument fails to meet the Performance Verification tests.

If the probe cannot be adjusted to meet the Performance Verification limits, repair may be necessary.

To assure instrument accuracy, check the calibration of the AP015 every year. Before calibration, thoroughly clean and inspect this unit as discussed in Cleaning earlier in this section.

Adequate guard bands were designed into this instrument to assure it will meet or exceed published specifications over the entire operating temperature range. To continue to meet the environmental specifications, all adjustments must be performed in a controlled environment with an ambient temperature of  $25^{\circ} \pm 5^{\circ}$  C. The instrument must also be at stable operating temperature before performing adjustments.

#### **Caution:**

*The adjustment procedure will require removal of the instrument covers. These covers are part of the ESD protection system of the AP015. To protect the instrument, the entire procedure should only be performed on a static dissipating work surface. The technician should wear an antistatic grounding wrist strap and follow standard static control procedures.*

### Test Equipment Required

The adjustment procedure requires a subset of the equipment required for Performance Verification. Refer to Table 1 located in the Performance Verification procedure.

If alternate test equipment is substituted, control settings or calibration equipment setups may need to be altered. Alternate models of test equipment may have different connector styles requiring adapters not included in the equipment list.

### Preliminary Procedure

1. Remove the two screws that secure the plastic cover on the cable end of the ProBus interface housing. Gently pull on the probe cable to slide the circuit board assembly from the metal housing.
2. Connect the AP015 (without the compensation box cover ) to the oscilloscope using the setup for the DC Accuracy check in the Performance Verification Procedure. (Refer to Figure 1 in the Performance Verification section).

#### **Caution:**

*The compensation box cover serves to align the ProBus connector pins during mating. With the cover removed, care must be used to assure correct alignment of the connector pins. Applying power with the pin alignment offset may damage the probe.*

3. Turn on the oscilloscope power switch to allow the probe to warm up at least 20 minutes before proceeding with the gain adjustment.

## Procedure

### A. Adjust R24, Gain

1. With the AP015 Current Probe removed from any signal and the slider returned to the LOCKED position, degauss the probe by pressing the **DEGAUSS** button, (located on the coupling menu), twice.
2. Connect the AP015 to the 50 Turn loop, and set the oscilloscope vertical scale to 20A/div.
3. With the power supply set to 0V, press the 'Null' button of the multimeter measuring the probe voltage to subtract the probe's offset voltage from the measurement. (If the multimeter being used does not have this capability, the offset value can be manually subtracted from the probe output values measured).
4. Increase the power supply voltage until the voltage measured at the 'Current Sense' terminals is approximately 100mV. (This corresponds to 10A at the probe head).
5. Carefully adjust R24 until the value measured by the multimeter measuring the probe output is equal to 10X the value measured by the current sense meter. (There are two adjustments on the circuit board; R24 is the one farther from the board edge).

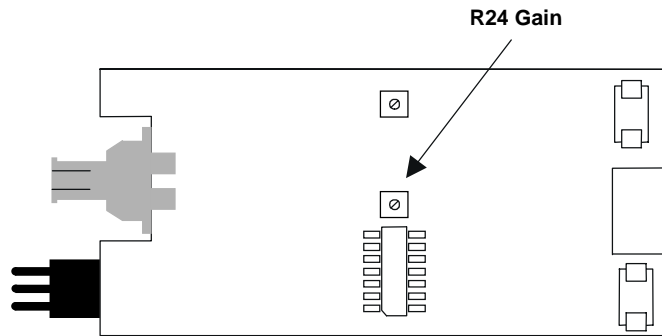


Figure 2. Gain Adjustment Location

6. After adjustment, calculate the accuracy (as in steps 15, 16 & 17 above) to confirm that the probe is measuring better than 1% accuracy.
7. Insert and tighten the two screws which secure the end panel to the ProBus interface housing. Avoid over tightening the screws as the cover may warp.
8. Repeat the Performance Verification procedure to assure compliance with the warranted Specifications.

### AP015 Performance Verification Test Record

This record can be used to record the results of measurements made during the performance verification of the AP015 Current Probe.

Photocopy this page and record the results on the copy. File the completed record as required by applicable internal quality procedures.

The section in the test record corresponds to the parameters tested in the performance verification procedure. The numbers preceding the individual data records correspond with the steps in the procedure which require data recording. Results recorded in the right most column, labeled "Test Result" are the actual specification limit check. The test limits are included in all of these steps. Other measurements and the results of intermediate calculations which support the limit check are recorded in the center column labeled "intermediate results".

Permission is granted to reproduce this page for the purpose of recording test results.

**Model:** AP015

**Serial Number:** \_\_\_\_\_

**Asset or Tracking Number:** \_\_\_\_\_

**Date:** \_\_\_\_\_

**Technician:** \_\_\_\_\_

**Equipment Used:**

	Model	Serial Number	Calibration Due Date
Digital Multimeter #1:	_____	_____	_____
Digital Multimeter #2:	_____	_____	_____
High frequency Sine Wave Generator:	_____	_____	_____
Power Meter: (If used to level Sine Wave Generator)	_____	_____	_____

**NOTES:** \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

### AP015 Performance Verification Test Record

Test Date: \_\_\_\_\_ S/N: \_\_\_\_\_ ID#: \_\_\_\_\_

Technician: \_\_\_\_\_ Temp: \_\_\_\_\_ Humd: \_\_\_\_\_

Before Results  After Results

Comments: \_\_\_\_\_

Step	Description	Intermediate Data	Test Result
<b>Bandwidth:</b>			
A-8	Probe Bandwidth (>50 MHz)	_____ MHz	
<b>DC Accuracy:</b>			
B-10a	15A Current Sense	(a) _____ V	
B-10b	15A Probe Output	(b) _____ V	
B-11	15A Current	(c) _____ A	
B-12	15A Accuracy (<±1%)		_____ %
B-15a	30A Current Sense	(d) _____ V	
B-15b	30A Probe Output	(e) _____ V	
B-16	30A Current	(f) _____ A	
B-17	30A Accuracy (<±2%)		_____ %
<b>Peak Current</b>			
C-2	50A DC Current (>10sec)		_____ sec