Agilent Technologies

User's Guide

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May 2005

Contents

Agilent 1146A AC/DC Oscilloscope Current Probe

Receiving Your Shipment

Upon receiving your shipment, check that the contents agree with the packing slip. If anything is missing, contact your nearest Agilent Technologies Sales Office. If the shipment was damaged, contact the carrier, then contact the nearest Agilent Technologies Sales Office.

Packaging

The 1146A AC/DC Current Oscilloscope Probe is shipped with a separate battery (not installed) and a User's Guide.

WARNING

- Connect the probe to the oscilloscope or voltage measuring instrument before clamping the probe around a conductor.
- Never use the probe on circuits rated higher than 600 Vac RMS CAT II or 300 Vac RMS CAT III or with float voltage greater than 600 V.
- Never leave the probe clamped around a conductor while it is not connected to an oscilloscope or voltage measuring instrument.
- Carefully center the conductor inside the probe jaws and ascertain that the probe is perpendicular to the conductor before closing the jaws.
- Avoid, if possible, the proximity of other conductors which may create noise.
- Check the magnetic mating surfaces of the probe jaws; these should be free of dirt, rust, or other foreign matter
- Do not use a probe which is cracked, damaged or has defective leads.

This symbol signifies that the 1146A AC/DC Oscilloscope Current Probe is protected by double or reinforced insulation. Only use specified replacement parts when servicing the instrument.

This symbol signifies CAUTION! and requests that the user refer to the user manual before using the instrument.

Description

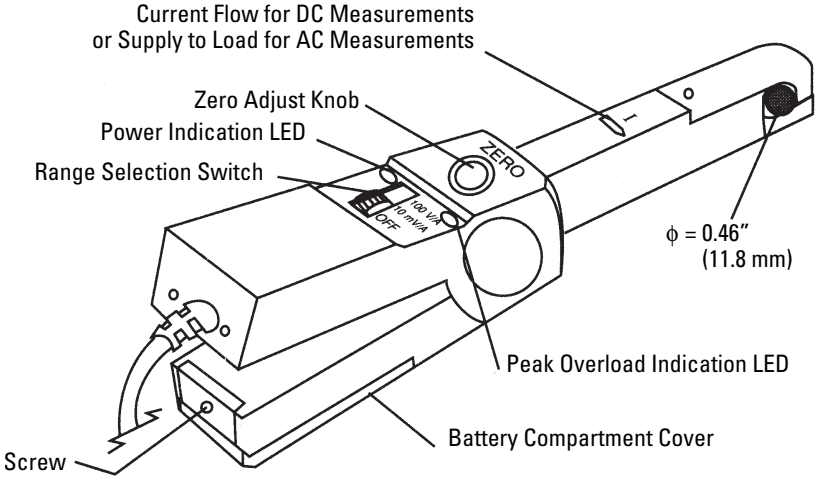
The 1146A AC/DC Current Oscilloscope Probe expands oscilloscope applications in industrial, automotive or power environments, and is ideal for analysis and measurement of distorted current waveforms and harmonics. The probe permits accurate display and measurement of currents from 100 mA to 100A rms, DC to 100 kHz without breaking into the circuit. The probe uses Hall effect technology to measure AC and DC signals. The probe connects directly to an oscilloscope through a 2 meter coaxial cable with an insulated BNC.

Compatibility

The 1146A AC/DC Current Oscilloscope Probe is compatible with any analog or digital oscilloscope or other voltage measuring instrument which has the following features:

- BNC input connector.
- Range capable of displaying 0.2 to 0.5 V per division.
- Minimum input impedance of 1 MΩ.

Control and Connector Identification



Control and Connector Identification

Specifications

All probe specifications are warranted based on the following conditions:

- Within one year of calibration
- 23° C ±5° C
- 20% to 75% relative humitidy
- Probe zeroed
- 1 minute warm up
- Battery at 9 V ±0.1 V
- External magnetic field <40 A/m
- No adjacent current carrying conductor
- 1 MΩ /100 pF probe termination

Measurement accuracy

Input Current (dc to 1kHz)	100mV/A	10 mV/A
50mA to 10A	<±3% of reading ±50mA	
50mA to 40A	n/a	<±4% of reading ±50mA
40A to 100A	n/a	<±15% of reading ±100mA

Bandwidth

(-3dB with derating - see Typical Response Curves)
dc to 100kHz

Characteristics

All probe characteristics are the typical performance values and are not warranted. Characteristics are based on these conditions:

- Within one year of calibration
- 23° C ±5° C
- 20% to 75% relative humitidy
- Probe zeroed
- 1 minute warm up
- Battery at 9 V ±0.1 V
- External magnetic field <40 A/m
- No adjacent current carrying conductor
- 1 MΩ /100 pF probe termination
- Conductor centered in jaw

Measurement Sensitivities and Ranges:

Sensitivity	Current Measurement Range
100mV/A	0A to 10A dc or peak ac
10mV/A	0A to 100A dc or peak ac

Other Measurement Characteristics:

	100 mV/A	10 mV/A
Phase Shift (DC to 1 kHz, no DC component)	< 1.5° dc to 65 Hz	< 1.0° dc to 65 Hz
Noise	480 µV	3 mV
Slew Rate	0.3 V/µs	20 mV/µs
Insertion Impedance (50 Hz/60 Hz)	0.01 Ω	0.01 Ω
Rise of Fall Time	3 µs	4 µs

Influence of Adjacent Conductor:
<0.2mA/A ac

Influence of Conductor Position in Jaw:
0.5% of reading in jaw

Overload Indication:
Red LED (OL) indicates input is out of range

Maximum Working Voltage (refer to safety warnings and standards):
600Vac RMS CAT II
300Vac RMS CAT III

Maximum Floating Voltage (refer to safety warnings and standards):
600Vac RMS CAT II
300Vac RMS CAT III

Battery Characteristics

Battery Type	9V Alkaline (NEDA 1604A, IEC 6LR61)
Low Battery Indication	Green LED (ON) when battery voltage ≧ 6.5V
Typical Battery Consumption	8.6mA
Typical Battery Life	55 hours

Environmental Conditions

Operating Temperature Range	0° C to 50° C
Storage Temperature Range	-30° C to 80° C
Temperature Influence	<0.2% per ° C
Max Operating Humidity	10° C to 30° C: 85% RH (without condensation) 40° C to 50° C: 45% RH (without condensation)
Altitude	Operating: 0 to 2000 m Non operating:0 to 12,000 m
Indoor Use	This probe is rated for indoor use only

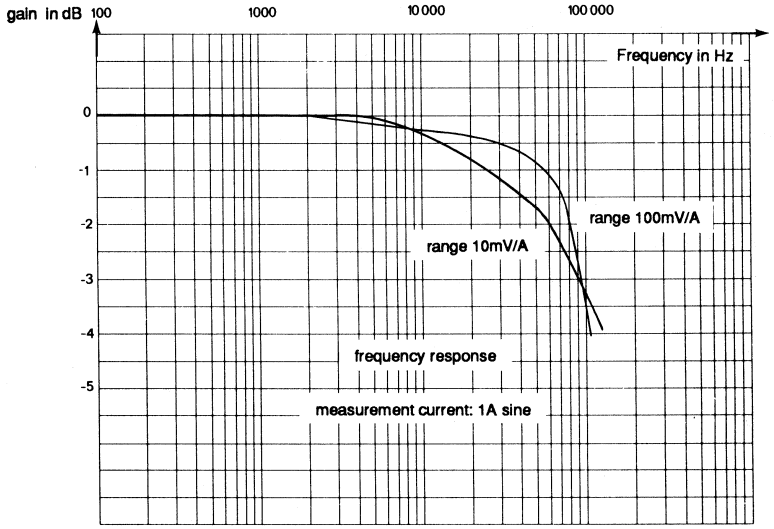
Mechanical Characteristics

Zero Adjustment	20 turn potentiometer
Maximum cable diameter	11.8 mm
Case Protection	IP20 per IEC 529
Drop Test	1.0 m on 38 mm of oak on concrete, tested according to IEC 1010
Mechanical Shock	100 G; test per IEC 68-2-27
Vibration	Tested per IEC 68-2-6, frequency range 10 Hz to 55 Hz, amplitude 0.15 mm
Handle	Lexan® 920A, UL 94 V2
Dimensions	231mm x 36mm x 67mm
Weight	330 g (11.6 oz) with battery
Color	Light gray
Output cable	Insulated coaxial cable with insulated BNC connector
Output cable length	2 m

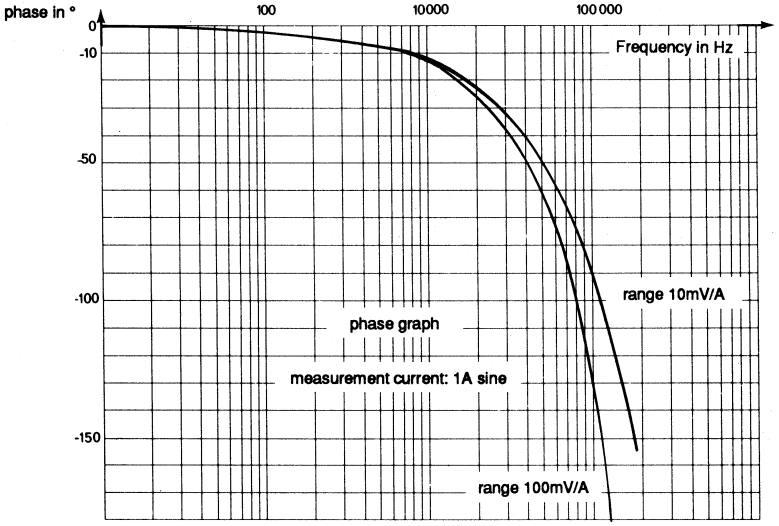
Safety Standards

- Double insulation or reinforced insulation between primary or secondary and outer case of the handle, per IEC 1010.
- 600 V Category III, Pollution degree 2.
- 300 V Category IV, Pollution degree 2.
- 5550 V 50/60 Hz between primary or secondary and the outer case of the handle.
- 3250V 50/60 Hz between primary and secondary

Typical Response Curves

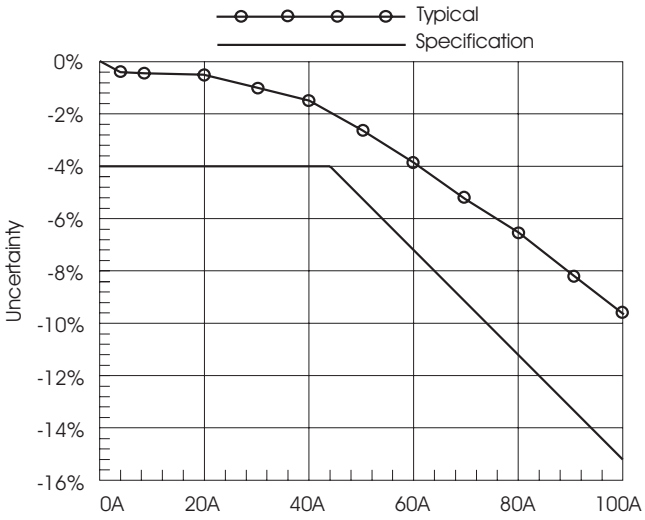


Frequency



Phase Shift

Linearity for a DC signal Range 10 mV/A



Accuracy

Operation

Zero Adjustment

The probe has a zero adjustment which should be adjusted before measurement. Alternatively, you may "zero" with the oscilloscope instead.

Current Measurement

Connect the current probe to the proper input channel on the oscilloscope. Begin with the least sensitive range on the current probe (10 mV/A). Select the 0.5 V/Division range on your oscilloscope. Clamp the probe on the conductor to be measured and read the current flowing directly on your oscilloscope.

You may also use your oscilloscope to amplify the signal while using the 100 mV/A probe range (which offers the best accuracy and least phase shift).

Important

It is possible to change the range on the current probe without removing the probe from the current carrying conductor, but it is important to remember not to exceed the permissible peak ratings of 1000 mV peak or 2000 mV peak to peak maximum. The peak ratings by range are: 10 A peak on the 100 mV/A range, 100 A peak on the 10 mV/A range.

Battery Indication (Green LED)

The probe has a battery condition LED. To ensure proper readings with your current probe, be sure that the green LED is lit during measurement. If not, replace the 9 V battery.

Peak Overload (OL) Indication (Red LED)

The 1146A offers an overload indicator. If the red LED illuminates during measurement, this indicates that the peak value exceeds the instrument response level and that the output is distorted. Switch the probe to a higher range if possible.

Maintenance

Cleaning the Probe

Be sure that mating surfaces of the jaw are free of dirt or foreign matter. Gently clean with a soft, lightly oiled cloth. Do not leave excessive oil residue.

Battery Replacement

When the probe is turned on, the green battery indication LED should light up. If not, replace the battery.

1 Disconnect the probe from the circuit and the oscilloscope.

   Do not replace the battery while probe is in use.

2 Turn the probe "OFF".

3 Unscrew the battery compartment screw (shown on page 3) and pull out the battery compartment cover.

4 Replace the 9 V battery and put the cover back on.

Measurement Performance Verification Test

Perform the following tests on the 1146A AC/DC Oscilloscope Current Probe to ensure that your instrument complies with the factory specifications.

If the probe fails any of the following tests:

1. Replace the battery. Verify that the battery voltage is 9 V ±0.1 V.
2. Ensure that:
   - The probe's magnetic contact surfaces are clean
   - The probe tip closes completely around the coil's conductors
   - The coil is centered in the probe tip opening
   - The probe tip is perpendicular to the coil's conductors
   - The probe current flow indicator points in the correct direction
3. Demagnetize the probe by opening and closing the clamp 5 to 10 times.

Equipment Required

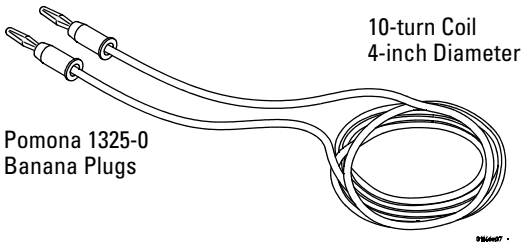
The following equipment is required to perform the tests in this section.

Table 1

Description	Critical Specifications	Recommended Model/Part Numbers
Digital Multimeter (2 required)	AC/DC voltage and current measurement accuracy better than ±0.1% of reading Input resistance in AC/DC voltage mode ≧ 1MΩ	Agilent 34401A or Agilent 3458A
Signal Generator	DC to 100kHz sine waves Able to generate more than 10mA in the test coil (e.g. an inductive load).	Agilent 33120Aor Fluke 5500A
Patch Cable Assembly	Banana plug connectors Length ≦ 36in (91cm)	Pomona 1440-36-0
Adapter	BNC (m) to dual banana	Pomona 1296
Adapter	BNC (f) to dual banana	Pomona 1269
Banana Jack (2 required)	Stackable	Pomona 1325-0
Coil	10 turns (requires about 4 ft or 1.2 m of transformer wire or wire wrap wire.)	OK Industries R30B-0100(100 ft roll of 30AWG wire wrap wire)

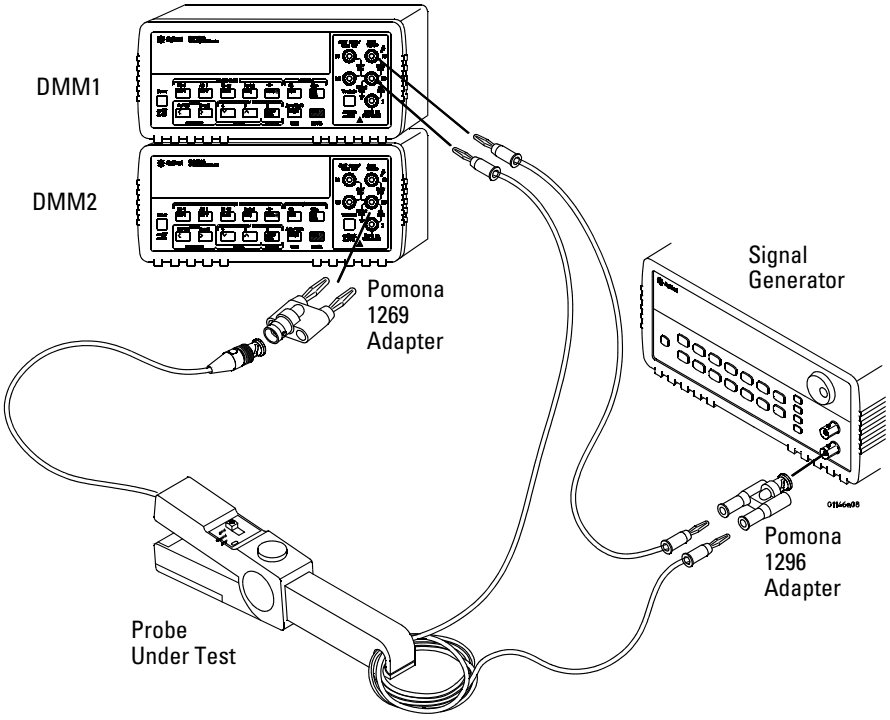
Connections:

Construct a 10-turn coil with a diameter of about 4 inches (10 cm) using wire wrap or transformer wire. Attach stackable banana plugs to the coil for connection to the instruments used in this test.



Test connector

Connect the instruments as shown below, and allow 30 minutes for warm up before starting the test procedure. While the test system is warming up, clean the magnetic contacts on the probe jaw.



Connect Equipement

DC Current Measurement Accuracy Check (10 mV/A range):

1 Configure the instruments as follows:
- DMM1: to measure DC Amps
- DMM2: to measure DC Volts
- Set the probe to the 10mV/A setting.

2 Configure DMM2 to measure DC Volts. Disconnect the probe from the coil and adjust the zero control to minimize the probe's DC output voltage. Record this zero offset voltage (V_Z) in Table 2.

3 Clamp the probe around the coil. Ensure that:
- The DC current direction in the coil matches the current direction arrow on the probe.
- The probe is as perpendicular as possible to the coil.

4 Set up the Agilent 33120A as follows:
- Wave shape: Sine
- Frequency: 1 kHz
- Amplitude: 500 m Vpp (the minimum value)
- Offset: +1.0 Vdc

5 Measure the current in the coil on DMM1.

The current in the coil must be $\geqq$ 10 mA. Increase the generator offset if necessary to achieve a current reading of at least 10mA in this step and record this value in Table 2.

6 Measure the voltage output by the probe on DMM2. Record this value in Table 2.

7 Do the calculations specified in Table 2 to determine if the probe passes the test.

Table 2

Probe Zero Offset Voltage (V_Z)	
Current in Coil (I_C)	
Probe Output Voltage (V_{PROBE})	
Calculate Maximum Probe Output Voltage As: $V_{PROBEMAX} = (I_C * 10 * 10\ m\ V/A * 1.04) + V_Z$	
Calculate Minimum Probe Output Voltage As: $V_{PROBEMIN} = (I_C * 10 * 10\ m\ V/A * 0.96) + V_Z$	
Probe Passes Test if: $V_{PROBEMIN} \leqq V_{PROBE} \leqq V_{PROBEMAX}$	

AC Current Measurement Accuracy Check (10 mV/A range)

1 Change the DMM modes
   - DMM1: to measure AC Amps
   - DMM2: to measure AC Volts

2 Set up the Agilent 33120A as follows
   - Wave shape: Sine
   - Frequency: 1 kHz
   - Amplitude: 5 Vpp
   - Offset: 0 Vdc

3 Measure the current in the coil on DMM1.

   The current in the coil must be ≧ 10 mA. Increase the generated amplitude if necessary to achieve a current of at least 10 mA and record the current reading in Table 3.

4 Measure the voltage output by the probe on DMM2 and record this value in Table 3.

5 Do the calculations specified in Table 3 to determine if the probe passes the test.

Table 3

Current in Coil (I_C)	
Probe Output Voltage (V_{PROBE})	
Calculate Maximum Probe Output Voltage As: $VP_{ROBEMAX} = (I_C * 10 * 10\ mV/A * 1.04)$	
Calculate Minimum Probe Output Voltage As: $V_{PROBEMIN} = (I_C * 10 * 10\ mV/A * 0.96)$	
Probe Passes Test if: $V_{PROBEMIN} \leqq V_{PROBE} \leqq V_{PROBEMAX}$	

Bandwidth Check (10 mV/A range)

1 Increase the generated frequency to 100 kHz.

2 Measure the current in the coil.

The current in the coil must be ≧ 10 mA. Increase the generated amplitude if necessary to achieve a current of at least 10 mA and record the current reading in Table 4.

3 Measure the voltage output by the probe on DMM2 and record this value in Table 4.

4 Do the calculations specified in Table 4 to determine if the probe passes the test.

Table 4

Current in Coil (I_C)	
Probe Output Voltage (V_{PROBE})	
Calculate Maximum Probe Output Voltage As: $V_{PROBEMAX} = (I_C * 10 * 10\ mV/A * 1.04)$	
Calculate Minimum Probe Output Voltage As: $V_{PROBEMIN} = (I_C * 10 * 10\ mV/A * 0.96) * 0.707$	
Probe Passes Test if: $V_{PROBEMIN} \leqq V_{PROBE} \leqq V_{PROBEMAX}$	

DC Current Measurement Accuracy Check (100 mV/A range):

1 Configure the instruments as follows:
- DMM1: to measure DC Amps
- DMM2: to measure DC Volts
- Set the probe to the 100 mV/A setting.

2 Configure DMM2 to measure DC Volts. Disconnect the probe from the coil and adjust the zero control to minimize the probe's DC output voltage. Record this zero offset voltage (V_Z) in Table 4.

3 Clamp the probe around the coil. Ensure that:
- The DC current direction in the coil matches the current direction arrow on the probe.
- The probe is as perpendicular as possible to the coil.

4 Set up the Agilent 33120A as follows:
- Wave shape: Sine
- Frequency: 1 kHz
- Amplitude: 500 mVpp (the minimum value)
- Offset: +1.0 Vdc

5 Measure the current in the coil on DMM1. Record this value in Table 5.

The current in the coil must be $\geqq$ 10mA. Increase the generator offset if necessary to achieve a current reading of at least 10 mA in this step and record this value (I_C) in Table 5

6 Measure the voltage output by the probe on DMM2. Record this value in Table 5.

7 Do the calculations specified in Table 5 to determine if the probe passes the test

Table 5.

Probe Zero Offset Voltage (V_Z)	
Current in Coil (I_C)	
Probe Output Voltage (VPROBE)	
Calculate Maximum Probe Output Voltage As: $V_{PROBEMAX} = (I_C * 10 * 100\ mV/A * 1.03) + V_Z$	
Calculate Minimum Probe Output Voltage As: $V_{PROBEMIN} = (I_C * 10 * 100\ mV/A * 0.97) + V_Z$	
Probe Passes Test if: $V_{PROBEMIN} \leqq V_{PROBE} \leqq V_{PROBEMAX}$	

AC Current Measurement Accuracy Check (100 mV/A range)

1 Change the DMM modes
   - DMM1: to measure AC Amps
   - DMM2: to measure AC Volts

2 Set up the Agilent 33120A as follows:
   - Wave shape: Sine
   - Frequency: 1 kHz
   - Amplitude: 5 Vpp
   - Offset: 0 Vdc

3 Measure the current in the coil on DMM1 and record this in Table 6.

   The current in the coil must be ≧ 10 mA. Increase the generated amplitude if necessary to achieve a current of at least 10 mA and record the current reading in Table 6.

4 Measure the voltage output by the probe on DMM2 and record this value in Table 6.

5 Do the calculations specified in Table 6 to determine if the probe passes the test.

Table 6

Current in Coil (I_C)	
Probe Output Voltage (V_{PROBE})	
Calculate Maximum Probe Output Voltage As: VPROBEMAX = (I_C * 10 * 100 mV/A * 1.03)	
Calculate Minimum Probe Output Voltage As: VPROBEMIN = (I_C * 10 * 100 mV/A * 0.97)	
Probe Passes Test if: $V_{PROBEMIN} \leqq V_{PROBE} \leqq V_{PROBEMAX}$	

Bandwidth Check (100 mV/A range)

1 Increase the generated frequency to 100 kHz.

2 Measure the current in the coil.

The current in the coil must be ≧ 10 mA. Increase the generated amplitude if necessary to achieve a current of at least 10 mA and record the current reading in Table 7.

3 Measure the voltage output by the probe on DMM2 and record this value in Table 7.

4 Do the calculations specified in Table 7 to determine if the probe passes the test.

Table 7

Current in Coil (I_C)	
Probe Output Voltage (V_{PROBE})	
Calculate Maximum Probe Output Voltage As: $V_{PROBEMAX} = (I_C * 10 * 10\ mV/A * 1.03)$	
Calculate Minimum Probe Output Voltage As: $V_{PROBEMIN} = (I_C * 10 * 100\ mV/A * 0.97) * 0.707$	
Probe Passes Test if: $V_{PROBEMIN} \leqq V_{PROBE} \leqq V_{PROBEMAX}$	

Safety Notices

This apparatus has been designed and tested in accordance with IEC Publication 1010, Safety Requirements for Measuring Apparatus, and has been supplied in a safe condition. This is a Safety Class I instrument (provided with terminal for protective earthing). Before applying power, verify that the correct safety precautions are taken (see the following warnings). In addition, note the external markings on the instrument that are described under "Safety Symbols."

Warnings

• Before turning on the instrument, you must connect the protective earth terminal of the instrument to the protective conductor of the (mains) power cord. The mains plug shall only be inserted in a socket outlet provided with a protective earth contact. You must not negate the protective action by using an extension cord (power cable) without a protective conductor (grounding). Grounding one conductor of a two-conductor outlet is not sufficient protection.

• Only fuses with the required rated current, voltage, and specified type (normal blow, time delay, etc.) should be used. Do not use repaired fuses or short-circuited fuseholders. To do so could cause a shock or fire hazard.

• If you energize this instrument by an auto transformer (for voltage reduction or mains isolation), the common terminal must be connected to the earth terminal of the power source.

• Whenever it is likely that the ground protection is impaired, you must make the instrument inoperative and secure it against any unintended operation.

• Service instructions are for trained service personnel. To avoid dangerous electric shock, do not perform any service unless qualified to do so. Do not attempt internal service or adjustment unless another person, capable of rendering first aid and resuscitation, is present.

• Do not install substitute parts or perform any unauthorized modification to the instrument.

• Capacitors inside the instrument may retain a charge even if the instrument is disconnected from its source of supply.

• Do not operate the instrument in the presence of flammable gasses or fumes. Operation of any electrical instrument in such an environment constitutes a definite safety hazard.

• Do not use the instrument in a manner not specified by the manufacturer.

To clean the instrument

If the instrument requires cleaning: (1) Remove power from the instrument. (2) Clean the external surfaces of the instrument with a soft cloth dampened with a mixture of mild detergent and water. (3) Make sure that the instrument is completely dry before reconnecting it to a power source.

Safety Symbols

Instruction manual symbol: the product is marked with this symbol when it is necessary for you to refer to the instruction manual in order to protect against damage to the product..

Hazardous voltage symbol.

Earth terminal symbol: Used to indicate a circuit common connected to grounded chassis.

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Notices

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01146-92003, May 2005

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CAUTION

A CAUTION notice denotes a hazard. It calls attention to an operating procedure, practice, or the like that, if not correctly performed or adhered to, could result in damage to the product or loss of important data. Do not proceed beyond a CAUTION notice until the indicated conditions are fully understood and met.

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