

## **Agilent 1146B AC/DC Current Probe**



*User's Guide*

# Manual Part Number

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## Notices

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Agilent Technologies, Inc

Oscilloscope Products Division

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## 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."

**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.

**WARNING.** A **WARNING** 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 personal injury or death. Do not proceed beyond a **WARNING** notice until the indicated conditions are fully understood and met.



**CAUTION.** Risk of Danger. Refer to the manual for more information.



**CAUTION.** Risk of Electric Shock. Refer to the manual for more information.



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

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## Operation

The 1146B 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.

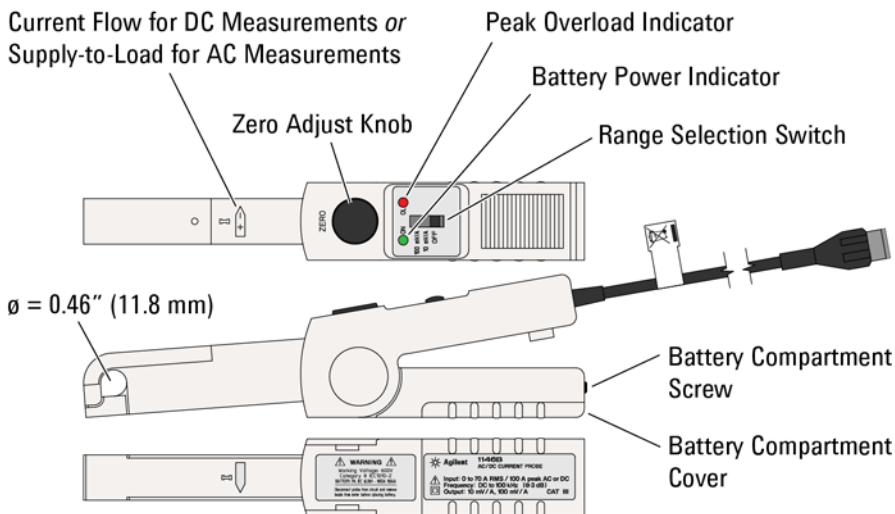
The 1146B probe is compatible with any analog or digital oscilloscope or other voltage measuring instrument which has the following features:

- BNC input connector.
- Range capable of displaying 0.2V to 0.5V per division.
- Minimum input impedance of 1 M $\Omega$ .

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### Before Using the Probe

- Install the battery that was shipped with the probe. Refer to “[To Install the Battery](#)” on page 6.
- Read the warnings listed under “[Safety](#)” on page 8.
- Confirm that the probe has not been damaged in transit. If the unit is damaged, or fails to operate according to the specifications, contact your dealer or Agilent representative.
- Check that the contents of the shipment 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.



**Figure 1 Control and Connector Identification**

**Zero-Adjust Knob.** Use the zero adjust knob to eliminate the probe's offset before performing a measurement.

**Battery Power Indicator.** To ensure proper readings with your current probe, be sure that the green battery indicator is lit during measurement. If not, replace the 9V battery as described in “[To Install the Battery](#)” on page 6.

**Peak Overload (OL) Indicator.** If the red Peak Overload indicator illuminates during measurement, this indicates that the peak value exceeds the instrument response level and that the output is distorted. Use the range selection switch to change the probe to a higher range, if possible.

**Range Selection Switch.** Use the range selection switch to turn the probe OFF and to select from two ranges: 10 mV/A and 100 mV/A.

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**WARNING** It is possible to change the current probe's range without removing the probe from the current carrying conductor, but never exceed the permissible peak ratings of 1000 mV peak or 2000 mV peak-to-peak maximum. The peak ratings by range are: 10A peak on the 100 mV/A range, 100A peak on the 10 mV/A range.

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## To Install the Battery

Before using the probe for the first time, you must install the battery. 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.

---

**WARNING** Do not replace the battery while probe is in use.

- 2 Set the probe's switch to the OFF position.
- 3 Unscrew the battery compartment screw (shown on [Figure 1 on page 5](#)) and pull out the battery compartment cover.
- 4 Install the new 9V battery and put the cover back on.

---

## To Perform a Current Measurement

- 1 Read the warnings in “Safety” on page 8.
- 2 Connect the current probe to an input channel on the oscilloscope.

---

**WARNING** Connect the probe to the oscilloscope or voltage measuring instrument before clamping the probe around a conductor.

- 3 Set the current probe to its least sensitive range (10 mV/A).
- 4 Select the 0.5 V/division range on the oscilloscope.
- 5 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).

---

**WARNING** It is possible to change the range on the current probe without removing the probe from the current carrying conductor, but never exceed the permissible peak ratings of 1000 mV peak or 2000 mV peak-to-peak maximum. The peak ratings by range are: 10A peak on the 100 mV/A range, 100A peak on the 10 mV/A range.

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## To Clean the Probe

- 1 Remove the probe from any circuit under test and from the oscilloscope.
- 2 Clean the external surfaces of the probe with a soft cloth dampened with a mixture of mild detergent and water.
- 3 Clean the mating surfaces of the probe's jaws so that they are free of dirt or foreign matter. If rust is present, gently clean the mating surfaces with a soft cloth that has been lightly oiled with standard machine oil. Do not leave excessive oil residue.

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**WARNING** Make sure that the probe is completely dry before reconnecting it to a power source.

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## Product Markings



This symbol indicates the Environmental Protection Use Period (EPUP) for the product's toxic substances for the China RoHS requirements.



The CE symbol indicates the European Community.



CAUTION. Risk of Danger. Refer to the manual for more information.



CAUTION. Risk of Electric Shock. Refer to the manual for more information.



This symbol signifies that the probe is protected by double or reinforced insulation. Only use specified replacement parts when servicing the probe.



WEEE Directive notice. This marking is on a notice sticker and is not actually fixed to the product.

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# Safety



This manual provides information and warnings essential for operating this probe in a safe manner and for maintaining it in safe operating condition. Before using this equipment and to ensure safe operation and to obtain maximum performance from the probe, carefully read and observe the following warnings, cautions, and notes.

This apparatus has been designed and tested in accordance with IEC61010, Safety Requirements for Measuring Apparatus, and has been supplied in a safe condition. Note the external markings on the instrument that are described in this document.

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**WARNING** Connect the probe to the oscilloscope or voltage measuring instrument before clamping the probe around a conductor.

---

**WARNING** 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.

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**WARNING** Never leave the probe clamped around a conductor while it is not connected to an oscilloscope or voltage measuring instrument.

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**WARNING** Carefully center the conductor inside the probe jaws and ascertain that the probe is perpendicular to the conductor before closing the jaws.

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**WARNING** Check the magnetic mating surfaces of the probe jaws; these should be free of dirt, rust, or other foreign matter

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**WARNING** Do not use a probe which is cracked, damaged or has defective leads.

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**WARNING** Avoid, if possible, the proximity of other conductors which may create noise.

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**WARNING** Do not install substitute parts or perform any unauthorized modification to the probe.

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**WARNING** Do not clamp the probe on a bare/un-insulated conductor.

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

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**WARNING** Do not use the probe or oscilloscope in a manner not specified by the manufacturer.

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**WARNING** 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.

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## Concerning the Oscilloscope or Voltage Measuring Instrument to Which the Probe is Connected

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

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**WARNING** If you energize the instrument by an auto transformer (for voltage reduction or mains isolation), the ground pin of the input connector terminal must be connected to the earth terminal of the power source.

---

**WARNING** 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.

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**WARNING** 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.

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

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# Specifications

All probe specifications are warranted based on the following conditions:

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

**Table 1 Specifications**

Item	Specification	
<b>Measurement Accuracy (Input Current: dc to 1 kHz)</b>	<b>100 mV/A Sensitivity Setting</b>	<b>10 mV/A Sensitivity Setting</b>
50 mA to 10A	< ±3% of reading ±50 mA	—
50 mA to 40A	n/a	< ±4% of reading ±50 mA
40A to 100A	n/a	< ±15% of reading ±100 mA
<b>Bandwidth</b>		
-3 dB	dc to 100 kHz (with derating, see “Typical Response Curves” on page 13)	

# 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 humidity
- Probe zeroed
- 1 minute warm up
- Battery at 9V ± 0.1V

- External magnetic field < 40 A/m
- No adjacent current carrying conductor
- 1 M $\Omega$  /100 pF probe termination
- Conductor centered in jaw

**Table 2 Characteristics**

Item	100 mV/A Sensitivity Setting	10 mV/A Sensitivity Setting
Current Measurement Range	0A to 10A dc or peak ac	0A to 100A dc or peak ac
Phase Shift (DC to 1 kHz, no DC component)	< 1.5° dc to 65 Hz	< 1.0° dc to 65 Hz
Noise	3 mV	480 $\mu$ V
Slew Rate	0.3 V/ $\mu$ s	20 mV/ $\mu$ s
Insertion Impedance (50 Hz/60 Hz)	0.01 $\Omega$	0.01 $\Omega$
Rise or Fall Time	3 $\mu$ s	4 $\mu$ s
Influence of Adjacent Conductor	<0.2 mA/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	

**Table 3 Environmental and Mechanical Characteristics (Sheet 1 of 2)**

Item	Characteristic
<b>Environmental Conditions</b>	
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 2000m Non operating: 0 to 12,000m
Indoor Use	This probe is rated for indoor use only
<b>Mechanical</b>	
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 61010
Mechanical Shock	100 G; test per IEC 68-2-27

## Characteristics

**Table 3 Environmental and Mechanical Characteristics (Sheet 2 of 2)**

Item	Characteristic
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	231 mm x 36 mm x 67 mm
Weight	330 g (11.6 oz) with battery
Color	Light gray
Output cable	Insulated coaxial cable with insulated BNC connector
Output cable length	2m

**Table 4 Battery Characteristics**

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

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## Safety Standards

- Double insulation or reinforced insulation between primary or secondary and outer case of the handle, per IEC61010.
- 600V Category III, Pollution degree 2.
- 300V Category IV, Pollution degree 2.
- 5550V 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

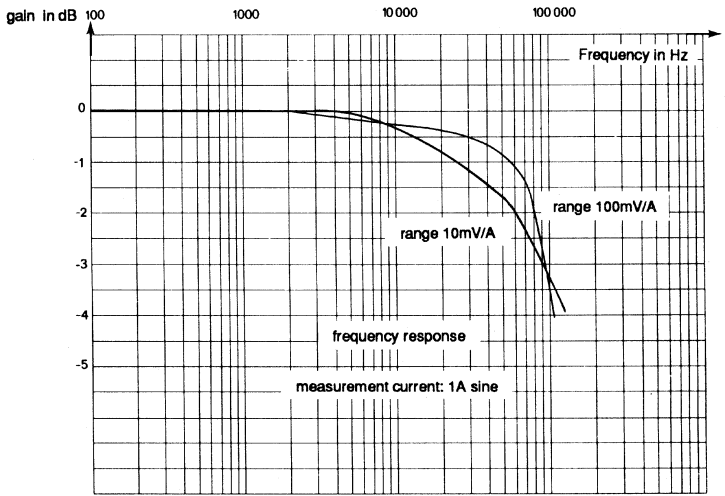


Figure 2 Typical Frequency Response Curve

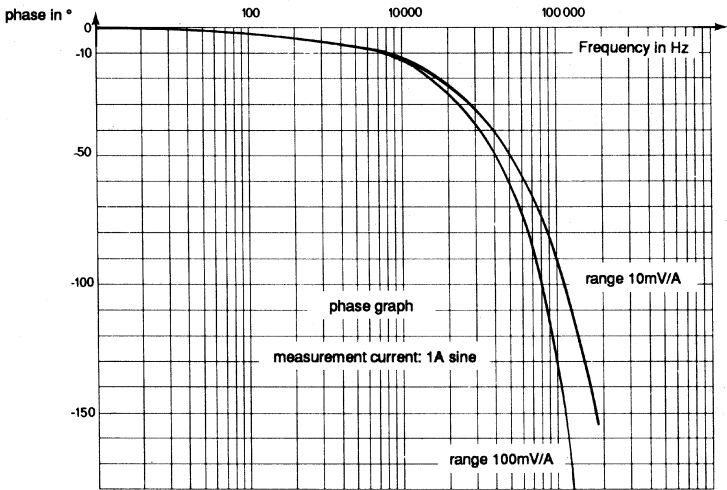
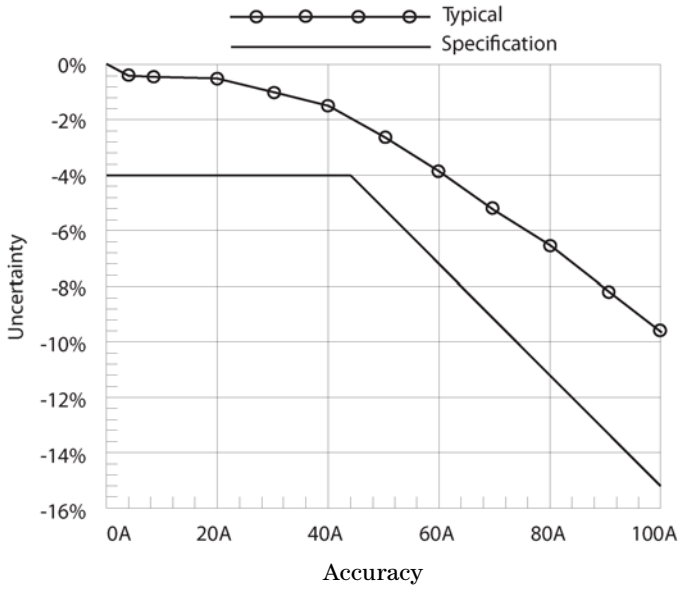


Figure 3 Typical Phase Shift Response Curve

# Characteristics



**Figure 4** Linearity for a DC Signal Range 10 mV/A

## Performance Verification

To ensure that the probe complies with the factory specifications, perform the six tests in this section in the order listed. Connect the required equipment listed in [Table 5](#) as shown in [Figure 6](#) on page 16.

**NOTE** Allow 30 minutes for warm up before starting the tests. While the test system is warming up, clean the magnetic contacts on the probe's jaw.

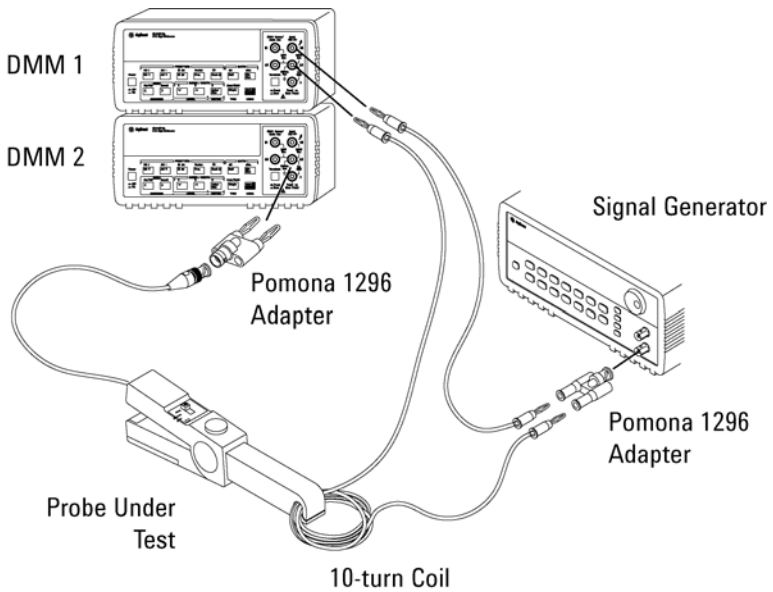
**Table 5 Required Equipment for Performance Verification Tests**

Description	Critical Specifications	Recommended Model/Part Numbers
Digital Multimeter (2 required)	AC/DC voltage and current measurement accuracy better than $\pm 0.1\%$ of reading Input resistance in AC/DC voltage mode $\geq 1M\Omega$	Agilent 34401A or Agilent 3458A
Signal Generator	DC to 100 kHz sine waves Able to generate more than 10 mA in the test coil (e.g. an inductive load).	Agilent 33120A or Fluke 5500A
Patch Cable Assembly	Banana plug connectors Length $\leq 36$ in (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)

Construct a 10-turn coil with a diameter of about 4 inches (10 cm) as shown in [Figure 5](#). Use wire wrap or transformer wire and attach stackable banana plugs to the coil for connection to the instruments during testing.



**Figure 5 10 Turn Coil**



**Figure 6** Equipment Setup

---

### **If the Probe Fails a Test**

- 1** Replace the battery. Verify that the battery voltage is  $9V \pm 0.1V$ .
- 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.



---

## Test 1. DC Current Measurement Accuracy (10 mV/A range)

- 1 Configure the instruments as follows:

DMM 1: ..... DC Amps  
 DMM 2: ..... DC Volts  
 Probe's Range Selector Switch ..... 10 mV/A

- 2 Disconnect the probe from the coil and adjust the zero control to minimize the probe's DC output voltage. Record this zero offset voltage ( $V_2$ ) in Table 6 on page 18.
- 3 Clamp the probe around the coil.

---

**NOTE** Ensure that the DC current direction in the coil matches the current direction arrow on the probe. Position the probe as perpendicular as possible to the coil.

---

- 4 Set up the Agilent 33120A as follows:

Waveform: ..... Sine  
 Frequency: ..... 1 kHz  
 Amplitude: ..... 500 mVpp (*minimum*)  
 Offset: ..... +1.0 Vdc

- 5 Measure the current in the coil on DMM 1 and record this value ( $I_C$ ) in Table 4.

---

**NOTE** The current in the coil must be  $\geq 10$  mA. Increase the generator offset if necessary to achieve a current reading of at least 10 mA.

---

- 6 Measure the voltage output by the probe on DMM 2 and record ( $V_{\text{PROBE}}$ ) in Table 6.
- 7 Do the calculations specified in Table 6 to determine if the probe passes the test.

**Table 6 DC Current Measurement Accuracy Record (10 mV/A range)**

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

## Test 2. AC Current Measurement Accuracy (10 mV/A range)

- 8 Set the DMM modes to:

DMM 1: ..... AC Amps

DMM 2: ..... AC Volts

- 9 Set the Agilent 33120A to:

Waveform: ..... Sine

Frequency: ..... 1 kHz

Amplitude: ..... 5 Vpp

Offset: ..... 0 Vdc

- 10 Measure the current ( $I_C$ ) in the coil on DMM 1 and record in [Table 7](#).

**NOTE** The current in the coil must be  $\geq 10$  mA. Increase the generated amplitude if necessary to achieve a current of at least 10 mA.

- 11 Measure the voltage output by the probe ( $V_{PROBE}$ ) on DMM 2 and record in [Table 7](#).
- 12 Do the calculations specified in [Table 7](#) to determine if the probe passes the test.

**Table 7 AC Current Measurement Accuracy Record (10 mV/A range)**

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

### Test 3. Bandwidth (10 mV/A range)

- 13** Increase the generated frequency to 100 kHz.
- 14** Measure the current in the coil ( $I_C$ ) and record in [Table 8](#).

**NOTE** The current in the coil must be  $\geq 10$  mA. Increase the generated amplitude if necessary to achieve a current of at least 10 mA.

- 15** Measure the voltage output ( $V_{PROBE}$ ) by the probe on DMM 2 and record in [Table 8](#) on [page 19](#).
- 16** Do the calculations specified in [Table 8](#) to determine if the probe passes the test.

**Table 8 Bandwidth Record (10 mV/A range)**

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

---

## Test 4. DC Current Measurement Accuracy (100 mV/A range)

17 Configure the instruments as follows:

DMM 1: ..... DC Amps  
DMM 2: ..... DC Volts  
Probe's Range Selector Switch ..... 100 mV/A

18 Disconnect the probe from the coil and adjust the zero control to minimize the probe's DC output voltage. Record this zero offset voltage ( $V_2$ ) in [Table 9 on page 21](#).

19 Clamp the probe around the coil.

---

**NOTE** Ensure that the DC current direction in the coil matches the current direction arrow on the probe. Position the probe as perpendicular as possible to the coil.

---

20 Set up the Agilent 33120A as follows:

Waveform: ..... Sine  
Frequency: ..... 1 kHz  
Amplitude: ..... 500 mVpp (*minimum*)  
Offset: ..... +1.0 Vdc

21 Measure the current in the coil on DMM 1. Record this value ( $I_c$ ) in [Table 9](#).

---

**NOTE** The current in the coil must be  $\geq 10$ mA. Increase the generator offset if necessary to achieve a current reading of at least 10 mA.

---

22 Measure the voltage output ( $V_{\text{PROBE}}$ ) by the probe on DMM 2, and record in [Table 9](#).

23 Do the calculations specified in [Table 9](#) to determine if the probe passes the test.

**Table 9 DC Current Measurement Accuracy Record (100 mV/A range)**

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

## Test 5. AC Current Measurement Accuracy (100 mV/A range)

**24** Change the DMM settings to:

DMM 1: ..... AC Amps  
DMM 2: ..... AC Volts

**25** Set up the Agilent 33120A settings to:

Waveform: ..... Sine  
Frequency: ..... 1 kHz  
Amplitude: ..... 5 Vpp  
Offset: ..... 0 Vdc

**26** Measure the current in the coil ( $I_C$ ) on DMM 1 and record this in Table 10 on page 22.

**NOTE** The current in the coil must be  $\geq 10$  mA. Increase the generated amplitude if necessary to achieve a current of at least 10 mA.

**27** Measure the voltage output ( $V_{PROBE}$ ) by the probe on DMM 2, and record in Table 10.

**28** Do the calculations specified in Table 10 to determine if the probe passes the test.

**Table 10 AC Current Measurement Accuracy Record (100 mV/A range)**

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

### Test 6. Bandwidth Check (100 mV/A range)

**29** Increase the generated frequency to 100 kHz.

**30** Measure the current in the coil ( $I_C$ ) and record the current reading in [Table 11](#).

**NOTE** The current in the coil must be  $\geq 10$  mA. Increase the generated amplitude if necessary to achieve a current of at least 10 mA.

**31** Measure the voltage output ( $V_{PROBE}$ ) by the probe on DMM 2, and record in [Table 11](#).

**32** Do the calculations specified in [Table 11](#) to determine if the probe passes the test.

**Table 11 Bandwidth Record (100 mV/A range)**

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

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