RIGOL

User's Guide

RP1003C/RP1004C/RP1005C
Current Probe

Apr. 2016
RIGOL TECHNOLOGIES, INC.

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Publication Number

UGE19105-1110

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If you have any problem or requirement when using our products or this manual, please contact **RIGOL**.

E-mail: service@rigol.com

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General Safety Summary

⚠CAUTION
This device is designed to comply with IEC 61010 Safety Standards, and has been thoroughly tested for safety prior to shipment. However, mishandling during use could result in injury or death, as well as damage to the device. Be certain that you understand the instructions and precautions in the manual before use.

Safety Terms and Symbols

Before using the device, be sure to carefully read the following safety notes.

	The ⚠ symbol printed on the device indicates that the user should refer to a corresponding topic in the manual (marked with the ⚠ symbol) before using the relevant function. In the manual, the ⚠ symbol indicates particularly important information that the user should read before using the device.
	The ⊗ symbol printed on the device indicates that only insulated conductors suited to the voltage of the circuit under test can be measured.

The following symbols in this manual indicate the relative importance of cautions and warnings.

⚠DANGER	Indicates that incorrect operation presents an extreme hazard that could result in serious injury or death to the user.
⚠WARNING	Indicates that incorrect operation presents a significant hazard that could result in serious injury or death to the user.
⚠CAUTION	Indicates that incorrect operation presents a possibility of injury to the user or damage to the device.
NOTE	Indicates advisory items related to performance or correct operation of the device.

Contents

Safety Precautions

⚠DANGER

1. Do not measure around a bare conductor. Doing so may result in short-circuit or electric shock. Take measurements at a location on an insulated wire where there is sufficient insulation for the circuit voltage.

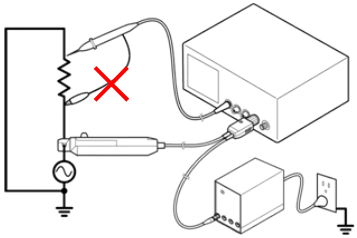
2. Refer to Appendix 2 Relation between Max Input Current and Frequency when measuring current that includes a high frequency component and never measure any current that exceeds the rated current.

3. Using the device in strong high-frequency magnetic fields may cause the device to become abnormally hot, resulting in fire, equipment damage, or burns (see Specifications).

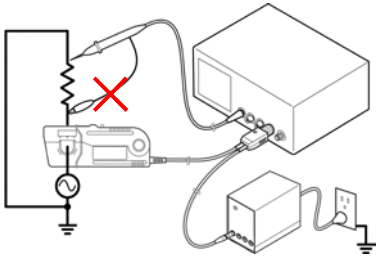
4. Observe the following to avoid electric shock and short circuits.
   1) Connect the device to the Power Supply and waveform measurement instrument first, and then to the active lines to be measured.
   2) When the sensor is opened, do not short circuit the conductor being measured.
   3) Be careful to avoid damaging the insulation surface while taking measurements.
   4) Before clamping the conductor being measured, make sure that the insulation on the conductor is undamaged. Also, take care not to damage the insulation when clamping the conductor. Any damage to the insulation could cause an electric shock.
   5) This device is made for use with the RP1000P power supply.
   6) To prevent fire or damage of the measurement target and device as well as burns, exercise caution concerning the following when measuring high-frequency currents or currents that contain high-frequency components:
      - ✧ Eddy current loss may cause heating of the sensor head.
      - ✧ Dielectric heating may cause heating of cord insulation and other materials.
   7) This device should only be connected to the secondary side of a breaker, so the breaker can prevent an accident if a short circuit occurs. Connections should never be made to the primary side of a breaker, because unrestricted current flow could cause a serious accident if a short circuit occurs.

8) Be sure to observe all operating precautions for the waveform monitoring instrument and other measurement instruments to which this device is connected.

9) When using a measurement instrument that does not provide isolation between its input terminals and chassis or other input terminals, please pay attention to the following points. If a signal is applied to an input terminal other than that to which this device is connected, do not connect the ground-side terminal to any non-ground potential. Otherwise, short-circuit current will flow through the RP1000P, or this device from the ground terminal, which could cause an electrical accident or damage.



RP1003C/RP1004C



RP1005C

⚠WARNING

1. Do not allow the device to get wet, and do not take measurements with wet hands. This may cause an electric shock.

2. Do not press the demagnetizing switch (DEMAG) to perform demagnetization while the conductor being measured is clamped. Doing so could damage the circuitry or cause an accident that might result in injury or death.

3. Ensure that the input does not exceed the maximum rated current to

avoid device damage, short-circuiting and electric shock resulting from heat building.

4. To avoid electric shock when measuring live lines, wear appropriate protective gear, such as insulated rubber gloves, boots and a safety helmet.

⚠CAUTION

1. To avoid damage to the device, protect it from vibration or shock during transport and handling, and be especially careful to avoid dropping.

2. This device should be installed and operated indoors only, between 0°C and 40°C and 80% RH or less.

3. Do not store or use the device where it could be exposed to direct sunlight, high temperature, humidity, or condensation. Under such conditions, the device may be damaged and insulation may deteriorate so that it no longer meets specifications.

4. This device is not designed to be entirely water-proof or dust-proof. To avoid damage, do not use it in a wet or dusty environment.

5. The sensor head is a precision assembly including a molded component, a ferrite core, and a Hall effect element. It may be damaged if subjected to sudden changes in ambient temperature, or mechanical strain or shock, and therefore great care should be exercised in handling it.

6. The matching surfaces of the sensor head are precision ground, and should be treated with care. If these surfaces are scratched, performance may be impaired.

7. Measurements are degraded by dirt on the mating surfaces of the sensor head, so keep the surfaces clean by gently wiping with a soft cloth.

8. Foreign substances such as dust on the contact surfaces of the sensor head can cause acoustic resonance (refer to the introduction about resonant soundresonant sound) and degrade measurement, so it should be cleaned by gently wiping with a soft cloth.

9. To avoid damaging the sensor cable and power supply cable, do not bend or pull the cables.

10. Do not apply a static electricity or other source of high voltage to the sensor. Doing so may damage its internal Hall elements and circuitry.

11. To clean the device, wipe it gently with a soft cloth moistened with water or mild detergent. Never use solvents such as benzene, alcohol, acetone, ether, ketones, thinners or gasoline, as they can deform and discolor the case.

12. When the power is on, keep closed, except when clamping them onto the conductor to be measured. The facing surface of the core section can be scratched while it is open.

13. Keep the sensor head closed when not in use, to avoid accumulating dust or dirt on the mating core surfaces, which could interfere with clamp performance.

14. Avoid stepping on or pinching the cable, which could damage the cable insulation.

15. Keep the cables well away from heat sources, as bare conductors could be exposed if the insulation melts.

NOTE

Correct measurement may be impossible in the presence of strong magnetic fields, such as near transformers and high-current conductors, or in the presence of strong electromagnetic fields such as near radio transmitters.

Service

When sending the device for repair, pack carefully to prevent damage in transit. Include cushioning material so the device cannot move within the package. Be sure to include details of the problem. **RIGOL** cannot be responsible for damage that occurs during shipment.

Periodic calibration is necessary in order to ensure that the device provides correct measurement results of the specified accuracy. If you need to calibrate the current probe, contact **RIGOL**.

Current Probe Overview

This device can be directly connected to a BNC input connector of a waveform measuring instrument, and by clamping on a conductor to be measured, allows the current waveform to be easily captured.

Main Features:

- Highly accurate current detection
- Easy current measurement
- Broadband frequency characteristics
  RP1003C: DC to 50MHz
  RP1004C: DC to 100MHz
  RP1005C: DC to 10MHz
- RP1003C/RP1004C: Compact design, permits measurement of low current levels
- RP1005C: Large diameter allows high-current measurements
- Easy protect function at excessive input
- Unique thin film Hall effect element

RP1003C/RP1004C Parts Overview

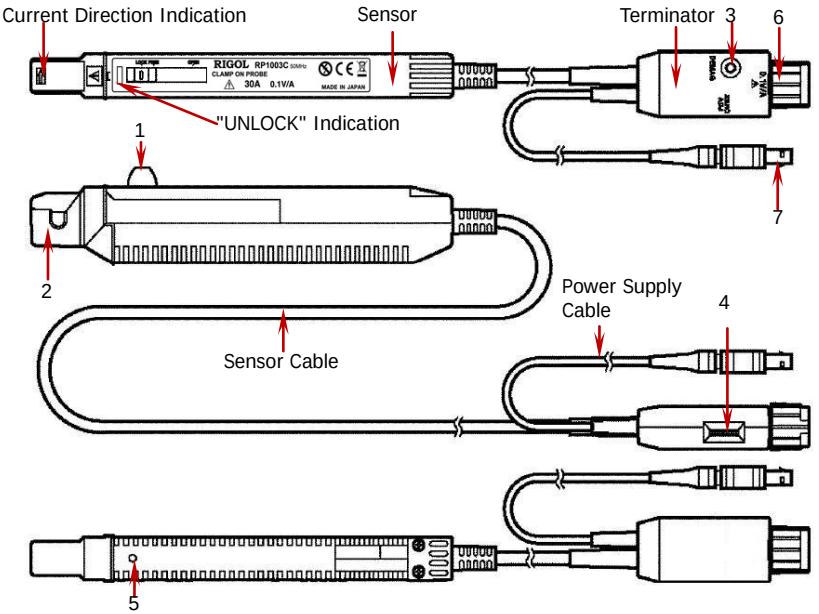


Figure 1 RP1003C/RP1004C Parts

For the parts from 1 to 7 noted in the above figure, please refer to Parts Introductions.

RP1005C Parts Overview

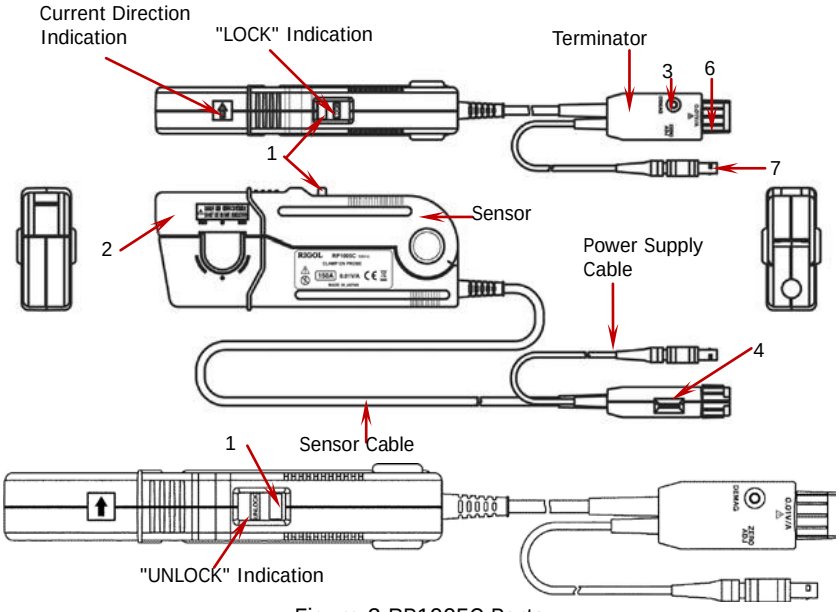


Figure 2 RP1005C Parts

For the parts from 1 to 7 noted in the above figure, please refer to Parts Introductions.

Parts Introductions

1. Opening lever

   It is used to open and lock the current sensor. You are recommended to lock the current sensor when measuring the conductor to be measured to avoid danger.

   For RP1003C/RP1004C, there are OPEN, FREE and LOCK indications on one side of the slide switch. The on/off status of the current sensor is related to the position of the slide switch.

   - ✧ When the slide switch is at the OPEN position, the current sensor is open and at this point, the conductor to be measured can be connected to the current sensor;
   - ✧ When the slide switch is at the FREE position, the current sensor is closed but not locked;
   - ✧ When the slide switch is at the LOCK position, the current sensor is locked and at this point, the UNLOCK indication is covered (cannot be seen).

   For RP1005C, there are LOCK and UNLOCK indications on the slide switch. The current sensor is locked when the LOCK indication is displayed on the slide switch (the UNLOCK indication disappears).

2. Sensor head

   This clamps the conductor being measured, and carries out the actual current measurement. It is a precision assembly including a molded component, a ferrite core, and a Hall effect element. It may be damaged if subjected to sudden changes in ambient temperature, or mechanical strain or shock, and therefore great care should be exercised in handling it.

3. Demagnetizing switch (DEMAG)

   This demagnetizes the core if it has been magnetized by switching the power on and off, or by an excessive input. Always carry out demagnetizing before measurement.

   The demagnetizing process takes about one second (RP1003C/RP1004C) or three seconds (RP1005C).

   During demagnetizing, a demagnetizing waveform is output.

4. Zero adjustment dial (ZERO ADJ)

   Use the zero adjustment dial to correct for the effect of a voltage offset or temperature drift on the device. When beginning measurement, after demagnetizing always carry out zero adjustment.

5. Coarse adjustment trimmer (Only for RP1003C/RP1004C)
   Use this only when adjustment is not possible within the range of the zero adjustment dial. Use a nonconductive screwdriver (e.g. ceramic driver) for adjustment.

6. Output connector
   The current waveform of the measured conductor is output at a constant rate. Connect to the BNC input connector of the waveform measuring instrument.
   Note:
   - Since the output resistance is 25Ω (RP1003C/RP1004C) or 7Ω (RP1005C), the device must be used with a waveform measurement instrument that has an input impedance of at least 1 MΩ. Accurate measurement is not possible with waveform measurement instruments that have an input resistance of 50Ω.
   - If using BNC-banana plug adapters or similar to connect to input terminals other than BNC connectors, make sure the polarity is correct.
   - Turn the collar until it clicks, and check that it is locked securely.

7. Power plug
   Connect this to the power supply receptacle to supply power to the sensor terminator.

To Use the Current Probe

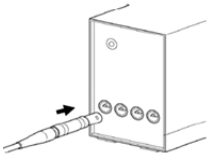
Before using the current probe, make sure to refer to Safety Precautions.

Preparations for Measurement

1. Have the RP1000P power supply and waveform measurement instrument for waveform measurement ready.
   ⚠CAUTION
   Before turning the device on, make sure the source voltage matches that indicated on the rear panel of the RP1000P. Connection to an improper supply voltage may damage the RP1000P and present an electrical hazard.

2. Turn the power switch off and connect the power cord.

3. Connect the power plug of the current probe to the power receptacle of the RP1000P.



4. Turn the RP1000P power switch on, and check that the front panel power indicator lights up.

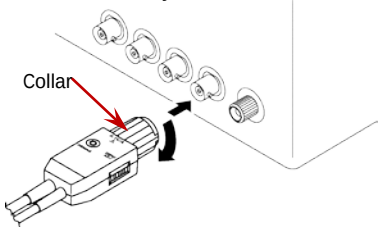
5. Wait at least 30 minutes after turning on the device. Immediately after power is supplied, offset drift may increase due to the effects of self-heating of the device and other factors. To ensure accurate measurement, wait at least 30 minutes after turning on the device before performing measurement.

Demagnetizing and Zero Adjustment

1. With the waveform measurement instrument input at ground, adjust the trace to the zero position.

2. Set the input coupling of the waveform measurement instrument to DC.

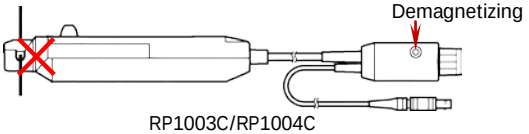
3. Connect the output connector of the current probe to the input connector of the waveform measurement instrument. Turn the collar until it clicks, and check that it is locked securely.



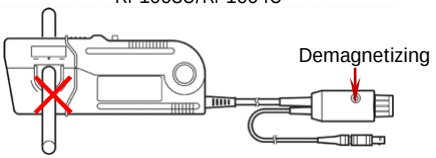
⚠CAUTION

- When disconnecting the output connector, be sure to release the lock before pulling off the connector. Forcibly pulling the connector without releasing the lock, or pulling on the cable, can damage the terminator.

- If using BNC-banana plug adapters or similar to connect to input terminals other than BNC connectors, make sure the polarity is correct.
- Do not demagnetize while the current probe is clamping a conductor to be measured. Demagnetizing causes current to flow into the conductor, which may damage parts in the circuit to be measured.



RP1003C/RP1004C



RP1005C

- Check that the conductor being measured is not clamped when supplying power to the current probe for the same reason. Demagnetized waveforms are generated when supplying electric power.

4. Make sure the current sensor is locked (for RP1003C and RP1004C, the slide switch should be at the LOCK position; for RP1005C, LOCK should be displayed on the slide switch and UNLOCK should disappear).

5. Press the demagnetizing switch (DEMAG) on the terminator.

6. Turn the zero adjustment dial on the terminator, to adjust the trace to the zero position.

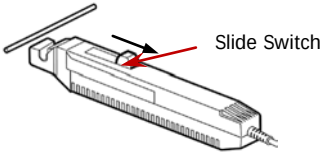
   NOTE

   For RP1003C/RP1004C, if zero adjustment is not possible in step 6, turn the coarse adjustment trimmer to bring the trace within the range of adjustment by the zero adjustment dial. While turning the coarse adjustment trimmer, do not subject it to a thrust. Doing so may cause the trimmer to come off. To turn the trimmer, use a screwdriver with the following flat blade made of a non-conductive material including ceramic: 0.4 mm in thickness, 1.8 mm in width, and 10 mm in length or longer.

Measurement Procedure

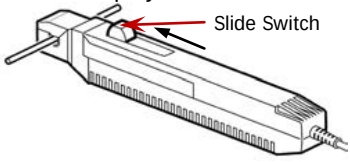
1. Check that the system is safe, and that the preparations described in the preceding section have been carried out.

2. Open the current sensor by pushing the slide switch in the direction of the arrow as shown in the figure below (for RP1003C/RP1004C, the slide switch should be at the OPEN position; for RP1005C, UNLOCK should be displayed on the slide switch and LOCK should disappear).



3. Align the sensor so that the current direction indication corresponds to the direction of current flow through the conductor to be measured, and clamp so that the conductor is in the center of the sensor aperture.

4. Lock the current sensor by pushing the slide switch in the direction of the arrow as shown in the figure below (for RP1003C/RP1004C, the slide switch should be at the LOCK position; for RP1005C, you need to first press the current probe to close the current sensor and then push the slide switch until LOCK is displayed and UNLOCK disappears).

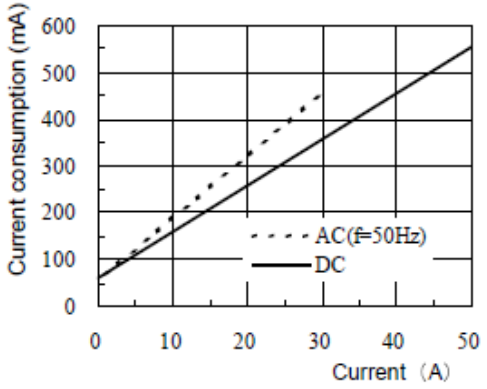


5. It is now possible to monitor the current waveform. The output rate is 0.1 V/A for RP1003C/RP1004C and 0.01V/A for RP1005C. The current sensitivity can be derived from the voltage sensitivity of the waveform measurement instrument. For example, for RP1003C, if the voltage sensitivity is 10mV/div, the current sensitivity is (10mV/div)/(0.1V/A)=100mA/div.

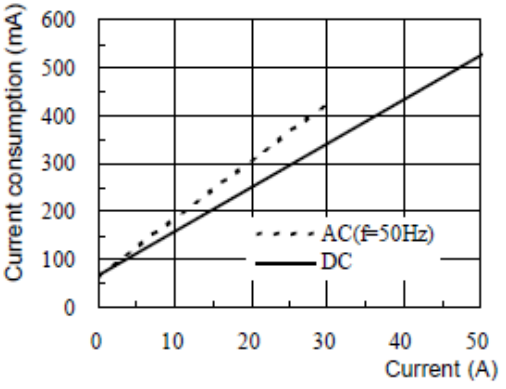
NOTE

- When using the current probes, note that two clamp-on probes may not be used simultaneously with the RP1000P, depending on the current to be measured.

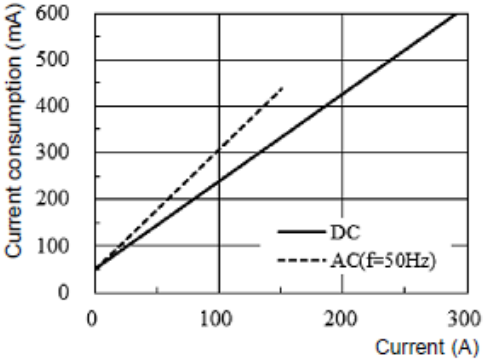
- The current consumption of the current probe depends on the current to be measured. Make sure that the total current consumption of the current probes do not exceed the rated output current of the power supply when multiple current probes are connected to the same power supply. The figure below is the relation curve between the output current and current consumption.



RP1003C



RP1004C



RP1005C

Note: The current consumption is the algebraic sum of the positive and negative current consumption.

Precautions for Measurement

⚠CAUTION

1. The maximum continuous input range is based on the heat that is internally generated during the measurement. Never input current in excess of this level. Exceeding the rated level may result in damage to the probe.

2. The device may sustain damage from self-heating even at current levels that are lower than the maximum current value defined by the maximum rated current.
   The maximum rated current is a recommended value that assumes sine-wave input under standard conditions. Self-heating may increase if the ambient temperature increases or the measurement current waveform contains other frequency components. Refer to Appendix 2 Relation between Max Input Current and Frequency.

3. If excess current is input, generated heat activates a built-in safety function that blocks normal output. If this happens, remove the input immediately (remove the sensor from the conductor being measured, or reduce the input current to zero). Wait until the sensor has had sufficient time to cool before resuming operation.

4. Heating generated during measurement of currents with a frequency of 1 kHz or higher is mainly attributed to the self-heating of the sensor heads. In this case, the built-in safety function will not be activated. Be careful to avoid accidents, such as a burn by heat, short-circuit, and damage to the sensor.

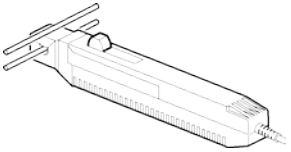
5. Even if the input current does not exceed the rated continuous maximum, continuous input for an extended period of time may result in activation of the safety circuit to prevent damage resulting from heating of the sensor.

6. At high ambient temperatures, the built-in safety circuit may activate at current input levels below the rated continuous maximum.

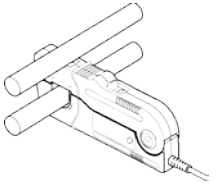
7. Continuous input of current exceeding the rated maximum or repeated activation of the safety function may result in damage to the device.

8. The maximum input range is indicated by the Maximum Continuous Input Range. It is also indicated by another product specification Maximum Peak Current Value. Make sure that the input does not exceed the continuous maximum input range in rms.

9. Do not place any unclamped conductor with an electric current of a frequency of 10kHz or higher near the sensor head. Current flowing in the conductor nearby may heat up the sensor head and cause its temperature to rise, leading to damage to the sensor.

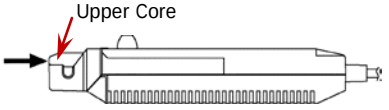


RP1003C/RP1004C



RP1005C

10. When opening the sensor head of the probe, be sure to operate with the opening lever. For RP1003C/RP1004C, if an upper core is forced to open, when the sensor head is locked, the open-close mechanism can be damaged.



NOTE

1. Immediately after powering on, this device may be subject to an appreciable offset drift due to the effect of self-heating. To counteract this, allow the device to warm up for about 30 minutes before carrying out measurement.

2. When performing continuous measurements, it is necessary to be aware that the offset voltage drifts, depending on factors such as the ambient temperature.

3. Under certain circumstances, oscillation may occur if the probe is connected to the power supply while the power supply is on. This does not indicate a malfunction. Oscillation can be stopped and operation restored to normal by opening and closing the clamp.

4. Depending on the amplitude and frequency of the current being measured, the sensor head may emit a resonant sound. This sound may also occur during demagnetizing operation, but it does not represent a malfunction (device failure).

5. If foreign matter becomes adhered to the facing surfaces on the sensor head so that a slight gap exists between the upper and lower sensors, the sensor head may emit a resonant sound. Any foreign matter should be removed using the cleaning method described in this manual.

6. An increase in the volume of the resonant sound during use may indicate that the gap between the upper and lower sensors has increased in size. Since the sensor characteristics may change, it is recommended to calibrate the device.

7. Pressing the demagnetizing switch (DEMAG) will cause a demagnetized waveform to be output from the instrument. Although it may be asymmetry with respect to the zero-volt line, the instrument has no malfunction.

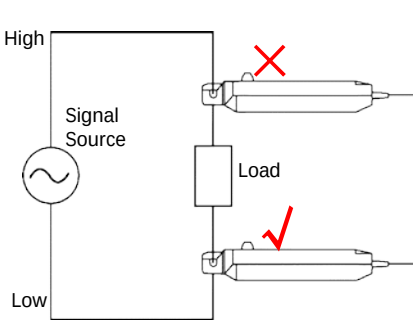
8. The reading may be affected by the position within the clamp aperture of the conductor being measured. The conductor should be in the center of the clamp aperture.

9. When carrying out measurement, make sure the sensor head is locked (for RP1003C/RP1004C, the slide switch should be at the LOCK position; for RP1005C, press the slider on the sensor head until the "UNLOCK"

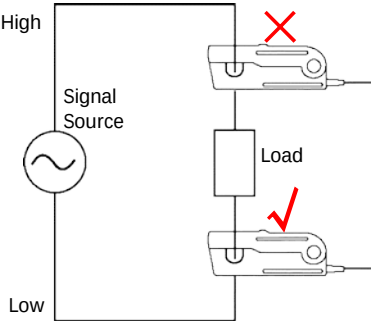
indication disappears, and hold it until LOCK appears). If the sensor head is not properly closed, accurate measurement will not be possible.

10. Accurate measurement may be impossible in locations subject to strong external magnetic fields, such as transformers and high current conductors, or in locations subject to strong external electric fields, such as radio transmission equipment.

11. At high frequencies, common mode noise may affect measurements taken on the high voltage side of circuits. If this occurs, reduce the frequency range of the waveform measuring instrument, or clamp onto the low-voltage side of the circuit, as appropriate.



RP1003C/RP1004C



RP1005C

Specifications

When the device works for at least 30 minutes at 23°C±5°C, the following specifications can be guaranteed.

RP1003C/RP1004C

Bandwidth	RP1003C: DC to 50MHz (-3dB), refer to Appendix 1 Amplitude-frequency Characteristics (RP1003C) RP1004C: DC to 100MHz (-3dB), refer to Appendix 1 Amplitude-frequency Characteristics (RP1004C)
Rise Time	RP1003C: ≤7ns RP1004C: ≤3.5ns
Maximum Continuous Input Range	30Arms, refer to Appendix 2 Relation between Max Input Current and Frequency (RP1003C/RP1004C)
Maximum Peak Current Value	Non-continuous 50A peak
Gain	0.1V/A
Amplitude Accuracy	±1.0%rdg±1mV, ≤30Arms ±2.0%rdg, ≤50A peak (DC, and 45 to 66 Hz, input within continuous maximum input range)
Noise	≤2.5mArms (for 20MHz band measuring instrument)
Input Impedance	Refer to Appendix 3 Input Impedance (Typical) (RP1003C/RP1004C)
Temperature Coefficient for Sensitivity	≤±2% (during input of 50Hz, 30Arms within range of 0°C to 40°C)
Maximum Rated Power	5.3VA
Rated Supply Voltage	+12V±0.5V
Operating Temperature and Humidity Range	0°C to 40°C, ≤80% RH (no condensation)
Storage Temperature and	-10°C to 50°C, ≤80% RH (no condensation)

Humidity Range	
Location for Use	Indoor, altitude up to 2000m, Pollution Degree 2
Effect of External Magnetic Fields	RP1003C: ≤20 mA (DC and 60 Hz, Magnetic field of 400 A/m) RP1004C: ≤5 mA (DC and 60 Hz, Magnetic field of 400 A/m)
Diameter of Measurable Conductors	5mm
Measurable Conductors	Insulated conductor
Guaranteed Accuracy Period	1 year (opening/closing up to 10,000 times)
Cable Lengths	Sensor cable: Approx. 1.5m Power supply cable: Approx. 1m
External Dimensions	Sensor: Approx. 175W×18H×40Dmm (excluding protrusions) Terminator: Approx. 27H×55W×18Dmm
Mass	RP1003C: Approx. 230g RP1004C: Approx. 240g
Accessories	User's Guide, Probe Case
Safety	EN61010
EMC	EN61326

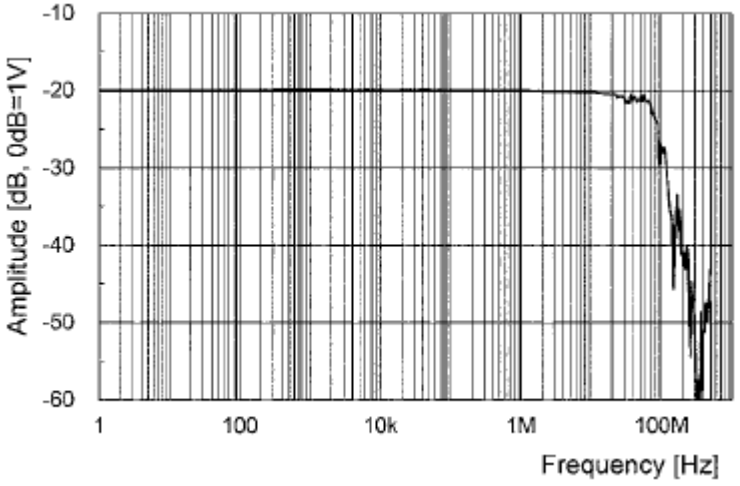
RP1005C

Bandwidth	DC to 10MHz (-3dB), refer to Appendix 1 Amplitude-frequency Characteristics (RP1005C)
Rise Time	≤35ns
Maximum Continuous Input Range	150A, refer to Appendix 2 Relation between Max Input Current and Frequency (RP1005C)
Maximum Peak Current Value	300A peak, non-continuous 500A peak, pulse width≤30μs
Gain	0.01V/A
Amplitude Accuracy	±1.0%rdg±1mV, ≤150A ±2.0%rdg, 150 A to 300A peak (DC, and 45Hz to 66Hz)
Noise	≤25mArms (for 20MHz band measuring instrument)

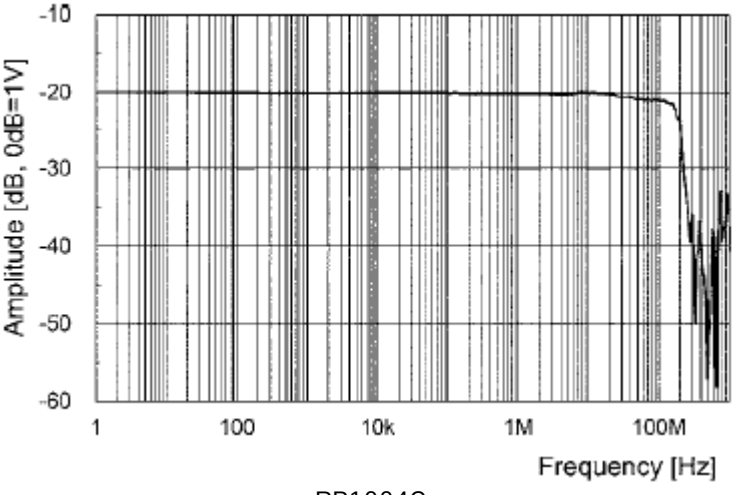
Input Impedance	Refer to Appendix 3 Input Impedance (Typical) (RP1005C)
Temperature Coefficient for Sensitivity	≤±2% (input: 55Hz, 150A, within a range of 0°C to 40°C)
Maximum Rated Power	5.5VA (within maximum continuous input range)
Rated Supply Voltage	+12V±1V
Operating Temperature and Humidity Range	0°C to 40°C, ≤80% RH (no condensation)
Storage Temperature and Humidity Range	-10°C to 50°C, ≤80% RH (no condensation)
Location for Use	Indoor, altitude up to 2000m, Pollution Degree 2
Period of Guaranteed Accuracy	1 year (opening/closing up to 10,000 times)
Effect of External Magnetic Fields	≤150mA (in a DC or 60 Hz, 400 A/m magnetic field)
Diameter of Measurable Conductors	20mm
Measurable Conductors	Insulated conductor
Cable lengths	Sensor cable: Approx. 2 m Power supply cable: Approx. 1 m
External dimensions	Sensor: Approx. 176W X 69H X 27D mm Terminator: Approx. 27H X 55W X 18D mm
Mass	Approx. 500g
Accessories	User's Guide, Probe Case
Safety	EN61010
EMC	EN61326

Appendix

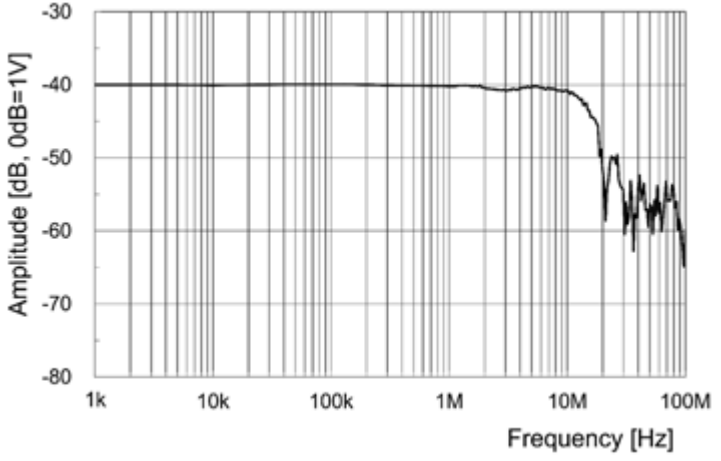
Appendix 1 Amplitude-frequency Characteristics



RP1003C

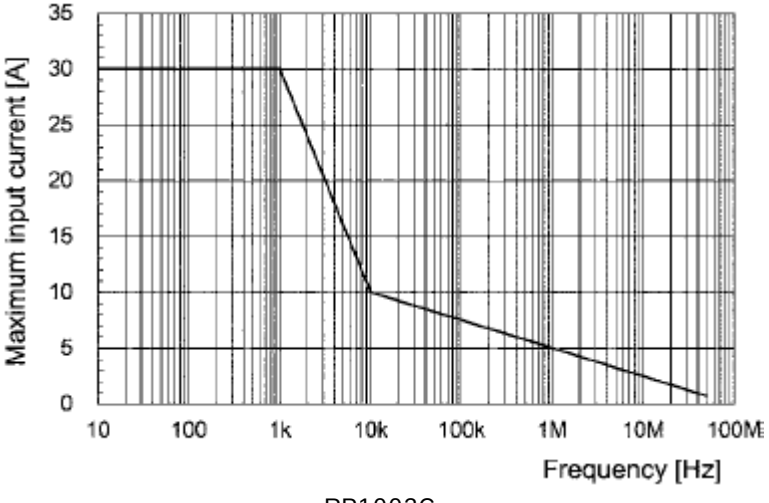


RP1004C

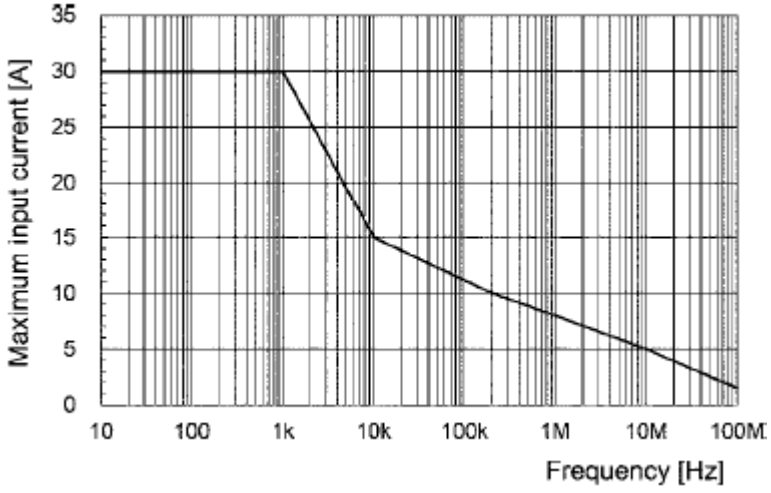


RP1005C

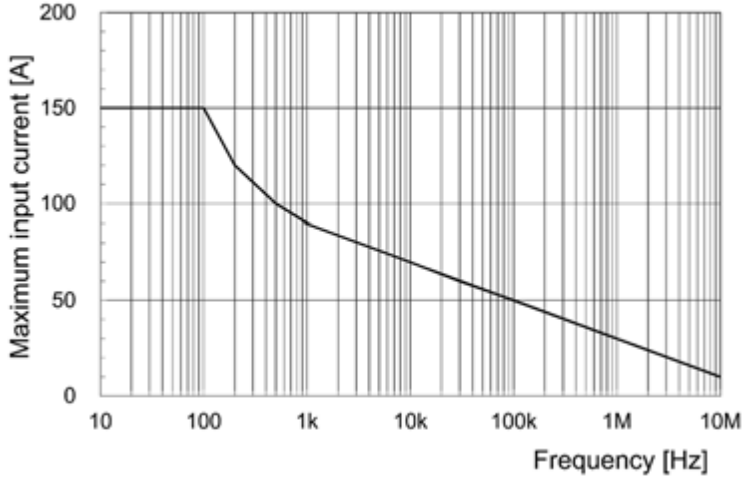
Appendix 2 Relation between Max Input Current and Frequency



RP1003C

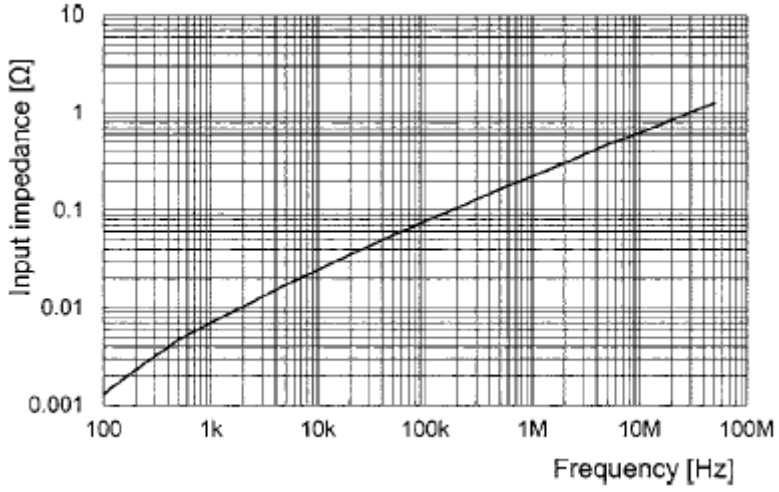


RP1004C

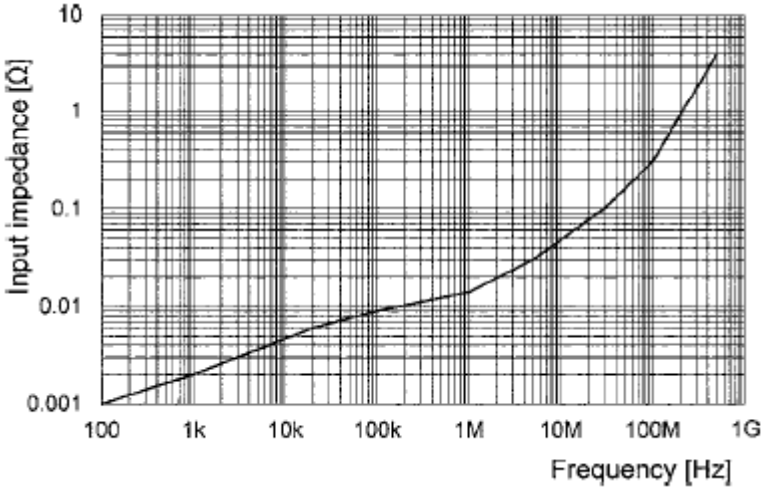


RP1005C

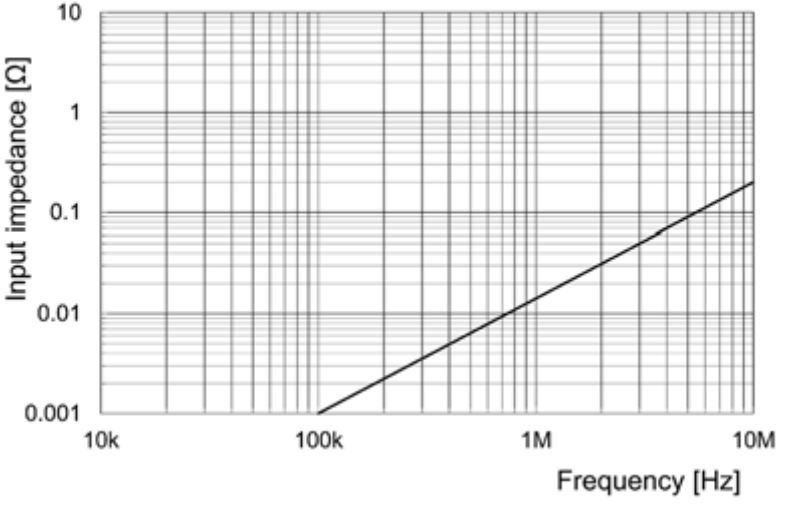
Appendix 3 Input Impedance (Typical)



RP1003C



RP1004C


10
1
0.1
0.01
0.001
Input impedance [Ω]
10k
100k
1M
10M
Frequency [Hz]

RP1005C