# CT6904A, CT6904A-1
## AC/DC CURRENT SENSOR



**Maximum rating 500 A, ultra-high-stability, high-accuracy, wideband DC to 4 MHz/2 MHz, high-CMRR, high-performance fluxgate technology, pass-through type**


3 year Warranty

CE

## Features

- ✓ **5 ppm linearity**
- ✓ **10 ppm offset**
- ✓ **Voltage output**
- ✓ **CT coil structure for broadband and superior frequency characteristics**
- ✓ **Built-in machined solid aluminum shield for excellent noise resistance (high CMRR)**
- ✓ **Aperture ϕ32mm for cables and bus-bars**
- ✓ **The Power Analyzer PW8001 automatically recognizes the current sensor's information (phase shift data, sensor model name, rated current, serial number) when connected.**

## Applications

- ✓ **Measurement of Loss in High-Frequency Reactors**
- ✓ **Automotive (e.g. xEV inverter motors)**
- ✓ **Efficiency measurement of high-efficiency energy converters**
- ✓ **Analysis of industrial inverter motors**
- ✓ **Calibration of shunt resistors**
- ✓ **Measurement of minute superimposed current in battery systems**
- ✓ **For feedback control in medical devices (MRI, CT, X-ray)**

| Specification highlights | Symbol | Unit | Min. | Typ. | Max. |
|---|---|---|---|---|---|
| Nominal primary DC current | $I_{PN}$ DC | A | -500 | | 500 |
| Nominal primary AC current | $I_{PN}$ AC | Arms | | | 500 |
| Measurement range | $I_{PM}$ | A | -550 | | 550 |
| Nominal output voltage | $V_{out}$ | V | -2 | | 2 |
| Primary/secondary ratio | Ratio | V/A | 0.004 | 0.004 | 0.004 |
| Linearity error | $\varepsilon_L$ | ppm | | ±5 | |
| Offset error | $\varepsilon_O$ | ppm | | ±10 | |
| Bandwidth (±3dB) | f | MHz | | CT6904A: 4<br>CT6904A-1: 2 | |
| Withstand voltage (1 mA, 50/60Hz for 1 minute) | $U_d$ | kV | | | 7.4 |
| Power supply voltages | $U_c$ | V | ±11.5 | | ±12.5 |
| Operating temperature range | $T_A$ | °C | -10 | | 50 |
| Output cable length | $L_{cable}$ | m | | CT6904A: 3m<br>CT6904A-1: 10m | |



HIOKI E.E. CORPORATION
Written in Japan

**Electrical specifications at $T_A$ = 23°C ±5°C, supply voltage (by using external PSU) = ±12 V unless otherwise stated**

| Parameter | Symbol | Unit | Min. | Typ. | Max. | Comment |
|---|---|---|---|---|---|---|
| Nominal primary DC current | $I_{PN}$ DC | A | -500 | | 500 | Refer to “Figure 1. Frequency derating” |
| Nominal primary AC current | $I_{PN}$ AC | Arms | | | 500 | Refer to “Figure 1. Frequency derating” |
| Measurement range | $I_{PM}$ | A | -550 | | 550 | Refer to “Figure 1. Frequency derating” |
| Maximum input current | $I_{MAX}$ | Apeak | -1000 | | 1000 | Not exceeding derating curve shown in Figure 1<br>However, it is allowable for up to 20 ms at 40°C or less |
| Nominal output voltage | $V_{out}$ | V | -2 | | 2 | |
| Primary/secondary ratio | Ratio | V/A | 0.004 | 0.004 | 0.004 | |
| Bandwidth (-3dB)<br>CT6904A<br>CT6904A-1 | f | MHz | | <br>4<br>2 | | Refer to “Figure 2. Frequency characteristics” |
| Output resistance | | Ω | 40 | 50 | 60 | |
| Input impedance | | mΩ | | 2.5 | | 100 kHz |
| Linearity error | $\varepsilon_L$ | ppm | | ±5 | | Refer to “Figure 3. Linearity error characteristics” |
| Offset error | $\varepsilon_O$ | ppm | | ±10 | | |
| Output noise | noise | µVrms | | | 300 | Measurement bandwidth: DC to 1 MHz |
| Effects of temperature<br>Amplitude sensitivity<br>Offset voltage<br>Phase | | <br>ppm of reading/°C<br>ppm of full scale/°C<br>±°/°C | <br>-20<br>-1<br>-0.01 | | <br>20<br>1<br>0.01 | Within the range of −10°C to 18°C or 28°C to 50°C |
| Effects of magnetization | | mA | | | 5 | Input equivalent, after 500 A DC is inputted |
| Common mode rejection ratio<br>50/60 Hz<br>100 kHz | CMRR | dB | <br>140<br>120 | | | (Effect on output voltage/common-mode voltage)<br>Refer to “Figure 4. CMRR characteristics” |
| Effects of conductor position<br>50/60 Hz<br>100 kHz | | % of reading | <br>-0.01<br>-0.2 | | <br>0.01<br>0.2 | When wire of outer diameter 10 mm is used<br>Refer to Figure 5. Effects of conductor position (typical) at 100 kHz |
| Effects of external magnetic field | | mA | | | 50 | Input equivalent, under a magnetic field of 400 A/m, DC |
| | | | | | 50 | Input equivalent, under a magnetic field of 400 A/m, 60 Hz |
| Effects of radiated radio-frequency electromagnetic field | | % of full scale | | | 0.5 | 10 V/m |
| Effects of conducted radio-frequency electromagnetic field | | % of full scale | | | 0.2 | 10 V |
| Fluxgate excitation frequency | $f_{Exc}$ | kHz | | 10.4 | | |
| Power supply voltages | $U_c$ | V | ±11.5 | | ±12.5 | |
| Positive current consumption | $I_{ps}$ | mA | | | 400 | DC + 500 A with ±12V |
| Negative current consumption | $I_{ns}$ | mA | | | -400 | DC - 500 A with ±12V |

**Isolation specifications**

| Parameter | Unit | Value | Comment |
|---|---|---|---|
| Rated insulation RMS voltage, basic insulation | V | 1000 | IEC 61010-1 conditions<br>• over voltage cat III<br>• pollution degree 2 |
| Rated insulation RMS voltage, reinforced insulation | V | 1000 | |
| RMS voltage for AC isolation test, 50/60 Hz, 1minute | kV | 7.4 | Between primary and secondary (and shield)<br>Sensed current: 1 mA |
| Clearance | mm | 20.7 | Shortest distance through air |
| Creepage distance | mm | 20.7 | Shortest path along device body |
| Comparative tracking index (CTI) | V | < 250 | Performance level category (PLC) = 3 |
| Standards | Safety: EN 61010<br>EMC: EN 61326 | | |

## Environmental and mechanical characteristics

| Parameter | Symbol | Unit | Min. | Typ. | Max. | Comment |
|---|---|---|---|---|---|---|
| Operating environment (altitude) | | m | | | 2000 | Indoor use, pollution degree 2 |
| Ambient operating temperature range | $T_A$ | °C | -10 | | 50 | |
| Ambient storage temperature range | $T_{Ast}$ | °C | -20 | | 60 | |
| Relative humidity | RH | % | | | 80 | Non-condensing |
| Dust resistance and water resistance | IP20 | | | | | EN 60529 |
| Measurable conductor diameter | $D_{meas}$ | mm | | | 32 | |
| Dimensions | W<br>H<br>D | mm | | 139<br>120<br>52 | | Refer to “Figure 6. Dimensions” |
| Output cable length<br>CT6904A<br>CT6904A-1 | $L_{cable}$ | m | | <br>3<br>10 | | |
| Mounting hole diameter | $D_{mout}$ | mm | | ϕ 5.2 | | M5 screw, recommended tightening torque: 1.5 Nm to 2.0 Nm |
| Weight<br>CT6904A<br>CT6904A-1 | m | kg | | <br>1.05<br>1.35 | | |

## Measurement accuracy (total accuracy including uncertainty in calibration system etc.)

**Electrical specifications at $T_A$ = 23°C ±5°C, supply voltage (by using external PSU) = ±12 V unless otherwise stated**

| Frequency [Hz] | Amplitude | | Phase [±°] |
|---|---|---|---|
| | [±% of reading] | [±% of full scale] | |
| DC | 0.025 | 0.007 | – |
| DC < f < 16 | 0.2 | 0.02 | 0.1 |
| 16 ≤ f < 45 | 0.1 | 0.02 | 0.1 |
| 45 ≤ f ≤ 65 | 0.02 | 0.007 | 0.08 |
| 65 < f ≤ 850 | 0.05 | 0.007 | 0.12 |
| 850 < f ≤ 1 k | 0.1 | 0.01 | 0.4 |
| 1 k < f ≤ 5 k | 0.4 | 0.02 | 0.4 |
| 5 k < f ≤ 10 k | 0.4 | 0.02 | 0.08 x f |
| 10 k < f ≤ 50 k | 1 | 0.02 | 0.08 x f |
| 50 k < f ≤ 100 k | 1 | 0.05 | 0.08 x f |
| 100 k < f ≤ 300 k | 2 | 0.05 | 0.08 x f |
| 300 k < f ≤ 1 M | 5 | 0.05 | 0.08 x f |
| Frequency range | 4 MHz/2 MHz (CT6904A-1) (±3 dB typical) | | – |

- The variable f in accuracy equations is expressed in kHz.
- Accuracy of amplitude and phase is specified with 110% of full scale input or less and not exceeding derating curve in Figure 1. Accuracy in range of DC < f < 10 Hz are design values.
- Add ±0.01% of reading to amplitude accuracy when input is 100% to 110% of full scale.
- For the CT6904A-1, add the following values to accuracy in the range of 50 kHz < f ≤ 1 MHz.
  Amplitude accuracy: ±(0.015 × f [kHz])% of reading

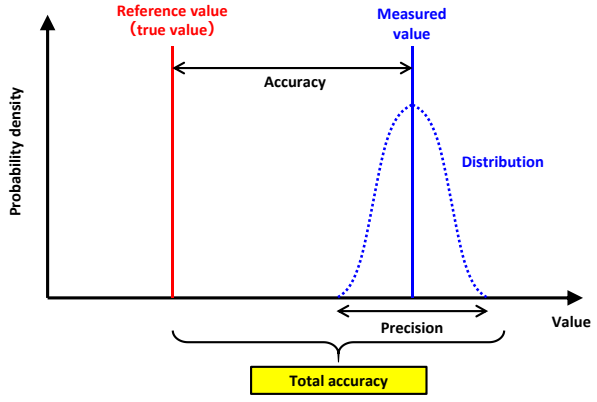
## Definition of on accuracy (total accuracy including uncertainty in calibration system etc.)

**Reading (displayed value) error:** Indicates the value displayed by the instrument. Limit values for reading errors are expressed as a percentage of the reading (“% of reading” or “% rdg”).

**Range error:** Indicates the instrument’s range. Limit values for range errors are expressed as a percentage of the range (“% of range”).

**Full scale (rated current) error:** Indicates the rated current. Limit values for full-scale errors are expressed as a percentage of full scale (“% of full scale” or “% f.s.”).

**Calibration:** The accuracy of HIOKI products includes all factors that affect the measurement results, such as calibration system errors, ambient temperature, and secular change, as "**uncertainty**".




HIOKI is accredited as an official ISO/IEC 17025 calibrator.

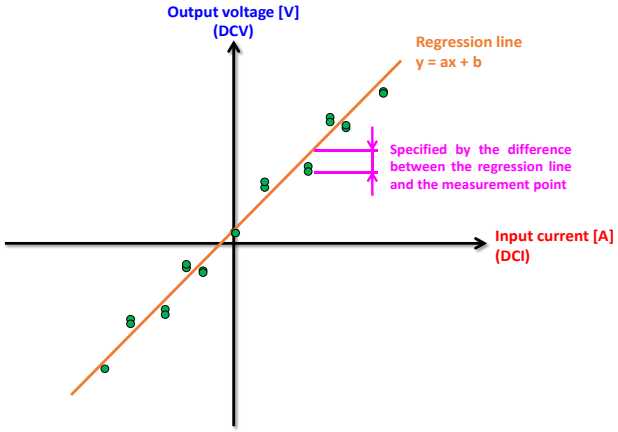
## Specific accuracy calculation example

**How to measure the current of DC 300 A of a conductor with a diameter of ϕ 30 mm or less with high accuracy.**
**Guaranteed specifications at $T_A$ = 23°C ±5°C**

| Measuring instrument configuration | CT6904A, CT6904A-1 | CT9555 | L9217 + 9704 | DM7276 |
|---|---|---|---|---|
| External view |  |  |  |  |
| Range (connection) | 500 A (2 V) | Front OUTPUT terminal (BNC terminal) | ✓ | 10 V |
| Output voltage | 300 A × 2 V / 500 A = 1.2 V | | | – |
| Error (reading) | 0.025% | – | – | 0.0009% |
| Error (full scale) | 0.007% | – | – | 12 µV |
| Total error | 1.2 V × (0.025 + 0.0009)% + 2 V × 0.007% + (12 µV × $10^{-6}$) V = 0.0004628 V | | | |
| Total error (input equivalent) | 0.0004628 V / 2 V × 500A = 0.1157 A | | | |
| Error range | **300 A ± 0.1157 A ⇨ 299.8843 A to 300.1157 A** | | | |

## Definition of linearity error

**Linearity error $\varepsilon_L$:** Indicates that the output (current or voltage) changes linearly in response to the input current.
A regression line is attained by measuring the output voltage in the sequence below in 100 A intervals:
+500 A → 0 A→ −500 A → 0 A → +500 A
It is defined as the difference between the regression line calculated from the above measurements and the measurement points.




## Definition of offset error

**Offset error $\varepsilon_O$:** Specified by the ratio of the average value ($\mu$) of the measured values of the offset voltage and the rated current (Imax) of each current sensor.

$$\varepsilon_O = \mu/\mathrm{Imax} \ \ [\mathrm{ppm}]$$

## Definition of amplitude error

**Amplitude error $\varepsilon_G$:** An index showing the degree of flatness of the frequency characteristics of gain.
DC error is defined as (linearity error + offset error).
AC error is defined as deviation from the 55 Hz measurement point.

$$\varepsilon_{G\,DC} = \varepsilon_L + \varepsilon_O \ \ [\mathrm{ppm}]$$

$$\varepsilon_{G\,AC} = \frac{\mathrm{Gain\ (f)} - \mathrm{Gain\ (55\ Hz)}}{\mathrm{Gain\ (55\ Hz)}} \times 100 \ \ [\%]$$

**Figure 1. Frequency derating**

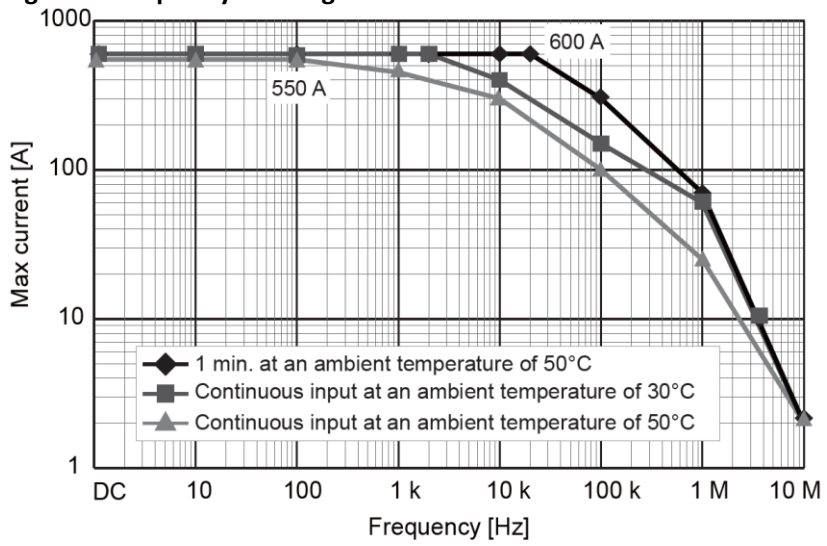
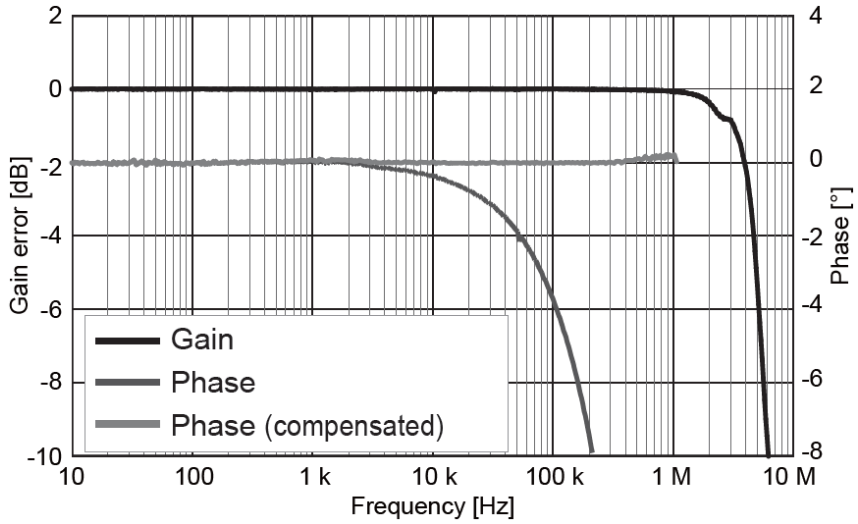



**Figure 2. Frequency characteristics**




**Phase Compensation Values**
Enter the following values (representative values) when performing phase compensation on the PW6001 or PW3390.
When connecting to the PW8001, it will be set automatically.

CT6904A: 300 kHz, -9.82°
CT6904A-1: 300 kHz, -9.82°

**Figure 3. Linearity error characteristics**

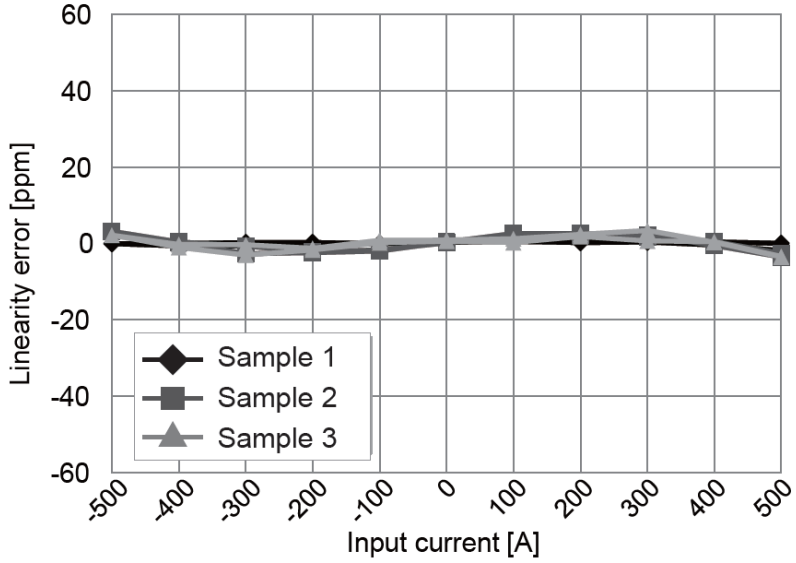


**Figure 4. CMRR characteristics**

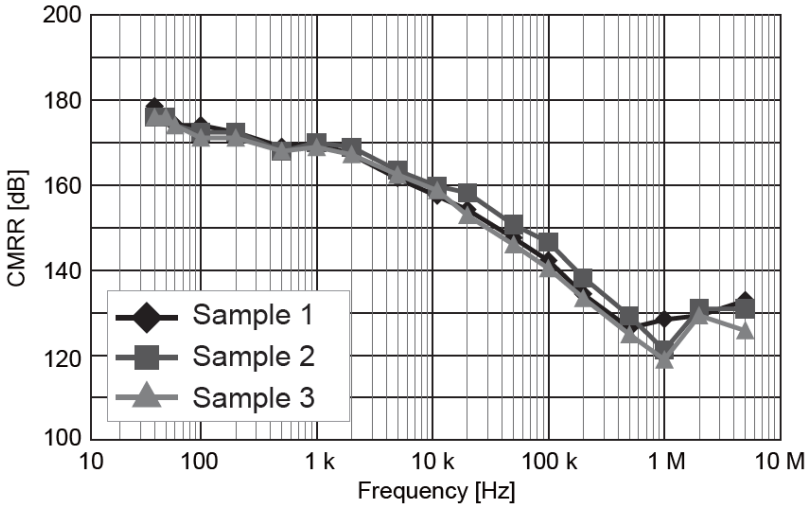



**Figure 5. Effects of conductor position (typical) at 100 kHz**

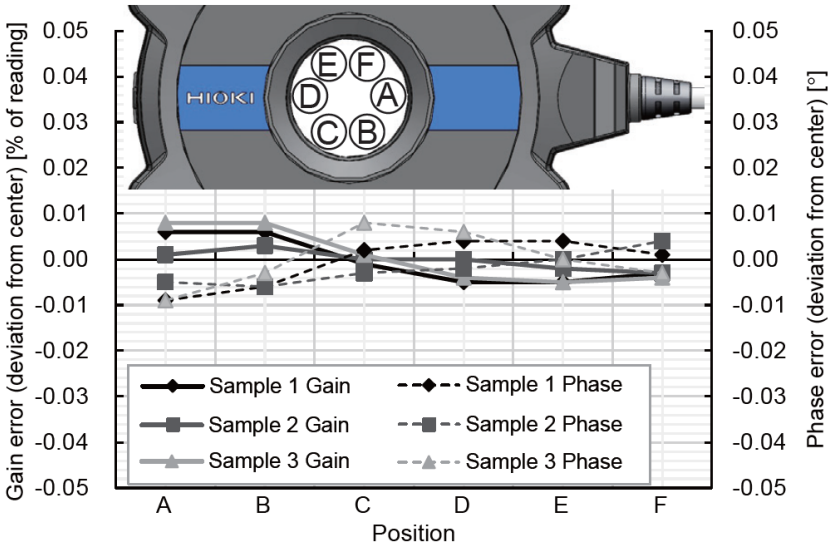


**Figure 6. Dimensions**

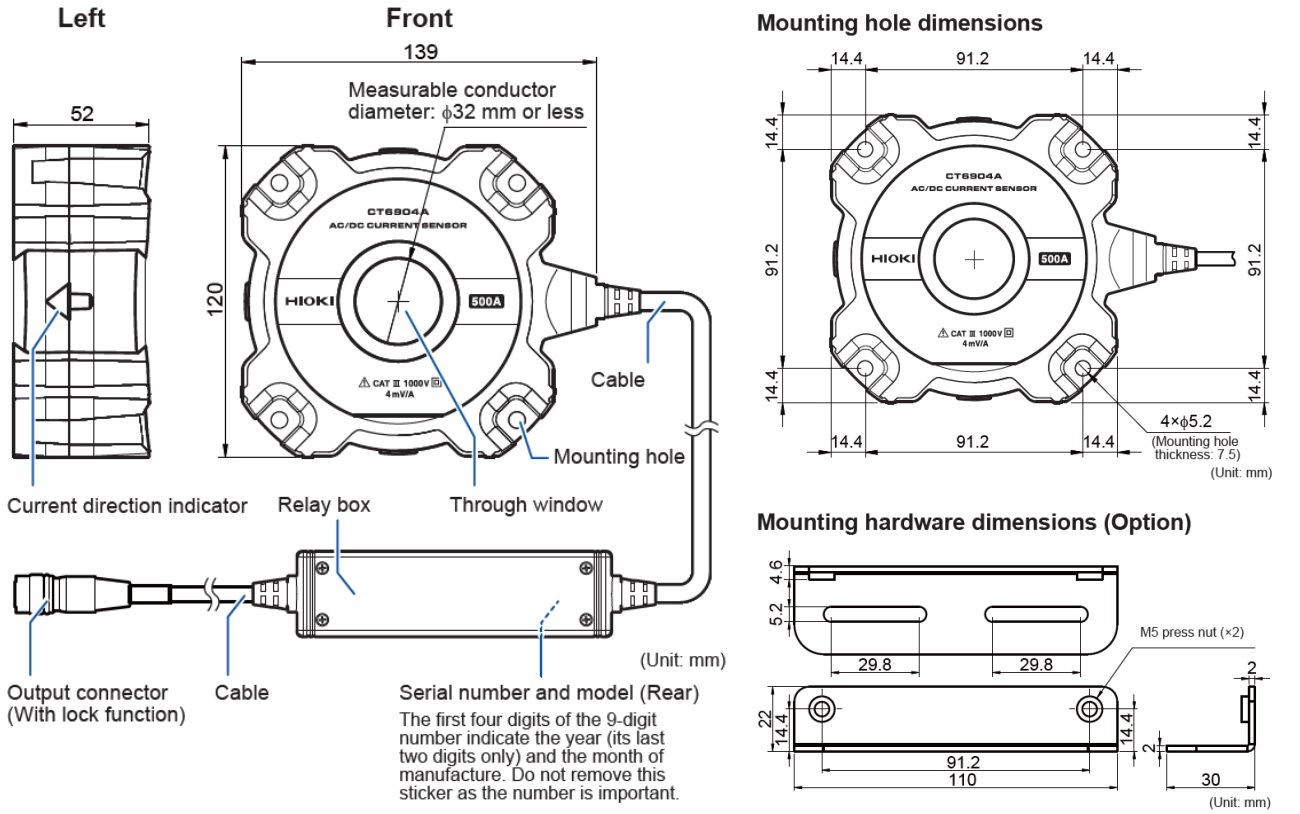
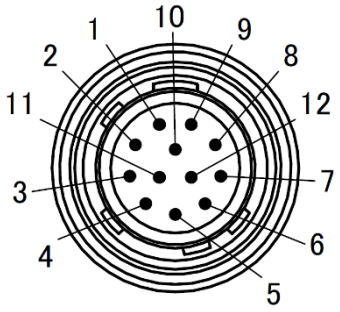



**Figure 7. Pin assignment (when not using the sensor units CT9555, CT9556, or CT9557)**




Output connector HIOKI ME15W of current sensors
HIROSE ELECTRIC CO., LTD.
HR10A-10P-12P (74)

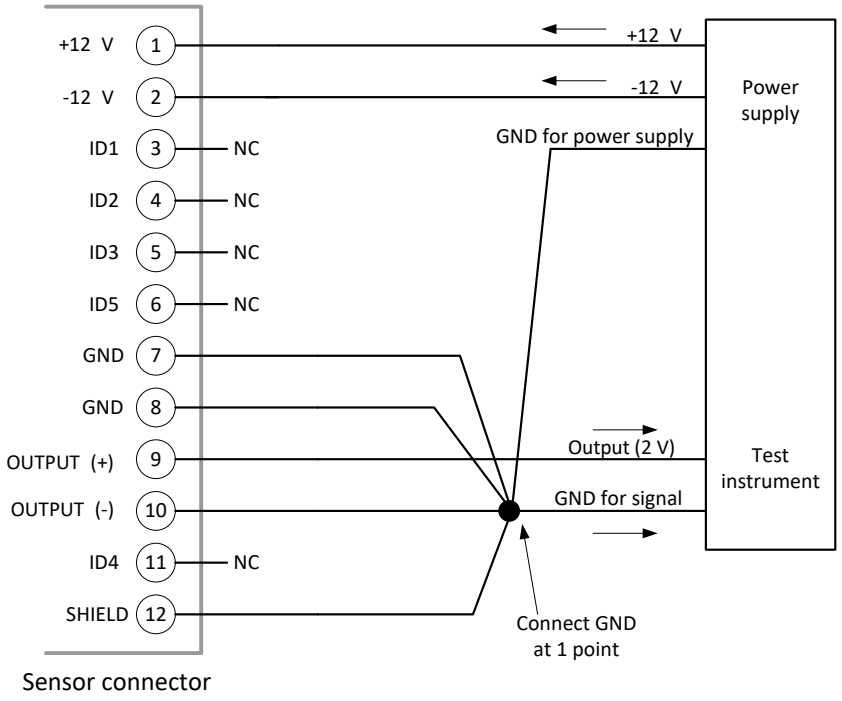
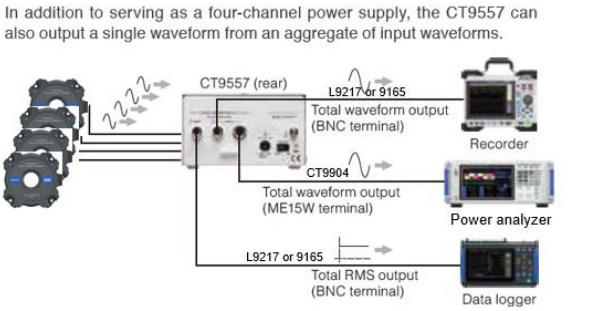


**Figure 8. Options and main combination**


**CT9904 CONNECTION CABLE**
ME15W (12 pin) - ME15W (12 pin) terminal
The CT9904 is the cable for the CT9557 addition output and POWER ANALYZER PW8001/PW6001/PW3390 connection.

**CT9902 EXTENSION CABLE**
ME15W (12 pin) - ME15W (12 pin) terminal
The CT9902 can be used to extend a current sensor's cable by 5 m.
Up two of these cables can be used for a maximum extension of 10 m.
*When using the CT9902, an addition must be made to accuracy.
For details, refer the sensor's instruction manual.

**Links**

1. Web site
   AC/DC CURRENT SENSOR CT6904A,-1 | HIOKI

2. Accuracy calculation tools
   POWER ANALYZER PW8001 & CT
   POWER ANALYZER PW6001 & CT
   POWER ANALYZER PW3390 & CT

Files and information such as the Power Analyzer accuracy calculation tools are updated regularly.
Instead of downloading them once and using them for a long time, download them from the download link just before using them.