HIOKI

PQ3100

Instruction Manual

POWER QUALITY ANALYZER

Be sure to read this manual before using the instrument.

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EN

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Contents

Introduction

Thank you for purchasing the Hioki PQ3100 Power Quality Analyzer. To obtain maximum performance from the instrument, please read this manual first, and keep it handy for future reference.

Registered trademarks

- Microsoft and Windows are either registered trademarks or trademarks of Microsoft Corporation in the United States and other countries.
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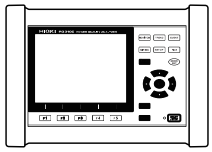
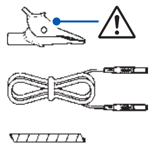
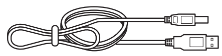
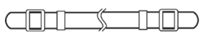
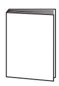
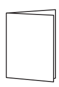
Verifying Package Contents

When you receive the instrument, inspect it carefully to ensure that no damage occurred during shipping. In particular, check the accessories, keys, switch, and connectors. If damage is evident, or if it fails to operate according to the specifications, contact your authorized Hioki distributor or reseller.
Check that the package contents are correct.

☐ **PQ3100 Power Quality Analyzer**	× 1	

Accessories		
☐ **L1000-05 Voltage Cord** Maximum rated voltage: 1000 V, maximum rated current: 10 A Alligator clips (black, red, yellow, blue, gray) 3 m banana plug leads (black, red, yellow, blue, gray) Spiral Tubes (Cord bundling) See “Bundling the voltage cords and current sensors (If required)” (p. 37), “Connecting Voltage Cords to Instrument” (p. 51), and “Connecting Voltage Cords to Objects” (p. 55).	 ×1 each ×1 each ×5	
☐ **Z1002 AC Adapter (with power cord)**	×1	
☐ **Z1003 Battery Pack**	×1	
☐ **USB cable**	×1	
☐ **Colored spiral tubes in red, yellow, and blue (color coding for current sensors)**	×2 each	
☐ **Spiral tubes in black (cord bundling for current sensors)**	×5	
☐ **Strap** See “Attaching the strap (if required)” (p. 39).	×1	
☐ **Instruction Manual***	×1	
☐ **Measurement Guide***	×1	
☐ **CD (computer application software)** See “11.2 Use of Application Software PQ One (Included)” (p. 133). The latest version can be downloaded from our website.	×1	

*: See Hioki website for other languages.

Precautions when transporting the instrument

Handle the instrument carefully so that it is not damaged due to a vibration or shock.

Options

The following options are provided for the PQ3100. Contact your authorized Hioki distributor or reseller when ordering.

For current measurement

- ☐ CT7126 AC Current Sensor (60 A, ϕ15 mm)
- ☐ CT7131 AC Current Sensor (100 A, ϕ15 mm)
- ☐ CT7136 AC Current Sensor (600 A, ϕ46 mm)
- ☐ CT7044 AC Flexible Current Sensor (6000 A, ϕ100 mm)
- ☐ CT7045 AC Flexible Current Sensor (6000 A, ϕ180 mm)
- ☐ CT7046 AC Flexible Current Sensor (6000 A, ϕ254 mm)
- ☐ CT7731 AC/DC Auto-Zero Current Sensor (100 A, ϕ33 mm)
- ☐ CT7736 AC/DC Auto-Zero Current Sensor (600 A, ϕ33 mm)
- ☐ CT7742 AC/DC Auto-Zero Current Sensor (2000 A, ϕ55 mm)
- ☐ CT7116 AC Leakage Current Sensor (6 A, ϕ40 mm)
- ☐ L9910 Conversion Cable (BNC-PL14)

For voltage measurement

- ☐ L1000-05 Voltage Cord (accessory)
  Maximum rated voltage: 1000 V, maximum rated current: 10 A
- ☐ 9804-01 Magnetic Adapter (Red: 1, for changing the voltage cord tips)
  Maximum rated voltage: 1000 V, maximum rated current: 2 A
- ☐ 9804-02 Magnetic Adapter (Black: 1, for changing the voltage cord tips)
  Maximum rated voltage: 1000 V, maximum rated current: 2 A
- ☐ 9243 Grabber Clip (Red/Black: 1 each, for changing the voltage cord tips)
  Maximum rated voltage: 1000 V, maximum rated current: 1 A

Power supply

- ☐ Z1002 AC Adapter (accessory)
- ☐ Z1003 Battery Pack (accessory)

Media for recording

- ☐ Z4001 SD Memory Card 2GB
- ☐ Z4003 SD Memory Card 8GB

Communication

- ☐ 9637 RS-232C Cable (9 pin-9 pin/1.8 m, cross cable)
- ☐ 9642 LAN Cable

Carrying Case

- ☐ C1009 Carrying Case (Bag)
- ☐ C1001 Carrying Case (Soft)
- ☐ C1002 Carrying Case (Hard)

Safety Information

This instrument is designed to conform to IEC 61010 Safety Standards, and has been thoroughly tested for safety prior to shipment. However, using the instrument in a way not described in this manual may negate the provided safety features.
Before using the instrument, be certain to carefully read the following safety notes.

⚠DANGER

Mishandling during use could result in injury or death, as well as damage to the instrument. Be certain that you understand the instructions and precautions in the manual before use.

⚠WARNING

With regard to the electricity supply, there are risks of electric shock, heat generation, fire, and arc discharge due to short circuits. Individuals using an electrical measuring instrument for the first time should be supervised by a technician who has experience in electrical measurement.

Notation

In this document, the risk seriousness and the hazard levels are classified as follows.

⚠DANGER	Indicates an imminently hazardous situation that will result in death or serious injury to the operator.
⚠WARNING	Indicates a potentially hazardous situation that may result in death or serious injury to the operator.
⚠CAUTION	Indicates a potentially hazardous situation that may result in minor or moderate injury to the operator or damage to the instrument or malfunction.
IMPORTANT	Indicates information related to the operation of the instrument or maintenance tasks with which the operators must be fully familiar.

	Indicates a high voltage hazard. If a particular safety check is not performed or the instrument is mishandled, this may give rise to a hazardous situation; the operator may receive an electric shock, may get burnt or may even be fatally injured.
	Indicates a strong magnetic-field hazard. The effects of the magnetic force can cause abnormal operation of heart pacemakers and/or medical electronics.
	Indicates a prohibited action.
	Indicates the action which must be performed.
MONITOR **(Bold character)**	Names on the screen are displayed in **bold characters**.
[ ]	Operation keys are displayed in brackets (**[ ]**).
*	Additional information is presented below.
(Available after the firmware update)	This function is not available with the present firmware. This function will be available after the firmware version update scheduled in May, 2017.

Symbols on the instrument

	Indicates cautions and hazards. When the symbol is printed on the instrument, refer to a corresponding topic in the Instruction Manual.
	Indicates DC (Direct Current).
	Indicates the ON side of the power switch.
	Indicates the OFF side of the power switch.
	Indicates a grounding terminal.
	Indicates an instrument that has been protected throughout by double insulation or reinforced insulation. (9243 Grabber Clip)

Symbols for various standards

	Indicates the Waste Electrical and Electronic Equipment Directive (WEEE Directive) in EU member states.
CE	Indicates that the product conforms to regulations set out by the EC Directive.
Ni-MH	This is a recycle mark established under the Resource Recycling Promotion Law (only for Japan).

Accuracy

We define measurement tolerances in terms of f.s. (full scale), rdg. (reading) and dgt. (digit) values, with the following meanings:

f.s.	(maximum display value, range) The maximum value that can be displayed. This is usually the name of the currently selected range.
rdg.	(reading or displayed value) The value currently being measured and indicated on the measuring instrument.
dgt.	(resolution) The smallest displayable unit on a digital measuring instrument, i.e., the input value that causes the digital display to show a “1” as the least-significant digit.

Protective gear

⚠ WARNING

This instrument measures live lines. To prevent electric shock, use appropriate protective insulation and adhere to applicable laws and regulations.

Measurement categories

To ensure safe operation of measuring instruments, IEC 61010 establishes safety standards for various electrical environments, categorized as CAT II to CAT IV, and called measurement categories.

⚠DANGER

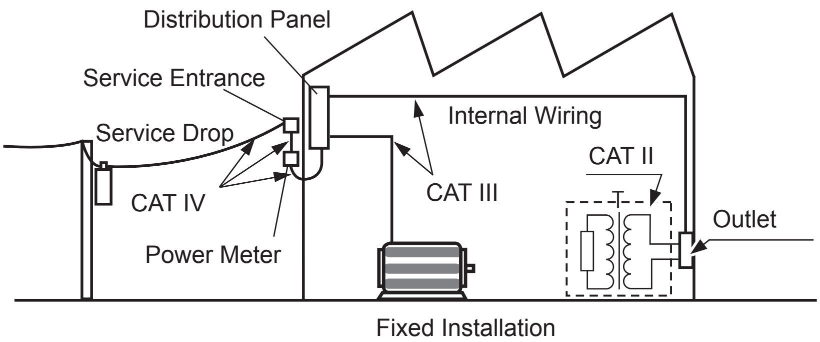
- **Using a measuring instrument in an environment designated with a higher-numbered category than that for which the instrument is rated could result in a severe accident, and must be carefully avoided.**
- **Never use a measuring instrument that lacks category labeling in a CAT II to CAT IV measurement environment. Doing so could result in a serious accident.**

The instrument conforms to the safety requirements for CAT III 1000 V, CAT IV 600 V measuring instruments.

CAT II: When directly measuring the electrical outlet receptacles of the primary electrical circuits in equipment connected to an AC electrical outlet by a power cord (portable tools, household appliances, etc.).

CAT III: When measuring the primary electrical circuits of heavy equipment (fixed installations) connected directly to the distribution panel, and feeders from the distribution panel to outlets.

CAT IV: When measuring the circuit from the service drop to the service entrance, and to the power meter and primary overcurrent protection device (distribution panel).



Operating Precautions

Follow these precautions to ensure safe operation and to obtain the full benefits of the various functions.

Preliminary Checks

Before using the instrument, verify that it operates normally to ensure that no damage occurred during storage or shipping. If you find any damage, contact your authorized Hioki distributor or reseller.

⚠DANGER

To prevent an electric shock, confirm that the white portion (insulation layer) inside the cable is not exposed. If a color inside the cable is exposed, do not use the cable.

Installation Environment

⚠WARNING

Installing the instrument in inappropriate locations may cause a malfunction of instrument or may give rise to an accident. Avoid the following locations:
- **Exposed to direct sunlight or high temperature**
- **Exposed to corrosive or combustible gases**
- **Exposed to a strong electromagnetic field or electrostatic charge**
- **Near induction heating systems (such as high-frequency induction heating systems and IH cooking equipment)**
- **Susceptible to vibration**
- **Exposed to water, oil, chemicals, or solvents**
- **Exposed to high humidity or condensation**
- **Exposed to high quantities of dust particles**

⚠CAUTION

Do not place the instrument on an unstable table or an inclined place. Dropping or knocking down the instrument can cause injury or damage to the instrument.

Handling the Instrument

⚠CAUTION

To avoid damage to the instrument, protect it from physical shock when transporting and handling. Be especially careful to avoid physical shock from dropping.

This instrument may cause interference if used in residential areas.
Such use must be avoided unless the use takes special measures to reduce electromagnetic emissions to prevent interference to the reception of radio and television broadcasts.

Handling Cords and Cables

⚠DANGER

If the insulation on a cord or cable melts, the metal conductor may be exposed. Do not use any cord or cable whose metal conductor is exposed. Doing so could result in electric shock, or other hazard.

⚠CAUTION

The cord and cable are hardened under the 0 degree or colder environment. Do not bend or pull them to avoid tearing their shield or cutting them.

Using Voltage Cords

⚠DANGER

To prevent an electric shock, confirm that the white portion (insulation layer) inside the cable is not exposed. If a color inside the cable is exposed, do not use the cable.

⚠WARNING

- **Use only the specified voltage cords. Using a non-specified cord may result in electric shock or short circuits.**
- **Avoid contact between the cord and the measured line in order to protect the cord from damage. Any contact can cause the instrument to malfunction and lead to short-circuits or electric shock.**

Using Battery Pack

⚠WARNING

- **To avoid the possibility of explosion, do not short circuit, disassemble or incinerate battery pack. Battery may explode if mistreated. Handle and dispose of batteries in accordance with local regulations.**

- **Be sure to observe the following precautions. Incorrect handling may result in liquid leaks, heat generation, ignition, bursting and other hazards.**
  - **The battery pack contains lye, which may cause blindness if it comes into contact with the eyes. Should battery liquid get into your eyes, avoid rubbing them. Flush them with water and seek immediate medical attention.**
  - **When storing the instrument, make sure no objects that could short-circuit the connectors are placed near them.**
- **For battery operation, use only the HIOKI Model Z1003 Battery Pack. We do not take any responsibility for accidents or damage related to the use of any other batteries.**
- **To avoid electric shock, turn off the power switch, disconnect all the power and voltage cords and current sensor from the device to be measured, and replace the battery pack.**
- **To prevent the instrument damage or electric shock, use only the screws (M6×12 mm) for securing the battery cover in place that are originally installed. If you have lost any screws or find that any screws are damaged, please contact your Hioki distributor for a replacement.**

⚠CAUTION

- Observe the following to avoid damage to the instrument.
  - Use the battery pack in an ambient temperature range of 0°C to 50°C and charge it in an ambient temperature range of 10°C to 35°C.
  - If the battery pack fails to finish charging within the stipulated time, disconnect the AC adapter to stop charging and contact your dealer or Hioki representative.
  - Consult your dealer or nearest service station should liquid leaks, strange odor, heat, discoloration, deformation and other abnormal conditions occur during use, charging or storage. Should these conditions occur during use or charging, turn off and disconnect the instrument immediately.
  - Do not expose the instrument to water and do not use it in excessively humid locations or locations exposed to rain.
- Do not expose the instrument to strong impact and do not throw it around.
- Heed the following instructions to avoid battery pack performance drop or leakage.

- The battery pack is a consumable. If you are able to use the instrument for only a limited period of time despite the battery pack being properly charged, the battery pack's service life is at an end, and it should be replaced.
- When a battery pack that has not been used for a long time is used, charging may end before the battery pack is fully charged. In such a case, repeat charging and discharging a number of time before use. (A battery pack may also be in such a state immediately after purchase.)
- The life of the battery pack (when capacity is 60% or more of initial capacity) is approximately 500 charge-discharge cycles. (The life differs depending on the conditions of use.)
- To prevent battery pack deterioration when the battery will not be used for 1 month or longer, remove it and store it in a dry location with an ambient temperature range of between −20°C to 30°C.
- When a battery pack is used, the instrument turns off automatically when the capacity drops. Leaving the instrument in this state for a long time may lead to over discharge so be sure to turn off the power switch on the instrument.
- The charging efficiency of the battery pack deteriorates at high and low temperatures.
- The battery pack is subject to self-discharge. Be sure to charge the battery pack before initial use. If the battery capacity remains very low after correct recharging, the useful battery life is at an end.

Attaching the Strap

⚠CAUTION

Attach the strap securely at 2 locations of the instrument. If insecurely attached, the instrument may fall and be damaged when carrying.

Using SD Memory Cards

⚠CAUTION

- Do not remove a card while data is being written to it. Doing so may damage the card. See “10.10 Removing SD Memory Card during Recording” (p. 127).

- Exercise care when using such products because static electricity could damage the SD card or cause malfunction of the instrument.

IMPORTANT

- Format the card with the instrument. Using a computer to format the card may reduce the card’s performance.
  See “10.9 Formatting SD Memory Card (Deleting All Files)” (p. 126).
- No compensation is available for loss of data stored on the SD memory card, regardless of the content or cause of damage or loss. Be sure to back up any important data stored on an SD memory card.
- Observe the following to avoid corruption or loss of stored data:
  - Do not touch the electrical contacts on the card or inside the insertion slot with your skin or metallic objects.
  - While writing or reading data, avoid vibration or shock, and do not turn the power off or remove the card from the instrument.
  - Before formatting (initializing) a card, confirm that it contains no important information (files).
  - Do not bend or drop the card, or otherwise subject it to intense shock.

- The operating lifetime of the SD memory card is limited by its flash memory. After long-term or frequent usage, data reading and writing capabilities will be degraded. In that case, replace the card with a new one.
- If you are unable to write data to an SD memory card, manipulate folders and files, or format the card, check the position of the write-protect lock and disengage it if necessary.
  The connector of the SD memory card is used to judge whether the card is write-protected.
  If the write-protected lock is in an intermediate position, the determination of whether the card is write-protected will depend on the connector. For example, even if the instrument determines that the card is not write-protected and allows data to be written to it, a computer may determine that it is write-protected, preventing data from being written to it.

Using AC Adapter

⚠WARNING

- **Use only the supplied Model Z1002 AC ADAPTER. AC adapter rated input voltage range is 100 to 240 V AC at 50/60 Hz. To avoid electrical hazards and damage to the instrument, do not apply voltage outside of this range.**
- **Turn the instrument off before connecting the AC adapter to the instrument and to AC power.**
- **To avoid electrical accidents and to maintain the safety specifications of this instrument, connect the power cord provided only to an outlet.**

⚠CAUTION

Avoid using an uninterruptible power supply (UPS) or DC/AC inverter with rectangular wave or pseudo-sine-wave output to power the instrument. Doing so may damage the instrument.

Turning On the Instrument

⚠WARNING

Before turning the instrument on, make sure the supply voltage matches that indicated on its power connector. Connection to an improper supply voltage may damage the instrument and present an electrical hazard.

⚠CAUTION

- Do not connect the supply voltage improperly. Doing so may damage the instrument's internal circuitry.

- If the power does not turn on, the AC adapter or the instrument may be malfunctioning or the power cord may be disconnected. Contact your authorized Hioki distributor or reseller.
- If an error during the self-test, the instrument is damaged. Contact your authorized Hioki distributor or reseller.

Using Magnetic Adapter

⚠DANGER

Persons wearing electronic medical devices such as a pacemaker should not use the Magnet Adapter. Such persons should avoid even proximity to the Magnet Adapter, as it may be dangerous. Medical device operation could be compromised, presenting a hazard to human life.

⚠CAUTION

Do not bring the Magnet Adapter near magnetic media such as floppy disks, magnetic cards, pre-paid cards, or magnetized tickets. Doing so may corrupt and may render them unusable. Furthermore, if the Magnet Adapter is brought near precision electronic equipment such as computers, TV screens, or electronic wrist watches, they may fail.

Wiring

⚠DANGER

- **Do not short-circuit two wires to be measured by bringing the metal part of the voltage cord clips or current sensor tips into contact with them. Doing so could result in a severe accident such as arcing.**
- **To prevent electrical shock and personal injury, do not touch any input terminals on the VT (PT), CT or the instrument when they are in operation.**
- **Do not use the instrument with circuits that exceed its ratings or specifications. Doing so may damage the instrument or cause it to become hot, resulting in bodily injury.**
- **To avoid electric shock, be careful to avoid shorting live lines with the voltage cords.**

- **We recommend measurements at the secondary side of the distribution panel. Measurements at the primary side cause unrestricted current flow. The instrument and equipment could be damaged if a short circuit occurs.**
- **To avoid short circuit or electric shock, do not touch the metal parts of the voltage cords or current sensor tips.**

⚠CAUTION

- To avoid damaging the instrument, do not short the voltage cord input terminals or current sensor input terminals or input any voltage to them.

- To ensure safe operation, use only the voltage cord and current sensor specified by Hioki.

Displayed values can frequently fluctuate due to induction potential even when no voltage is applied. This, however, is not a malfunction.

Using USB Connector (USB Cable)

⚠CAUTION

- To avoid equipment failure, do not disconnect the USB cable while communications are in progress.
- Use a common ground for both the instrument and the computer. Using different ground circuits will result in a potential difference between the instrument's ground and the computer's ground. If the USB cable is connected while such a potential difference exists, it may result in equipment malfunction or failure.

- If the instrument and computer are both off and connected with the USB cable, turn on the computer and then the instrument. Powering up the devices in a different order may prevent the instrument and computer from communicating.
- Copying large data files from the SD memory card to a computer via the instrument's USB interface can be time-consuming. When you need to copy a large data file to a computer, it is recommended to use an SD memory card reader.

Connecting the Instrument to an External Device

⚠CAUTION

- Use a common ground for both the instrument and the computer. Using different ground circuits will result in a potential difference between the instrument's ground and the computer's ground. If the communications cable is connected while such a potential difference exists, it may result in equipment malfunction or failure.
- Before connecting or disconnecting any communications cable, always turn off the instrument and the computer. Failure to do so could result in equipment malfunction or damage.
- After connecting the RS-232C cable, tighten the screws on the connector securely. Failure to secure the connector could result in equipment malfunction or damage.

Using External I/O Terminals

⚠WARNING

To avoid electric shock or damage to the equipment, always observe the following precautions when connecting to external terminals or connectors.
- **Always turn off the power to the instrument and to any devices to be connected before making connections.**
- **Be careful to avoid exceeding the ratings of external terminals and connectors.**
- **During operation, a wire becoming dislocated and contacting another conductive object can be serious hazard. Use screws to secure the external connectors.**

CD precautions

- Exercise care to keep the recorded side of discs free of dirt and scratches. When writing text on a disc's label, use a pen or marker with a soft tip.
- Keep discs inside a protective case and do not expose to direct sunlight, high temperature, or high humidity.
- Hioki is not liable for any issues your computer system experiences in the course of using this disc.

1 Overview

1.1 Procedure for Investigating Power Quality

By measuring power quality parameters, you can assess the power quality and identify the causes of various power supply malfunctions. The ability of the instrument to measure all power quality parameters simultaneously makes this process a quick and simple one.
The following is the description of the investigation process for the power quality.

Step 1: Clarifying the purpose

To find the cause for the power supply malfunction

A power supply malfunction such as an equipment failure or malfunction has occurred and you wish to address it quickly.

Go to Step 2 (p. 16).

To assess power supply quality (power quality)

There is no known problem with the power supply, and you just want to assess the power quality.
- Periodic power quality statistical investigation
- Testing after the installation of electric or electronic equipment
- Load investigation
- Preventive maintenance

Go to Step 3 (p. 16).

Step 2: Identifying the malfunctioning component (measurement location)

Check the following:

(1) Where is the issue occurring?

- Principal electrical system
  Large copier, uninterruptible power supply, elevator, air compressor, air conditioning compressor, battery charger, cooling system, air handler, time-controlled lighting, variable-speed drive, etc.
- Electric distribution system
  Conduit [electrical conduit] damage or corrosion, transformer heating or noise, oil leak, circuit breaker operation or overheating

(2) When does the issue occur?

- Does it occur continuously, regularly, or intermittently?
- Does it occur at a specific time of the day or on a specific day of the week?

(3) What type of investigation (measurement) should be performed to find the cause?

- Measure the voltage, current (power) continuously to analyze voltage and current trends when the issue occurs.
- Concurrent measurements at more than one location
  Examples:
  - Dedicated systems lines in the electrical substation (can be measured only by the power companies)
  - High-voltage and low-voltage lines of the service entrance
  - Distribution panels and switchboards
  - Power feeder and outlets of power supply for electric and electronic equipment

(4) What is the expected cause?

- Abnormal voltage
  RMS value trends, waveform distortion, transient overvoltage
- Abnormal current
  Leakage current, inrush current

Step 3: Checking investigation (measurement) locations (collecting site data)

Collect information (site data) from as many locations as possible to prepare for the investigation. Check the following:

(1) Wiring

1P2W / 1P3W /
3P3W2M / 3P3W3M / 3P4W

3P4W2.5E (available after the firmware update)

(2) Declared input voltage

100 V to 800 V

(3) Frequency

50 Hz/60 Hz

(4) Is the voltage between the neutral line and ground, and neutral line current required to be measured?

If the measurements are required, CH4 of the wiring settings should be set to ON. See p. 48, and p. 64.

(5) Current capacity

Current capacity is required to select current sensors used for the measurements.

(6) Other items related to the whole facility

- Other systems causing power supply malfunctions
- Principal electrical system operating cycle
- Any additions or changes to facility equipment
- Check of the power distribution system in the facilities

Step 4: Making measurements with the power quality analyzer (measurement procedure)

Measurements are performed using the following procedure:

Preparations

Attach accessories and optional equipment required for the measurements to the Power Quality Analyzer.
See “2 Preparing for Measurement” (p. 35).

Measurement settings/Connections/Wiring*

Configure the conditions required for the measurements and connect voltage cord and current sensors to the instrument.
Connect the wires to the measuring object and check if there is any mistake.
See “Installation Environment” (p. 7) and “4 Wiring (WIRING Screen)” (p. 47).

Recording settings/Event settings*

Configure the conditions and events required for recording.
If the EVENT indicator on the screen (p. 32) frequently changes to red, too many events have occurred.
When the number of events reaches 9999 during recording/measurement, subsequent events will not be recorded (trend recording continues). Adjust the event settings as required.
See “5 Setting Change (SET UP Screen)” (p. 63).

Measured value check

Press the **[MONITOR]** key, and use the **MONITOR** screen to check if there is any problem with the values measured.
See “6 Verifying the Waveform, Measured Values (MONITOR Screen)” (p. 81).

Recording start*

Press the **[START/STOP]** key to start recording.
See “7 Recording (Save) (SET UP Screen)” (p. 91).

Analysis/Actions

Continue recording for the period necessary for the analysis, check the state of the power supply malfunction based on the detected events.

Check while recording	▶	“8 Verifying the Trends (Fluctuations) in Measured Values (TREND Screen)” (p. 95), and “9 Checking Events (EVENT Screen)” (p. 105).
Check after recording is stopped	▶	“11 Analysis (with Computer)” (p. 129)

Next, take the preventive measures for the power supply malfunction.
(The instrument is effective not only for the power supply investigation but also to check after taking the measures for the power supply malfunction.)

*: Use “Quick Set” for easy and secure setting, and recording start!

The Quick Set allows easy and secure procedure for setting and recording start by following the navigation of the instrument.
The event settings also allows typical setting by only selecting the menu.
(Menu: Voltage events, Inrush current, Trend record only, EN50160)
See “3 Quick Set” (p. 45), supplied Measurement Guide.

Advice for identifying the cause of abnormalities

■ Record voltage and current trends at the power circuit inlet.

If the voltage drops while the building's current consumption rises, the likely cause for power abnormality lies inside the building. If the voltage and current are both low, the cause is likely to lie outside the building.
It's extremely important to select the right measurement locations and measure current for troubleshooting.

■ Check power trends.

Overloaded equipment can cause problems. By understanding power trends, you can more easily identify problematic equipment and locations.
See "8 Verifying the Trends (Fluctuations) in Measured Values (TREND Screen)" (p. 95).

■ Check when the problem occurs.

Equipment that is operating or turning on or off when events (abnormalities) are recorded may be the cause of malfunction. By understanding the precise times at which events start and stop, you can more easily identify problematic equipment and locations.
See "9 Checking Events (EVENT Screen)" (p. 105).

■ Check for heat and unusual sounds.

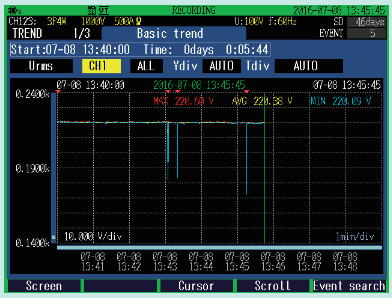
Motors, transformers, and wiring may produce heat or unusual sounds due to causes such as overloading or harmonics.

1.2 Product Overview

The PQ3100 Power Quality Analyzer is a measuring instrument used to manage power quality and identify abnormalities of the power line to analyze the cause of the trouble.

All parameters can be recorded simultaneously.

Trends and power abnormalities (events) of all parameters can be recorded simultaneously.



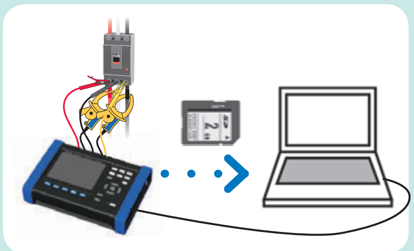
The instrument guides the procedures.

The Quick Set function allows proper and easy item settings and connections required for measurements by following the steps.

See “3 Quick Set” (p. 45), Measurement Guide (provided separately).

Data can be easily analyzed and reported.

The data loaded to a computer can be easily analyzed and reported with the supplied software.



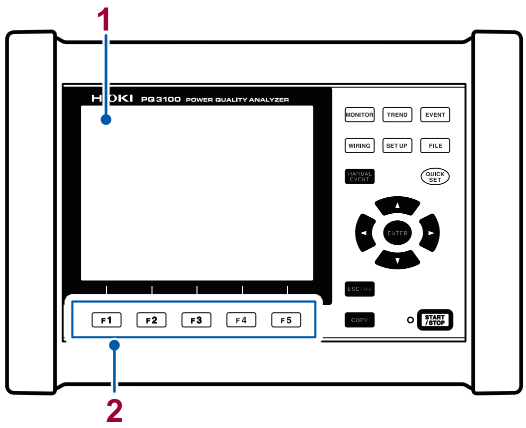
See “11 Analysis (with Computer)” (p. 129) and “12 Communications (USB/LAN/RS-232C)” (p. 137).

1.3 Features

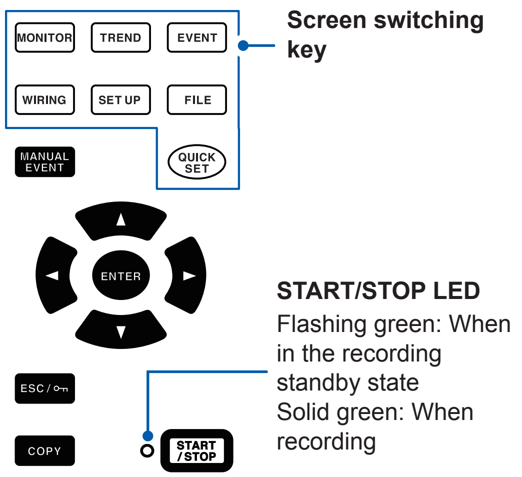
Long-term event waveform recording	Waveforms for up to 11.2 s when event occurs (1 s before event, 0.2 s on event, 10 s after event) can be saved for power abnormality analysis.
DC (Direct Current) measurements	DC voltages can be measured. AC/DC Auto Zero Sensor allows DC current measurements.
Easy and secure	The Quick Set allows easy operations by following the steps for secure measurements. Continuous calculation without a gap also allows simultaneous measurements of all the parameters required for the power quality measurements to securely identify the phenomenon.
Wiring check	Checks the wiring state. If the instrument has been connected improperly, tips for correct connections will be displayed by the help function.
Easy analysis and reporting of data	The supplied software PQ One allows easy analysis and reporting of the data.
Safety	Compatible with CAT III 1000 V and CAT IV 600 V
High accuracy	Voltage measurement accuracy of ±0.2% rdg. Complies with the IEC61000-4-30 Class S international power quality standard
4 voltage channels 4 current channels	Measurements for voltage between neutral line and ground, and neutral line current are available for 3-phase 4-wire wiring.
Transient measurements	Transient measurements for 5 kHz to 40 kHz, up to 2200 V
3-channel simultaneous ΔV10 flicker measurement	(Available after the firmware update) 3-channel simultaneous ΔV10 flicker measurement is available.
Simultaneous measurement of line voltage and phase voltage for 3-phase	For 3-phase 3-wire 3-watt meter measurement (3P3W3M) and 3-phase 4-wire measurement (3P4W), both line voltage and phase voltage are measured and output. Line voltage or phase voltage, whichever is selected, is displayed.
Extensive lineup of current sensors	You can choose the best current sensors for your measurement application ranging from leakage currents to a maximum rating of 6,000 A. The instrument can feed the power to both Flexible Current Sensor and AC/DC Auto-Zero Sensor enabling you to make long-term measurements without worrying about the power supply.
Ability to operate for about 8 hours on battery power	Even when AC power is not available, the supplied battery pack can be used for about 8 hours of measurement.
Broad operating temperature range	Operating temperature range is from −20°C to 50°C. However, the operating temperature range is from 0°C to 50°C when Battery Pack is used.
Saving to SD memory cards	Data can be continuously recorded to an optional 2 GB or an 8 GB memory card for up to one year.
TFT color LCD	The instrument uses an LCD that is easy to see in both dim and bright conditions.
Communications functionality	The instrument includes standard USB and Ethernet interfaces to connect a computer for the following operations. • To configure the instrument using a computer. • To download data from the instrument to the computer. • To operate the instrument remotely. See “12 Communications (USB/LAN/RS-232C)” (p. 137).

1.4 Names and Functions of Parts

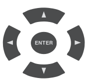
Front



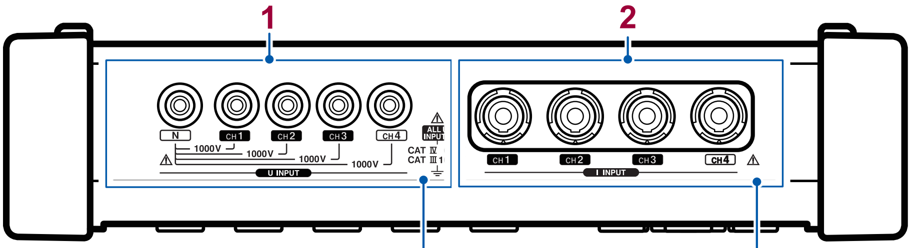
Operation keys



No.	Name and description	Reference
1	**Display** 6.5″ TFT color LCD	p. 24
2	**Function key ([F1] to [F5] key)** Select and change display contents and settings.	—

Keys	Description	Reference
MONITOR	Displays and changes the **MONITOR** screen (waveform and measured values).	p. 81
TREND	Displays and changes the **TREND** screen (time series trend graphs).	p. 95
EVENT	Displays and changes the **EVENT** screen (event status). (Version upgrade supported for switching)	p. 105
WIRING	Displays and changes the **WIRING** screen (wiring settings, wiring check).	p. 47
SET UP	Displays and changes the **SET UP** screen (settings).	p. 63
FILE	Displays and changes the **FILE** screen (SD memory card/internal memory).	p. 115
QUICK SET	Displays and changes the **QUICK SET** screen. Pressing this key during recording allows checking the current main settings.	p. 45 Measurement Guide
MANUAL EVENT	An event occurs at the timing when this key is pressed during recording. The voltage and current waveforms and measured values when an event occurs are recorded.	—
	Moves the cursor on the screen. Scrolls through graphs or waveforms. ENTER: Selects items on the screen and accepts changes.	—
ESC / O-	Cancels any selections or changes made and reverts to the previous settings. Switches to the previous screen. Pressing and holding this key for at least 3 s activates the key lock function. (Same operation for unlock)	—
COPY	Outputs the image of the currently displayed screen to the SD memory card.	p. 121
START / STOP	Starts and stops recording.	p. 91

Upper

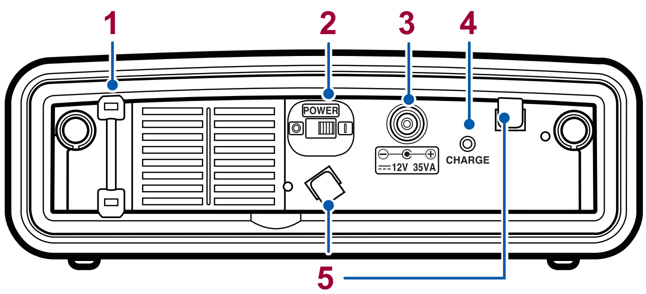


⚠ “4.3 Connecting Voltage Cords to Instrument” (p. 51)

⚠ “4.4 Connecting Current Sensors and Configuring Current Sensor Settings” (p. 52)

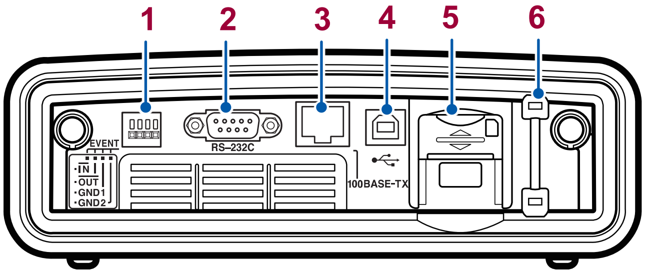
No.	Name	Description	Reference
1	**Voltage input terminal**	Connects supplied L1000-05 voltage cord to one of the jacks.	p. 51
2	**Current input terminal**	Connects optional current sensors.	p. 52

Left



No.	Name	Description	Reference
1	**Strap eyelet**	Attaches the strap.	p. 39
2	**POWER Switch**	Turns the instrument on and off.	p. 44
3	**AC adapter connection jack**	Connects the AC adapter.	p. 43
4	**CHARGE LED**	Lights up when the Z1003 Battery Pack is charging.	p. 38
5	**Hook for AC adapter**	Loops the AC adapter cord through these hooks.	p. 43

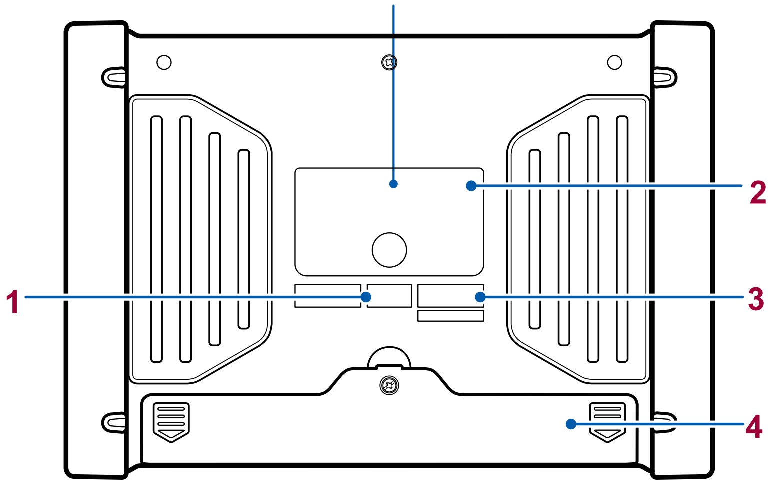
Right



No.	Name	Description	Reference
1	**External I/O terminals**	Uses commercially available wires to connect with external devices.	p. 147
2	**RS-232C interface**	Connects to a computer using the optional RS-232C cable.	p. 145
3	**LAN interface**	Connects to a computer using the LAN cable.	p. 138
4	**USB port**	Connects to a computer using the supplied USB cable.	p. 131
5	**SD memory card slot**	Inserts an SD memory card. Be sure to close the cover when recording.	p. 42
6	**Strap eyelet**	Attaches the strap.	p. 39

Back

⚠ “Installing the battery pack” (p. 38)

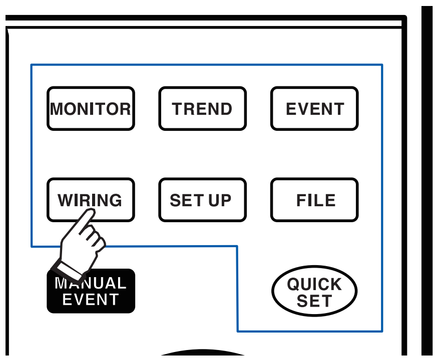


No.	Name	Description	Reference
1	**MAC address label**	Displays the instrument’s unique MAC address. This address is used when configuring a LAN connection. Do not remove the label as the information is necessary for managing the device.	p. 138
2	**Label**	Indicates the warning, CE mark, KC mark, WEEE Directive mark, and manufacturer.	—
3	**Serial No.**	Do not remove the label as the information is necessary for managing the device.	—
4	**Battery compartment**	Installs the supplied Z1003 Battery Pack within the compartment.	p. 38

1.5 Screen Configuration

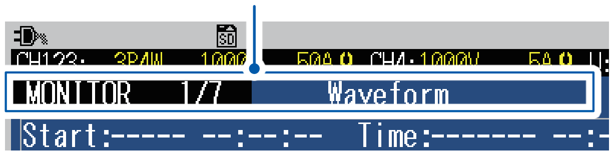
Displaying and switching screens

<table>
<tr><th>Use operation keys (screen switching key)</th><th>Use [F1] (SCREEN) key to switch screens</th></tr>
<tr><td>



The screens consist of seven screens each of which corresponds to the operation keys.
The screen corresponding to the key pressed is displayed.
The screen can be switched by pressing the key repeatedly.

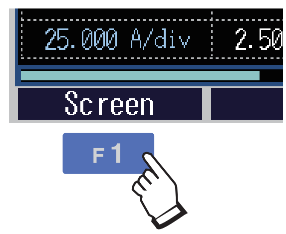
Screen name



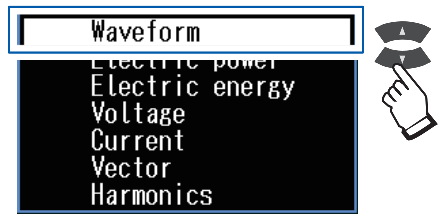
</td><td>

Screen example: **MONITOR** screen

1



2



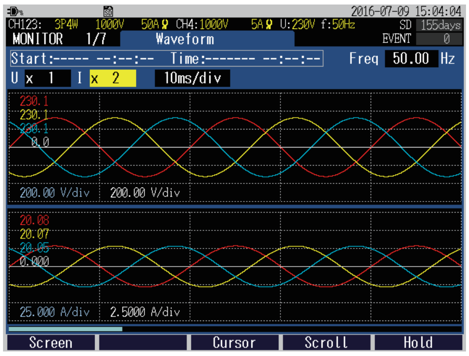
</td></tr>
</table>

MONITOR screen

A screen that is used to monitor instantaneous values. This screen is used to view voltage and current instantaneous waveforms, and the measured values.

Display/switch screen: **[MONITOR]** key
See “6 Verifying the Waveform, Measured Values (MONITOR Screen)” (p. 81).

Waveform screen



Voltage and current waveforms of CH1 to CH4 are displayed.

Electric power screen

RMS voltage, RMS current, frequency, power, power factor, active energy (consumption) and elapsed time are displayed.

Electric energy screen

Electric energy, energy cost, start time, stop time, elapsed time, power and power factor are displayed.

Voltage screen

Measured values related to voltage are displayed.

Current screen

Measured values related to current are displayed.

Vector screen

Phase relationship between voltage and current is displayed in a vector diagram.

Harmonics screen

Harmonic current, harmonic voltage, and harmonic power from 0 to 50th order are displayed.

Zoom screen (available after the firmware update)

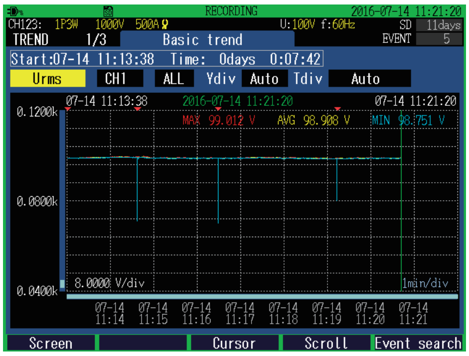
Enlarged view of 6 user-selected parameters are available.

TREND screen

A screen used to check the trend (fluctuations) of the measured values.

Display/switch screen: **[TREND]** key
See “8 Verifying the Trends (Fluctuations) in Measured Values (TREND Screen)” (p. 95).

Basic trend screen



This screen is used to check fluctuation width of maximum, minimum and average values between recording intervals.

Detail trend screen

This screen is used to check fluctuation width of maximum and minimum values between recording intervals for the following parameters.

- RMS voltage refreshed each half-cycle
- RMS current refreshed each half-cycle
- Inrush current
- Frequency (1 wave)

Electric energy screen

This screen is used to check electric energy trends for each recording interval.

Demand screen (available after the firmware update)

This screen is used to check demand trends.

Harmonics trend screen (available after the firmware update)

This screen is used to check trends of harmonics and interharmonics.

Flicker screen (available after the firmware update)

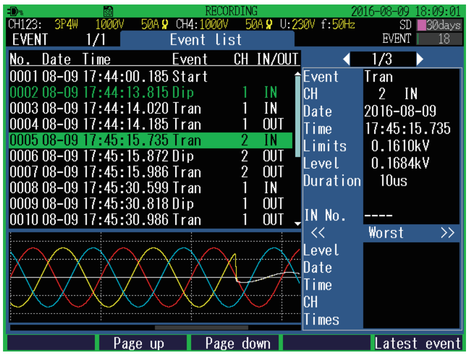
This screen is used to check trends of IEC flicker or ΔV10 flicker.

EVENT screen

A screen used to check the event status.

Display/switch screen: **[EVENT]** key
See “9 Checking Events (EVENT Screen)” (p. 105).

Event list screen



Events can be checked on the list.
The events are sorted in the order of occurrence.

Event statistics screen (available after the firmware update)

This screen is used to check the statistical results for each event type.

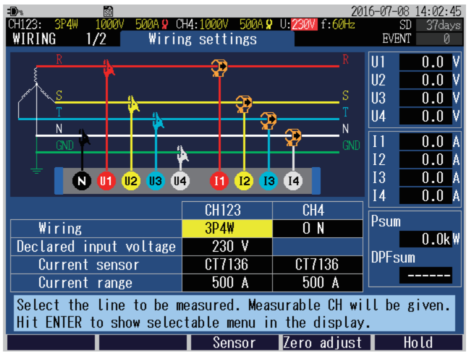
EVENT MONITOR screen: See p. 111.

WIRING screen

A screen used to check the wiring settings.

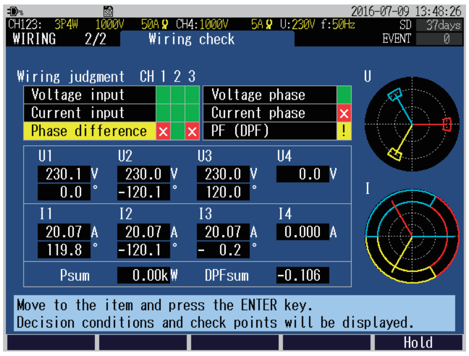
Display/switch screen: **[WIRING]** key
See “4 Wiring (WIRING Screen)” (p. 47).

Wiring settings screen



This screen is used to configure the wiring.
Make wiring by checking the wiring diagram.

Wiring check screen



This screen is used to check whether the instrument has been connected properly.

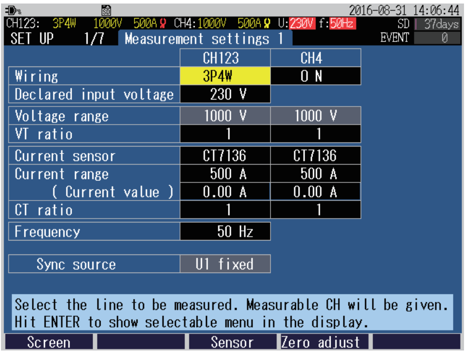
SET UP screen

A screen used to configure settings.

Display/switch screen: **[SET UP]** key

See “5 Setting Change (SET UP Screen)” (p. 63).

Measurement settings 1 screen



This screen is used to configure the wiring.

Measurement settings 2 screen

This screen is used to configure settings for calculation method, energy cost, and flicker (available after the firmware update).

Recording settings screen

This screen is used to configure the settings for recording.

Event settings 1 screen

This screen is used to configure the event threshold value and hysteresis for voltage and current.

Event settings 2 screen

This screen is used to configure the timer event, external event, and event waveform recording time.

System settings screen

This screen is used to configure the clock, beep sound, language, display color, and phase name.

Interface settings screen

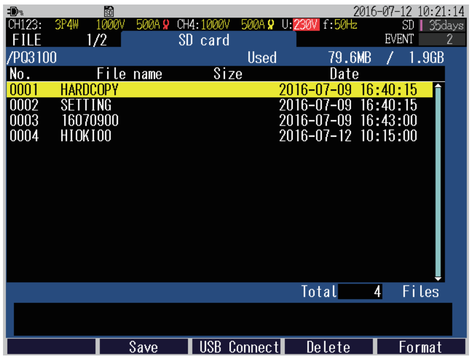
This screen is used to configure the settings for LAN, RS-232C, and external output.

FILE screen

A screen used for file operations.
This screen allows listing and operations for files of the SD memory card and internal memory.

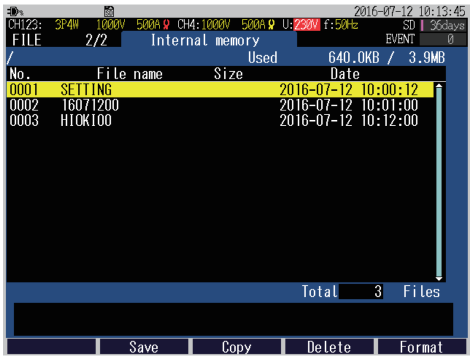
Display/switch screen: **[FILE]** key
See "10 File Saving and Operations (FILE Screen)" (p. 115).

SD card screen



This screen shows lists of folders and files in the SD memory card.

Internal memory screen



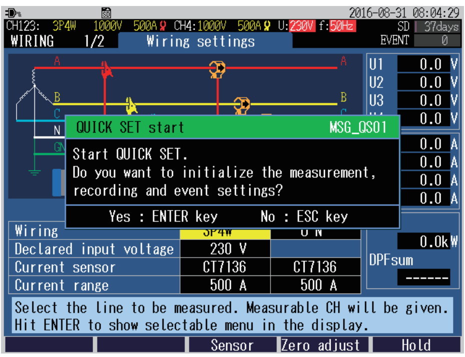
This screen shows lists of folders and files in the internal memory.

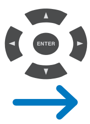
QUICK SET screen

Minimum conditions required for recording can be set by following the Quick Set instructions.

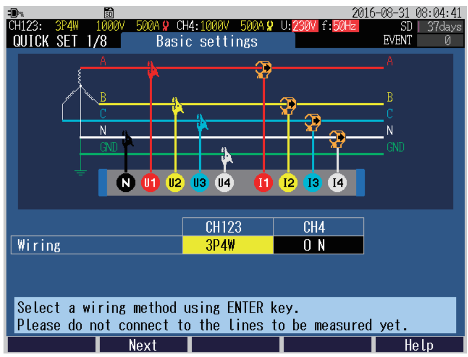
Quick Set start: **[QUICK SET]** key
See "3 Quick Set" (p. 45) and refer to Measurement Guide (provided separately).

Quick Set start dialog





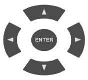
Press the **[ENTER]** key.

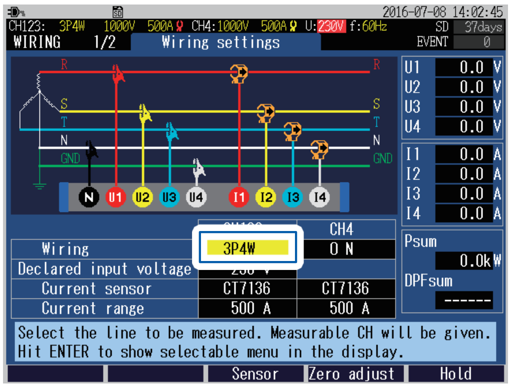


1.6 Basic Key Operations

See “1 Displaying and switching screens” (p. 24).

Changing the required items

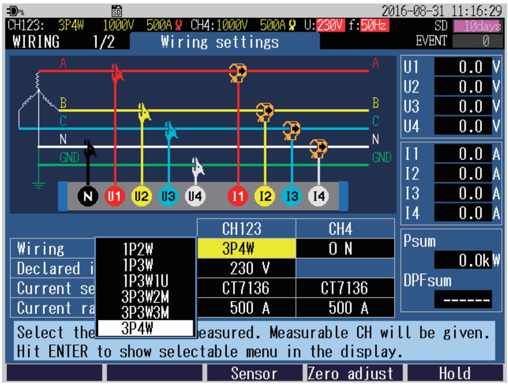
1  **Move the cursor to the item.**



2  **The drop down list will be displayed.**

3  **Select an item.**

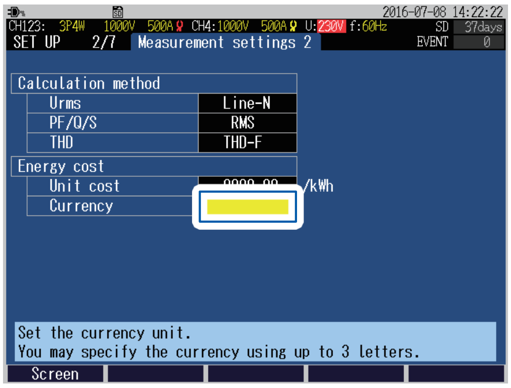
4  **Accept the setting.**



On the **MONITOR** screen and the **TREND** screen, the items can be changed by pressing the keys  without the drop-down list box displayed.

Entering characters

1 **Move the cursor to the item.**



2 ENTER A dialog box will be displayed.

3

: **Character selection**

ENTER: **Input**

ESC / : **Delete a character**

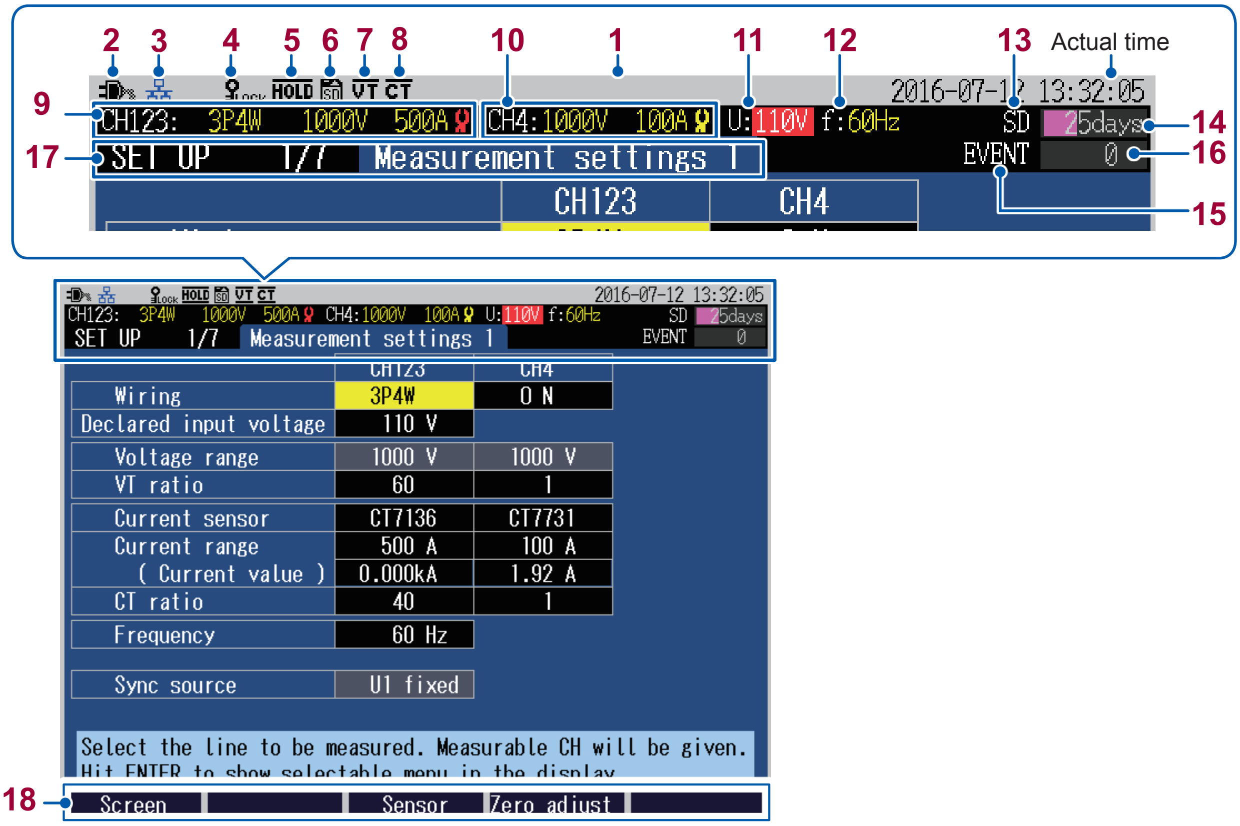
4

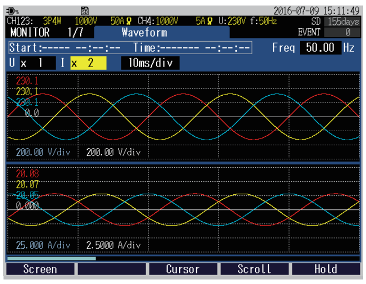
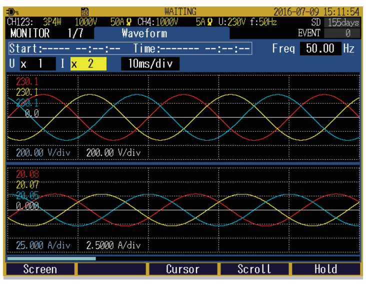
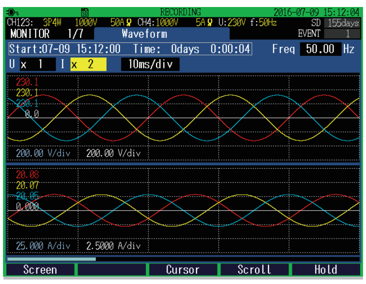
F4: **OK**
The setting will be accepted.

F5: **Cancel**
The entry will be canceled.

1 Overview

1.7 Screen Display



No.	Display	Description	
1	Operation status		**Gray (no character):** (START/STOP LED: Off) • Recording is stopped. • The setting can be changed.
			**Yellow (WAITING):** (START/STOP LED: Blinking) • Recording is in standby. • This screen is shown from the time the **[START/STOP]** key is pressed until the recording actually starts. • During repeated recording, this screen is also displayed when recording is stopped. • The setting cannot be changed.
			**Green (RECORDING):** (START/STOP LED: On) • Recording is in progress. • The setting cannot be changed.

No.	Display	Description	Reference
2		The instrument is operating with the AC adapter.	p. 43
		The instrument is running on the battery.	p. 38
	(Blinking)	The instrument is running on the battery, which is almost out of charge. Connect the AC adapter and charge the battery.	p. 38
3	(Black)	The LAN is connected.	p. 138
	(Blue)	The HTTP server is connected.	p. 143
4	LOCK	The key lock is engaged.	p. 21
5	HOLD	Holding the screen display.	p. 58 p. 81
6	SD (Black)	The SD memory card is inserted and identified.	p. 42
	SD (Red)	The SD memory card is locked. Unlock it.	
7	VT	The VT ratio has been set.	p. 64
8	CT	The CT ratio has been set.	
9	CH123:	Wiring, voltage range, and current range for CH1 to CH3. (Red): No current sensors are connected. Otherwise, the sensors are erroneously configured. (p. 52) (Yellow): The current sensors are correctly configured.	p. 48 p. 64
10	CH4:	Voltage range and current range for CH4. When CH4 is OFF, no icon is displayed. (Red): No current sensor is connected. Otherwise, the sensor is erroneously configured. (p. 52) (Yellow): The current sensor is correctly configured.	
11	U:230V	Declared input voltage.	
12	f:60Hz	Measuring frequency (nominal frequency).	p. 64
13	SD (Black background)	The SD memory card has been inserted in the instrument.	p. 42
	SD (Green background)	The SD memory card is being accessed.	
	MEM (Black background)	As no SD memory card is inserted to the instrument, measured data will be saved in the instrument's internal memory. The shortest recording interval of the internal memory is 2 s. If the interval is set to 1 s or less, measured data cannot be saved in the internal memory.	
	MEM (Green background)	The internal memory is being accessed.	
14	25days	Indicates how much recording time or days remains on the SD memory card or in the instrument's internal memory. If the event data is recorded as well, the actual recording time will become shorter than the displayed recording time. The utilization status is indicated with a level meter.	

No.	Display	Description	Reference
15	EVENT (Black background)	No event has been detected.	
	EVENT (Red background)	Event IN (detection) state.	
16	1234	Number of events recorded. Up to 9999 events. The event detection status is indicated with a level meter.	
17	**Screen name**	This is the screen name. Select with the key. [(Present screen number) / (number of screens)] is displayed within the screen. (See “1.5 Screen Configuration” (p. 24) for details.)	
18	**F key text**	Texts of function keys assigned for each screen.	

1.8 Error Screen Display

Display	Description
1000V	If a voltage peak over, i.e., that the peak of the voltage exceeds 2200 V or falls below −2200V, occurs, the background of the voltage range turns red.
1000V	If a voltage overrange, i.e., that the voltage exceeds 1300 V, occurs, the background of the voltage range turns yellow.
50A	If a current peak over, i.e., that the peak of the current exceeds 400% of the present range or falls below −400% of it, occurs, the background of the current range turns red.
50A	If a current overrange, i.e., that the current exceeds 130% of the present range, occurs, the background of the current range turns yellow.
U:230V	When a voltage value exceeds a certain ratio based on the declared input voltage, the background color turns any of the following colors: 110% < Yellow 90% ≤ (Regular background color) ≤ 110% 80% ≤ Yellow < 90% Red < 80%
f:50Hz	When the measured value is different from the declared frequency, the background of the declared frequency turns red.
over	Measured value became overrange (the measurement is out of measuring range). The voltage that the instrument is capable of measuring is being exceeded. Immediately disconnect the instrument. If the current is overrange, increase the current range.
--------	Measurement is not possible. Shown instead of the measured value. If there is no input, the power factor cannot be measured.

2 Preparing for Measurement

Before starting measurement, connect accessories and options to this instrument. Before performing measurement, be sure to read “Operating Precautions” (p. 7) and to inspect the instrument, accessories, and options to ensure that there is no damage.

2.1 Preparation Flowchart

Follow the procedure for preparation described below. (The items preceded by † need to be performed only during the first use.)

† Initial Measurement Preparations

- Color coding of current sensor (for channel identification) (p. 36)
- Bundling the voltage cords and current sensors (If required) (p. 37)
- Installing the battery pack. (p. 38)
- Attaching the strap (if required) (p. 39)
- Setting the language, clock, and measurement frequency (p. 40)

↓

Pre-Measurement Inspection (p. 41)

↓

Inserting the SD Memory Card (p. 42)

↓

Power Supply (p. 43)

↓

Turning On the Instrument (p. 44)

↓

Warm-up (p. 44)

- At least 30 min

2.2 Initial Measurement Preparations

Color coding of current sensor (for channel identification)

Be sure to read “Handling Cords and Cables” (p. 8).

At both the ends of the current sensor cable, connect the spiral tube of the same color as the channel which is to be connected to the current sensor, to avoid wiring mistakes.

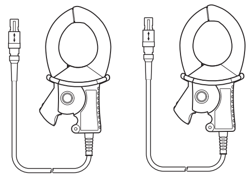
Example: In the case of using 2 current sensors

Required items

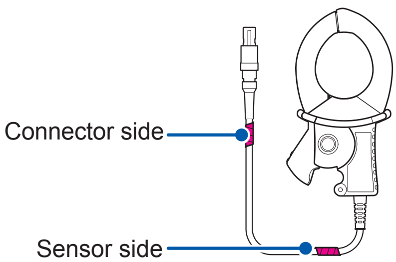
☐ Color Spiral tubes
(for color-coding the current sensor)

Red (thin) × 2
Yellow (thin) × 2

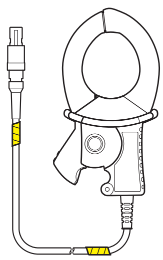
☐ Current sensor in use × 2



(Diagram of Model CT7136)



Color Spiral tubes for CH1 (red)



Color Spiral tubes for CH2 (yellow)

Measuring object	Number of current sensors in use (Colors of the CH and color spiral tubes)
Single-phase 2-wire (1P2W)	1 (CH1 red)
Single-phase 3-wire (1P3W)	2 (CH1 red, CH2 yellow)
3-phase 3-wire (3P3W2M)	
3-phase 3-wire (3P3W3M)	3 (CH1 red, CH2 yellow, CH3 blue)
3-phase 4-wire (3P4W)	

Bundling the voltage cords and current sensors (If required)

Be sure to read “Handling Cords and Cables” (p. 8), “Using Voltage Cords” (p. 8).

If required, group the cables together by using the spiral tubes (black).

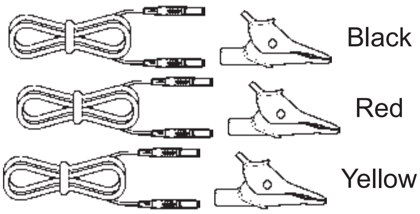
Example: In the case of using 3 voltage cords and 2 current sensors

Required items

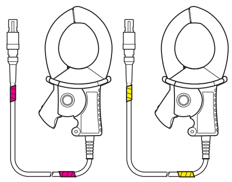
☐ Spiral tubes (for grouping the cables together)

 Black (thick) ×10

☐ Model L1000-05 Voltage Cord ×3

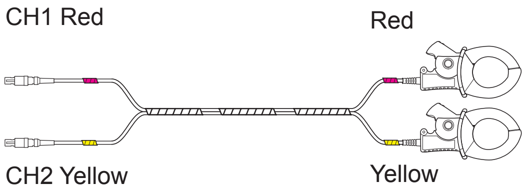


☐ Current sensor in use ×2



(The model illustrated above is Model CT7136)

Model L1000-05 Voltage Cord



Current sensor

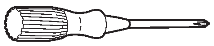
Installing the battery pack

Be sure to read “Using Battery Pack” (p. 9).

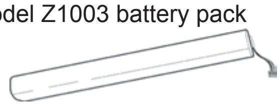
The battery pack is subject to self-discharge. Be sure to charge the battery pack before initial use (See Step 7).
If the battery can only be used for a considerably short time even after correct charging, replace it with a new battery pack.

Required items

- ☐ Phillips screwdriver (No. 2)



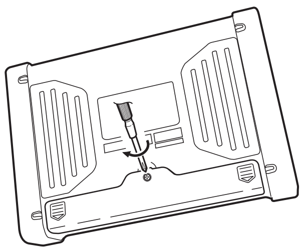
- ☐ Model Z1003 battery pack



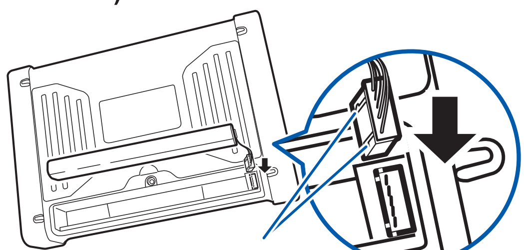
1 **Turn off the instrument. (p. 44)**

2 **Remove all cords.**

3 **Turn the instrument over, remove the screws on the primary battery compartment and remove the cover.**



4 **Connect the plug of the Model Z1003 battery pack to the connector of the instrument. (Turn the 2 projection surfaces of the plug to the left and connect.)**

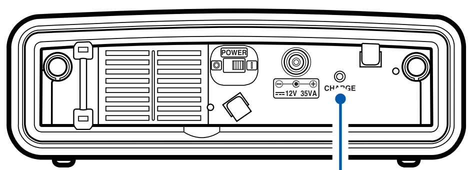


5 **Insert the battery pack in the direction that is indicated by the labeling on the battery pack.**
Be careful not to pinch the wires of the battery pack.

6 **Put the cover and tighten the screws.**

7 **Connect the AC adapter (p. 43) to the instrument and charge the battery pack.**
The battery pack will be charged regardless of whether the power is ON or OFF.

(Left side surface of the instrument)



CHARGE LED

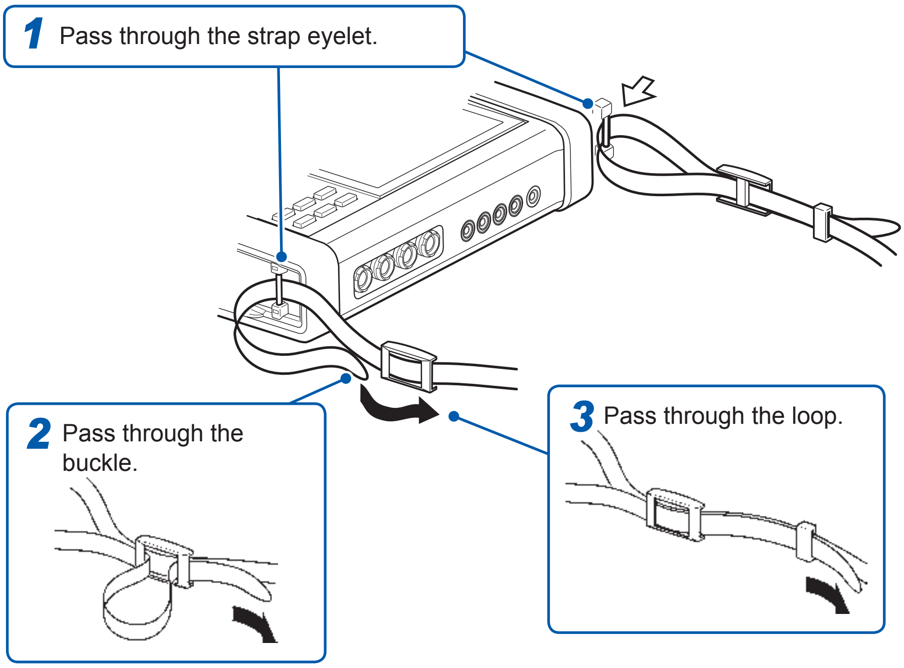
Solid red	During charging
Off	Fully charged or when the battery is not attached

- The battery pack is used as a backup power supply for the instrument during interruption. When fully charged, it can provide backup power for approximately 8 hours in the event of an interruption.
- Note that if an interruption occurs while the battery pack is not being used, the displayed time series data will be erased. (Data that has been recorded on the SD memory card and instrument’s internal memory will be retained.)
- For more information about the operating temperature and humidity and the storage temperature and humidity, see “14.1 General Specifications” (p. 153).

Attaching the strap (if required)

Be sure to read “Attaching the Strap” (p. 10).

If required, attach the strap when carrying the instrument or hanging it on a hook at the installed location.



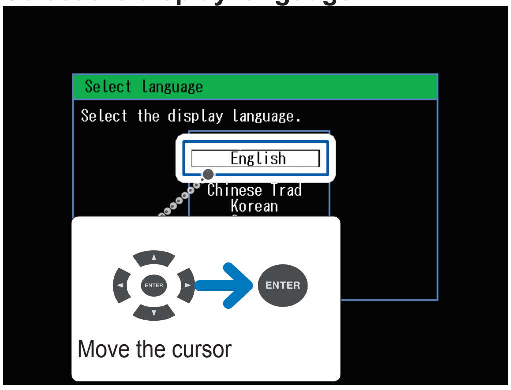
Tighten the straps securely to avoid loosening or twisting.

Setting the language, clock, and measurement frequency

When you turn on the instrument for the first time after purchase, the language setting screen, clock setting screen, and frequency setting screen will be displayed. Configure these settings.
Similarly, these settings must be configured if a factory reset (p. 77) is performed to reset the instrument to its default settings.

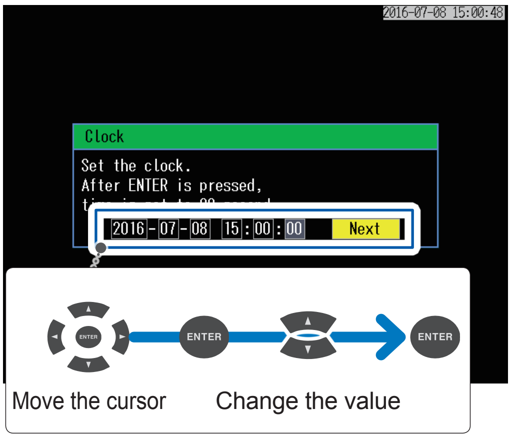
1 **Turn on the instrument. (p. 44)**

2 **Select the display language.**



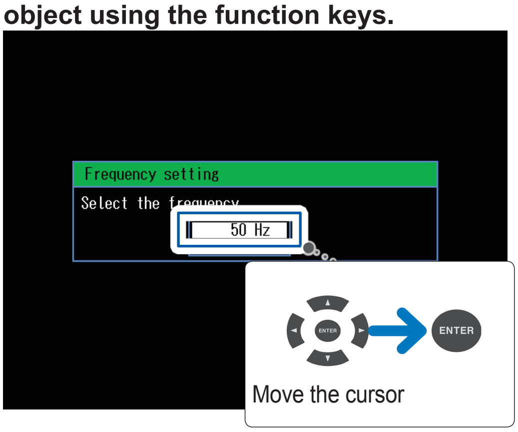
Japanese
English
Chinese Simple
Chinese Trad
Korean
German
French
Italian
Spanish
Turkish

3 **Set the date and time.**



The seconds cannot be set. If you press the **[Enter]** key after changing value, the seconds will be set to 00.

4 **Select the frequency for the measuring object using the function keys.**



The WIRING, wiring setting screen will be displayed.

Once you have set the display language, time, and measurement frequency, this settings screen will not be shown again when the instrument is turned on.
You can change these settings on the setting screen.
See Display language, time“System Settings” (p. 75), and measurement frequency“SET UP, Measurement Settings 1 screen” (p. 64).

2.3 Pre-measurement Inspection

Before using the instrument, verify that it operates normally to ensure that no damage occurred during storage or shipping. If you find any damage, contact your authorized Hioki distributor or reseller.

(1) Inspect the voltage cords
Is the insulation of the voltage cord damaged, or is bare metal exposed?

Yes → **Do not use if damage is present, as you could receive an electric shock. Contact your authorized Hioki distributor or reseller.**

No ↓

(2) Inspect the current sensor
- Is there any crack or damage in the jaw part?
- Is the insulation on the cables torn?

Yes → **Do not use if damage is present, as you could receive an electric shock. Contact your authorized Hioki distributor or reseller.**

No ↓

(3) Inspect the AC adapter
- Is damage to the AC adapter evident?
- Is the power cord's insulation damaged?

Yes → **Do not use if damage is present, as you could receive an electric shock. Contact your authorized Hioki distributor or reseller.**

No ↓

(4) Inspect the instrument
Is the device damaged?

Yes → **Do not use if damage is present, as you could receive an electric shock. Contact your authorized Hioki distributor or reseller.**

No ↓

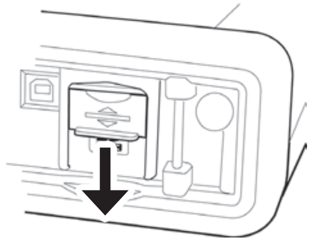
Inspection complete

2.4 Inserting the SD Memory Card

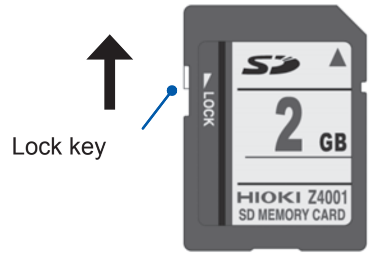
Be sure to read “Using SD Memory Cards” (p. 10).

1 **Turn off the instrument. (p. 44)**

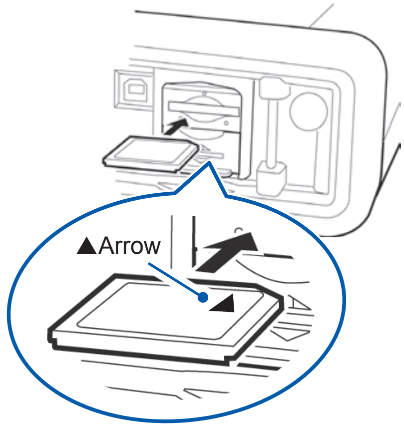
2 **Open the cover.**



3 **Disengage the lock.**

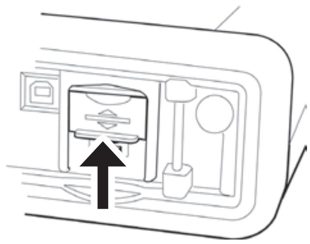


4 **Insert the SD memory card inside.**



Insert the card horizontally. Inserting the SD memory card at an angle may cause the write-protect lock to engage, preventing data from being written to the card.

5 **Close the cover.**



How to remove:

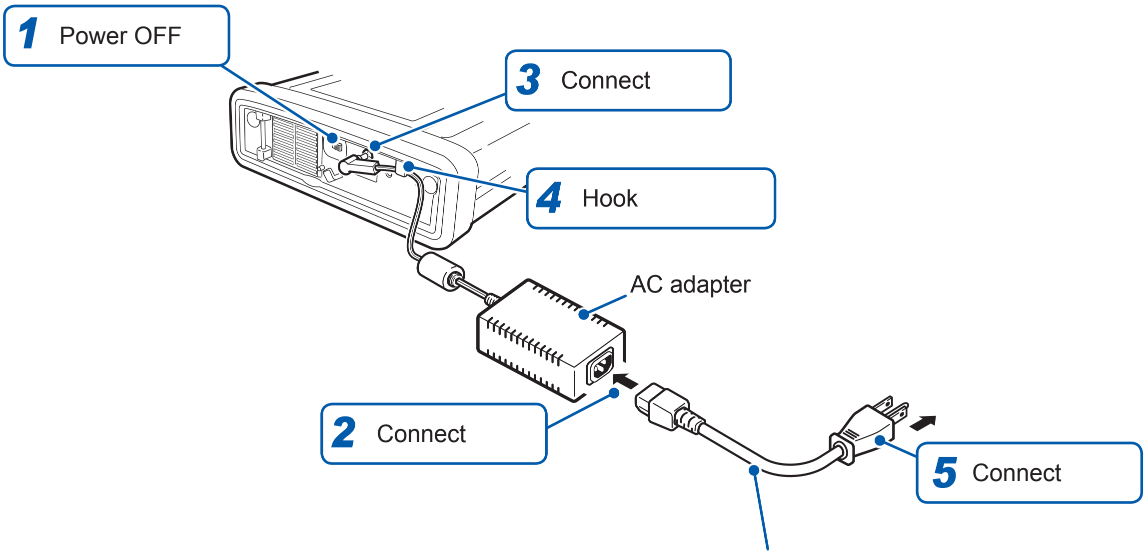
Open the cover, push in the SD memory card and then pull it out.

When storing the data to the SD memory card, configure the recording settings.
See “5.2 Recording Settings” (p. 69).

2.5 Power Supply

Be sure to read "Using AC Adapter" (p. 11).

Required items	
☐ Model Z1002 AC adapter	 (AC adapter + power cord)

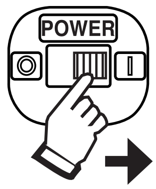


2.6 Turning On/Off the Instrument

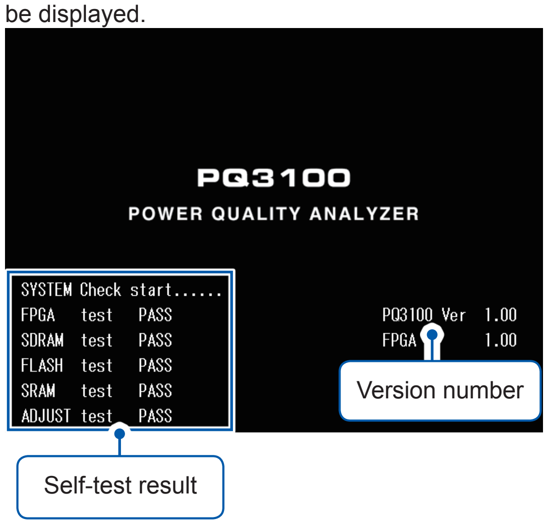
Be sure to read “Turning On the Instrument” (p. 11).
Turn on the instrument. After the measurement is complete, always turn off the power.

How to turn on the instrument

Slide the knob of the POWER switch toward ON (|) .



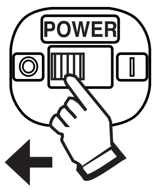
When the instrument is turned on, the Self-test screen will be displayed.



After the self-test is complete, the screen that appears before turning off the instrument will be displayed.
(When the instrument is turned on for the first time, the **WIRING, wiring settings** screen will be displayed.)

How to turn off the instrument

Slide the knob of the POWER switch toward OFF (○).



2.7 Warm-up

Warm up the instrument before performing the measurement to ensure accurate measurements.
After turning on the instrument, allow it warm-up for at least 30 min.

3 Quick Set

The Quick Set function allows easy settings for minimum recording/measurement requirements by following the guidance.
The setting proceeds in the following order: “1. Basic Settings,” “2. Device Connections,” “3. Voltage Wiring,” “4. Current Wiring,” “5. Wiring Check,” “6. Event Settings,” “7. Recording Settings,” and “8. Recording Start.”
See the supplied Measurement Guide for details.

3.1 Configurable Items

The items listed below can be configured with the Quick Set.
To configure other items not listed here*, see “3.2 Adding Settings” (p. 46).

*Example:
- Set the VT and CT ratios.
- Change the event settings.

Setting	Details
Wiring	Configure the wiring.
Current sensor	Configure the current sensor.
Declared input voltage	Configure the declared input voltage.
Current range	Configure the current range.
Easy settings course	After this course is selected, event settings and recording interval will be automatically configured.
Recording interval	Configure the recording interval.
Recording start method	Configure the recording start method.
Recording stop method	Configure the recording stop method.
Folder/File name	Configure the folder/ file name.
Clock	Configure the clock.

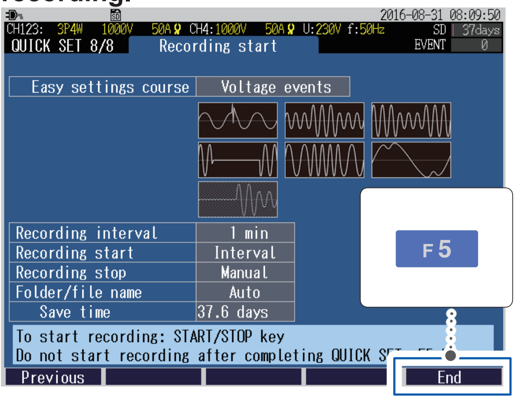
3.2 Adding Settings

Using the following procedure, normal settings can be applied in combination with the Quick Set to perform recording as desired:

1 **Press the [QUICK SET] key to start the Quick Set.**

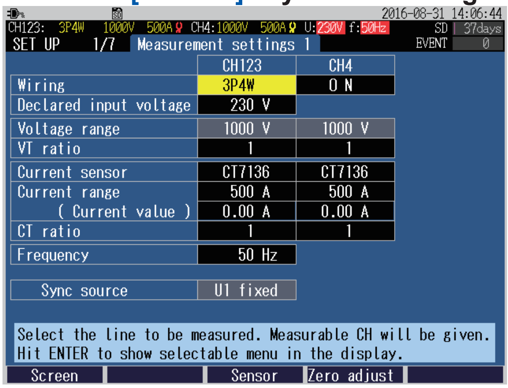
2 **Follow the Quick Set to proceed with the operations up to the QUICK SET, Recording start screen.**

3 **Exit the Quick Set without starting a recording.**



The Quick Set will be completed. All the setting that have been configured with the Quick Set will not be deleted.

4 **Press the [SET UP] key to add settings.**

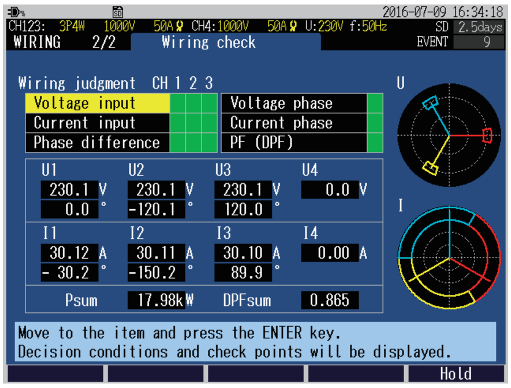


Example: Configure the VT ratio or CT ratio, change the event settings.

See “5 Setting Change (SET UP Screen)” (p. 63).

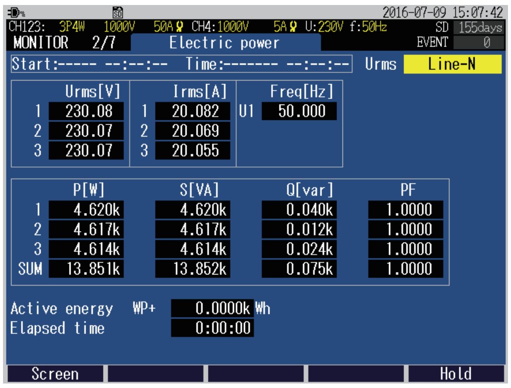
5 **Press the [WIRING] key to display the WIRING, Wiring check screen.**

6 **Reconfirm the wiring and measured values.**



See “4.9 Checking Wiring” (p. 59).

7 **Press the [MONITOR] key as required to check the measured values on the MONITOR screen.**



See “6 Verifying the Waveform, Measured Values (MONITOR Screen)” (p. 81).

8 **Press the [START/STOP] key.**

The recording will start.

4 Wiring (WIRING Screen)

4.1 Wiring Procedure

Connect the voltage codes and the current sensors to the instrument according to the following procedure.
This chapter explains the procedure for wiring without using the Quick Set.

Setting the wiring method and the declared input voltage

"4.2 Wiring Method and Declared Input Voltage Settings" (p. 48)

↓

Connecting the cords and the sensors and performing the zero adjustment

"4.3 Connecting Voltage Cords to Instrument" (p. 51)
"4.4 Connecting Current Sensors and Configuring Current Sensor Settings" (p. 52)
"4.5 Zero Adjustment" (p. 54)

↓

Connecting the voltage cords to the measuring object

"4.6 Connecting Voltage Cords to Objects" (p. 55)

↓

Attaching the current sensor to the measuring object

"4.7 Attaching Current Sensors to Objects" (p. 56)

↓

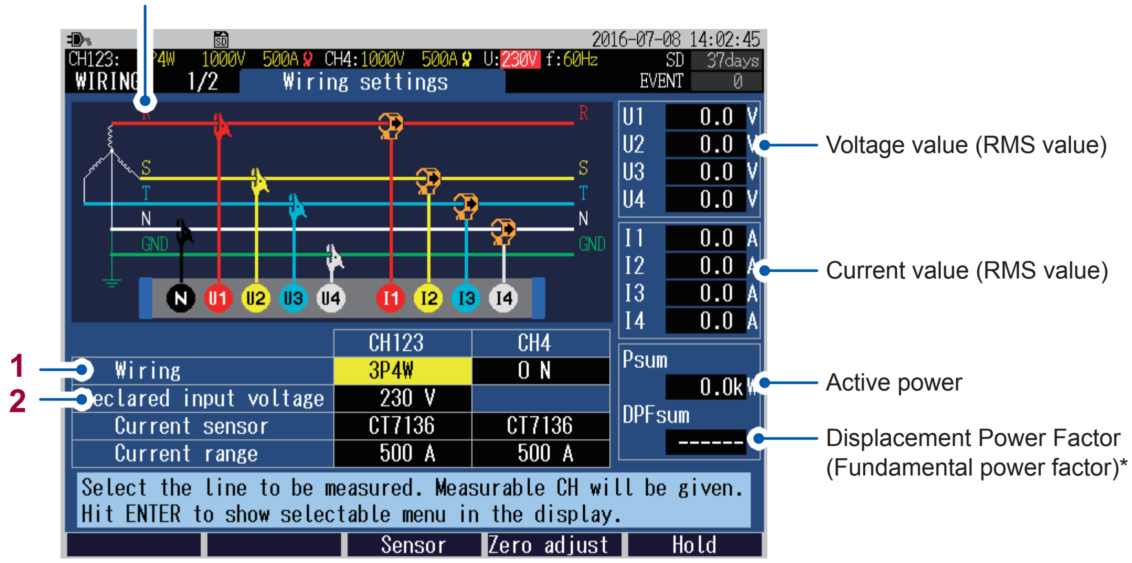
Checking the wiring

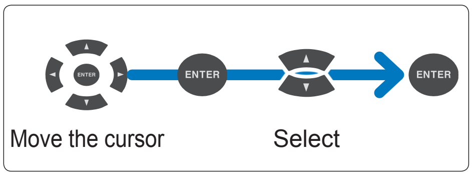
"4.9 Checking Wiring" (p. 59)

4.2 Wiring Method and Declared Input Voltage Settings

Press the **[WIRING]** key to display the **WIRING, wiring settings** screen.
Sets the wiring method and declared input voltage.

The wiring diagram (p. 50) of the specified wiring mode is displayed.





*: DPF (Displacement Power Factor) is displayed as the power factor irrespective of **PF/Q/S** calculation method settings of the **SET UP, measurement settings 2** screen in the **WIRING, wiring** setting screen.
See “SET UP, Measurement Settings 2 screen” (p. 66), and “Terminology” (p. Appx.24).

1 Enables you to select the wiring method for CH1 to CH3, and select ON/OFF of the input to CH4.

CH123	**1P2W**	Single-phase 2-wire line
	1P3W	Single-phase 3-wire line
	1P3W1U	Single-phase 3-wire line (1-voltage measurement) Although voltages should be usually input to 2 channels for the single-phase 3-wire line, a voltage is input to only CH1 in a simplistic way. Additionally, the power of 1P3W is calculated, assuming that the voltage U2 is equal to U1.
	3P3W2M	3-phase 3-wire line (2-watt meter method) Two line voltages and two line currents are measured to perform the 3P3W2M measurement. U3 is calculated from U1 and U2; I3, from I1 and I2. Although the active power of the 3-phase line as a whole is equal to the one measured by the 3P3W3M measurement, the balance of the each phase cannot be checked. To check the balances, select the **3P3W3M**. See “Appx. 7 3-phase 3-wire Measurement” (p. Appx.21).
	3P3W3M	3-phase 3-wire line (3-watt meter method) Three phase voltage from the virtual neutral point and three line currents are measured to obtain results for the 3-phase 3-wire line.
	3P4W	3-phase 4-wire line
	3P4W2.5E	3-phase 4-wire line (2-voltage measurement) Only the voltage U1 and U3 are measured to obtain results for the 3-phase 4-wire line. U2 is calculated from U1 and U3. (available after the firmware update)
CH4	**ON**	Enables the input to CH4. Voltage: To measure a voltage between the neutral line and the grounding wire To obtain the voltage values, the potential differences between the terminal N and each of the channels, CH1 through CH4. The voltage terminal N is shared by CH1 through CH3 and CH4. Inputting a voltage to CH1 through CH3 enables the U4 field to display the value even though no voltage is input to CH4. Current: To measure a neutral line current of 3P4W or 1P3W To measure a leakage current
	OFF	Disables the input to CH4.

2 Enables you to set the declared input voltage for the measurement line. It will be referenced for the event settings (swell, dip, interruption).
See “SET UP, Event Settings 1 screen” (p. 72).

Variable (**50 V** to **800 V** in 1 V increments), **100**, **101**, **110**, **115**, **120**, **127**, **200**, **202**, **208**, **220**, **230**, **240**, **277**, **347**, **380**, **400**, **415**, **440**, **480**, **600**

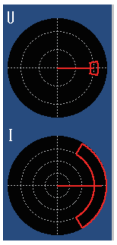
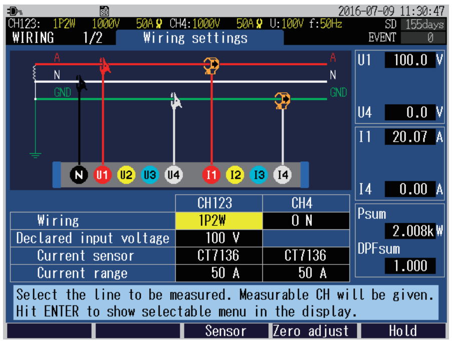
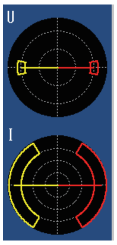
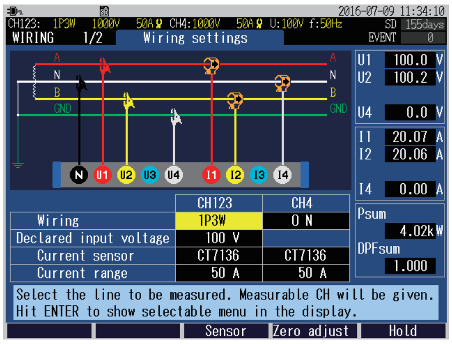
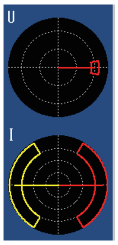
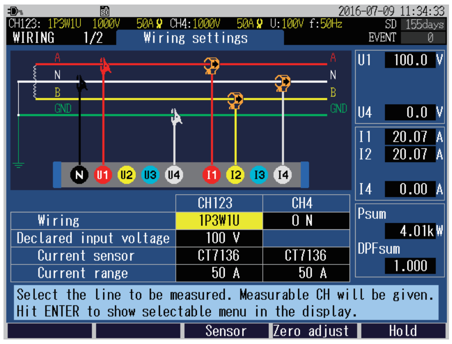
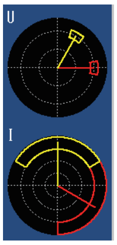
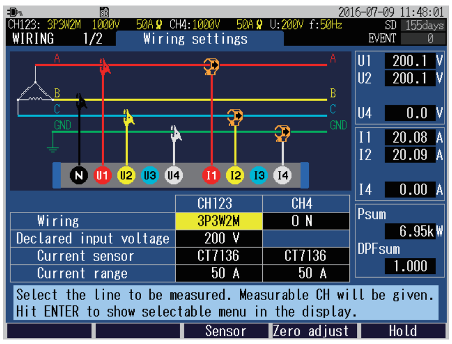
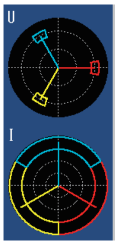
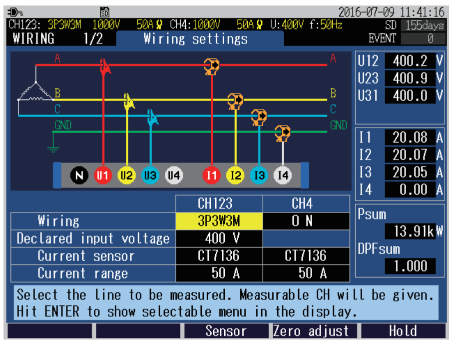
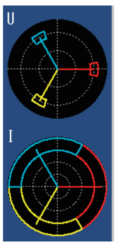
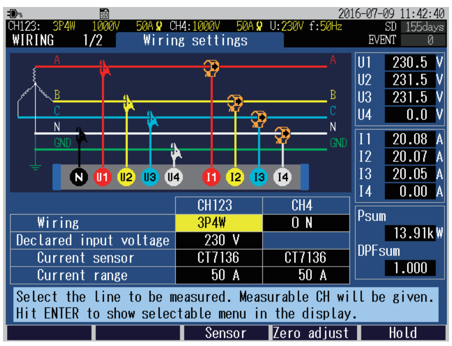
The settings can also be configured in the **SET UP, measurement settings** screen or in the Quick Set screen.
See “SET UP, Measurement Settings 1 screen” (p. 64), and refer to Measurement Guide.

4

Wiring (WIRING Screen)

Wiring diagram

The vector diagram in the following screen example shows the measurement line in its ideal (balanced, power factor 1) state.

<table>
<tr><th>Wiring selection vector diagram</th><th>Screens</th><th>Wiring selection vector diagram</th><th>Screens</th></tr>
<tr><td>1P2W
</td><td></td><td></td><td></td></tr>
<tr><td>1P3W
</td><td></td><td>1P3W1U
</td><td></td></tr>
<tr><td>3P3W2M
</td><td></td><td>3P3W3M*
</td><td></td></tr>
<tr><td>3P4W
</td><td></td><td>3P4W2.5E</td><td>(Available after the firmware update)</td></tr>
</table>

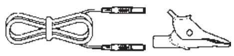
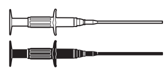
*: If 3P3W3M is selected, do not apply a voltage to CH4 even with CH4 set to ON.

4.3 Connecting Voltage Cords to Instrument

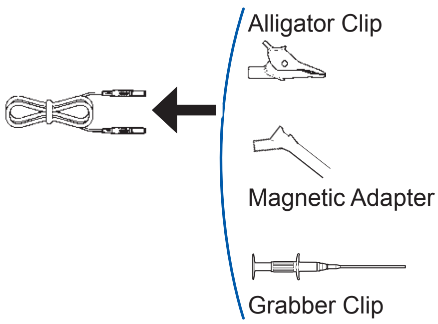
Be sure to read “Handling Cords and Cables” (p. 8), “Using Voltage Cords” (p. 8).

Connect a Model L1000-05 voltage cord to the voltage input terminal of this instrument.
Secure the cords together with a spiral tube if necessary.
See“Bundling the voltage cords and current sensors (If required)” (p. 37).

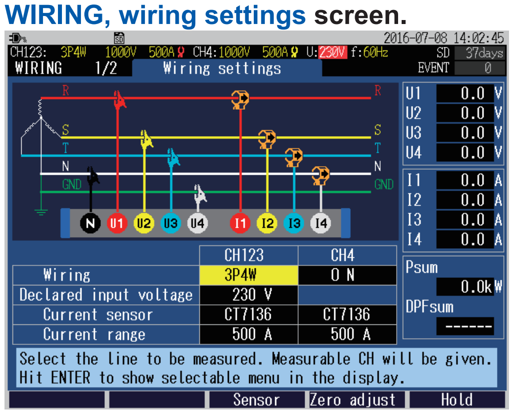
Required items

☐ Model L1000-05 Voltage Cord	 (Necessary number of cords)
☐ Model 9804-01 Magnetic Adapter (Optional)	 Red, compatible with the M6 pan head screw
☐ Model 9804-02 Magnetic Adapter (Optional)	 Black, compatible with the M6 pan head screw
☐ Model 9243 Grabber Clip (Optional)	 Red and black, 1 each

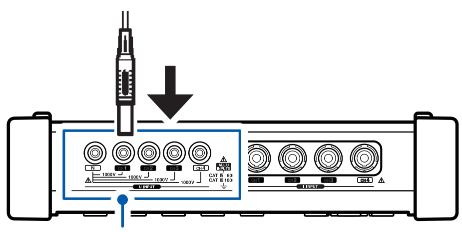
1 **Insert alligator clip magnetic adapter or grabber clips into the socket at the tip of the cord.**



2 **Press the [WIRING] key to display the WIRING, wiring settings screen.**



3 **Insert the voltage cord while checking the channel on the screen.**



Voltage input terminal
Insert the cord into the terminal as far as it will go.

4.4 Connecting Current Sensors and Configuring Current Sensor Settings

Be sure to read “Handling Cords and Cables” (p. 8).

Connect the optional current sensor to the current input terminal of this instrument.

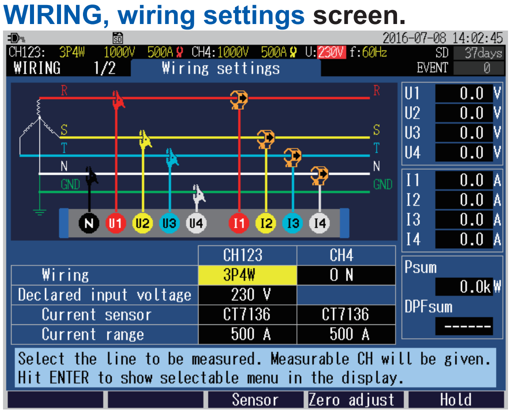
- To make it easier to identify channels, color-code the cords with colored spiral tubes. See“Color coding of current sensor (for channel identification)” (p. 36).
- Secure the cords together with a spiral tube if necessary. See“Bundling the voltage cords and current sensors (If required)” (p. 37).
- Refer to the instruction manual supplied with the current sensor for specification details and usage procedures.

When measuring power lines that use multiple channels

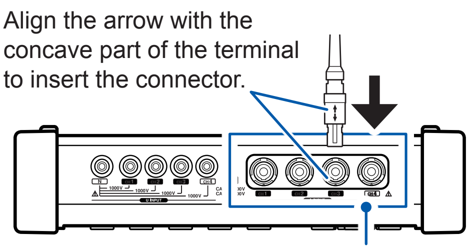
Use a current sensor of the same model.
Example: Use current sensors of the same model from CH1 to CH3 for the 3-phase 4-wire system.

Connecting the optional current sensor

1 **Press the [WIRING] key to display the WIRING, wiring settings screen.**

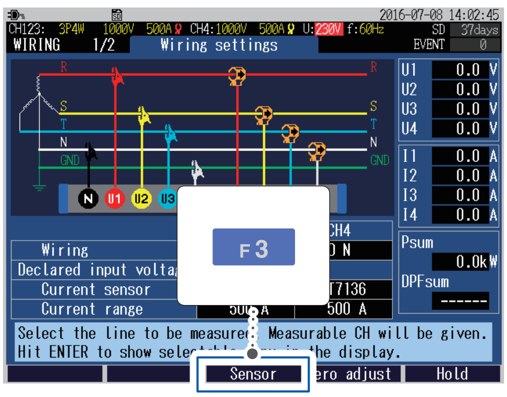


2 **Insert the connector of the current sensor while checking the channel on the screen.**



When disconnecting the current sensor, be sure to grip the part of the connector indicated by the arrows and pull it straight out.

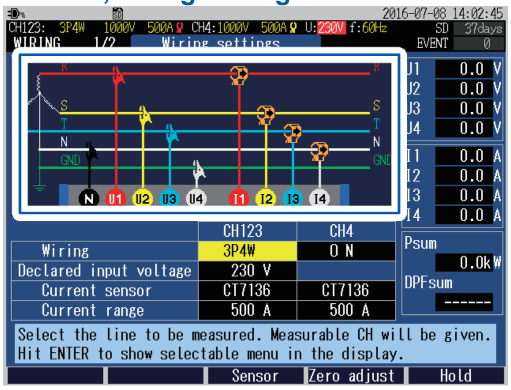
3



The current sensor and the maximum current range are set automatically.

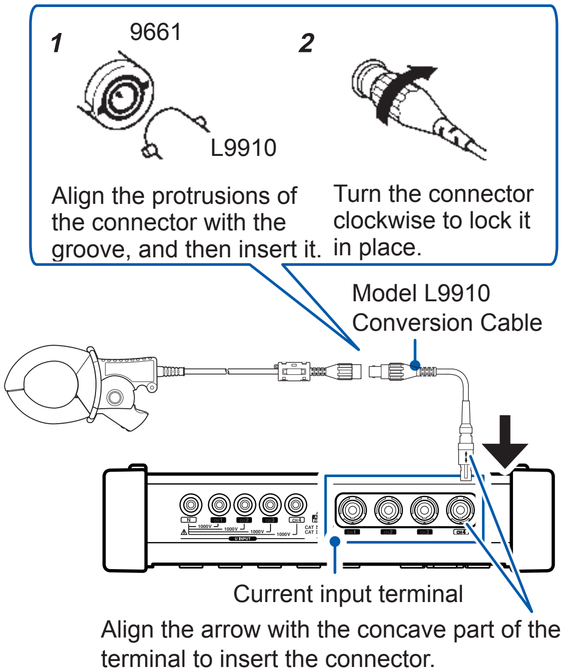
Connecting current sensors other than the optional sensors

1 **Press the [WIRING] key to display the WIRING, wiring settings screen.**

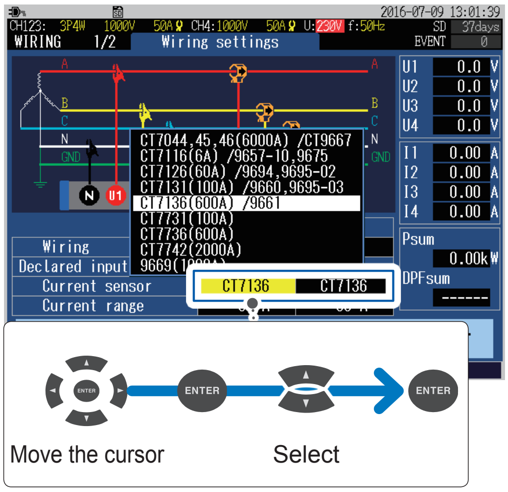


2 **Insert the connector of the current sensor while checking the channel on the screen.**

Example: Model 9661 clamp on sensor



3 **See the table given on the right side, and select the corresponding optional current sensor.**



Example: Select **CT7136** for Model 9661 clamp on sensor

Current sensor		
Other than the optional*	**Optional**	
CT9667-01* CT9667-02* CT9667-03*	**CT7044** **CT7045** **CT7046**	AC Flexible Current Sensor
9657-10 9675	**CT7116**	AC Leakage Current Sensor
9694 9695-02	**CT7126**	AC Current Sensor
9660 9695-03	**CT7131**	
9661	**CT7136**	
9669	**9669**	Clamp On Sensor

*: Set the range switch of the sensor to 500 A when the **current range** of this instrument is set to **500 A** or **50 A**.

4

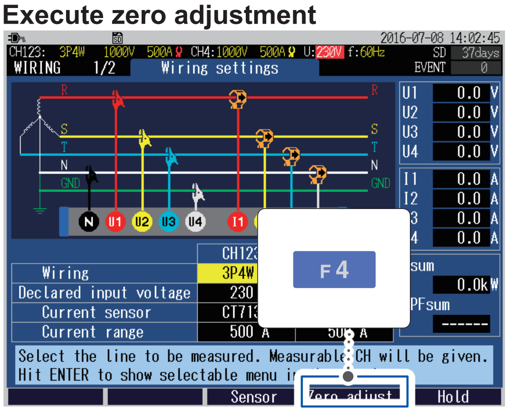
Wiring (WIRING Screen)

4.5 Zero Adjustment

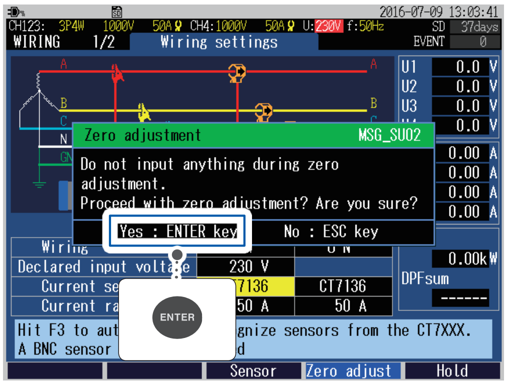
This function adjusts the DC components superimposing on voltage and current to zero.
In order to obtain precise measurements, it is recommended to perform the zero adjustment in advance of the measurements after allowing the instrument to warm-up for more than 30 min.

1 **Press the [WIRING] key to display the WIRING, wiring settings screen.**

2 **Execute zero adjustment**



3

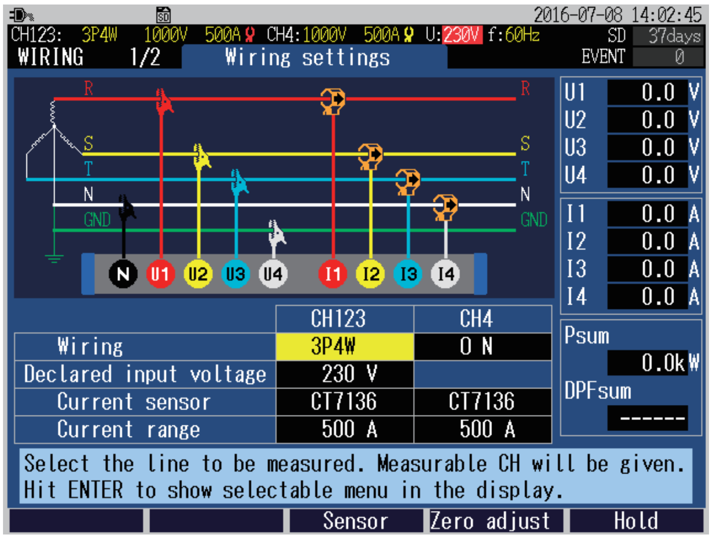


The DC components superimposing on voltage and current are adjusted to zero. It will takes approximately 20 s.

- Perform zero adjustment only after connecting the current sensor to the instrument.
- Perform zero adjustment before wiring to the measurement line. (The zero adjustment must be performed when there is no input of voltage and current.)
- In order to obtain precise measurements, zero adjustment should be performed at an ambient temperature level, that falls within the range defined by the device specifications.
- The key operations are disabled during zero adjustment.

4.6 Connecting Voltage Cords to Objects

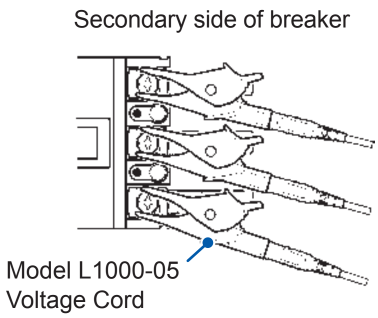
Be sure to read “Wiring” (p. 12).
Connect the voltage cords to the measuring objects while checking the **WIRING, wiring settings** screen.



Use alligator clips or Model 9243 Grabber Clip.

Securely clip the cords to metal parts such as bus bars and screws on the secondary side of the breaker.

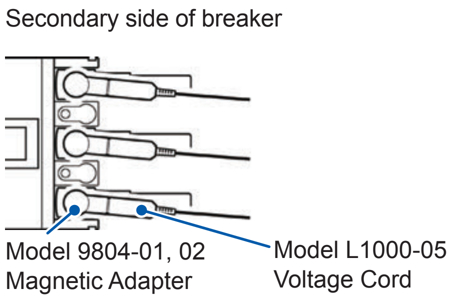
Method to open and close Model 9243



Example: Alligator clip

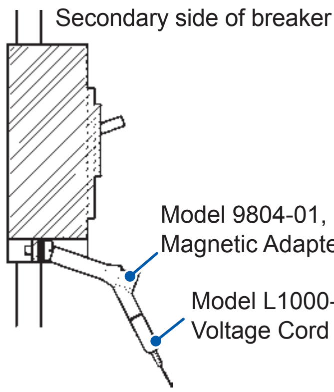
Using Model 9804-01 (9804-02) Magnetic Adapter

Connect the magnetic adapter to the screws on the secondary side of the breaker.



The weight of the voltage cords may prevent you from making a perpendicular connection between the magnetic adapter and the head of the screw.
In this case, connect each cord such that it hangs off the adapter in a manner that balances its weight. Check the voltage values to verify that the connections have been made securely.

* Optional, standard screws: M6 small pan head screws

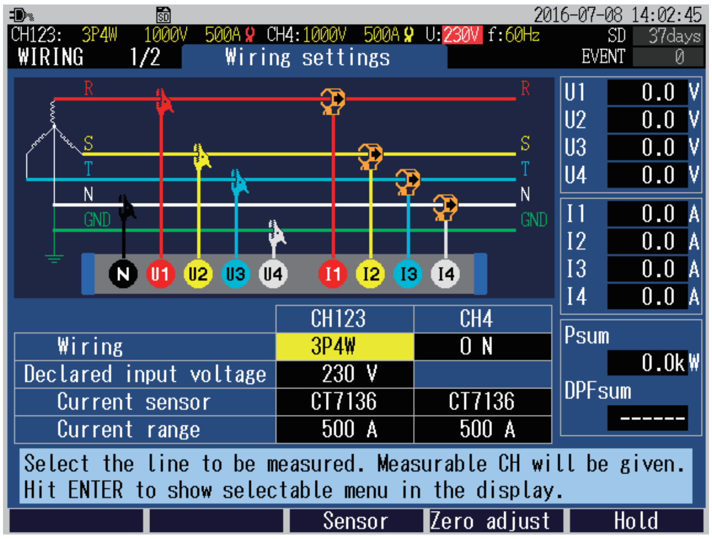


4

Wiring (WIRING Screen)

4.7 Attaching Current Sensors to Objects

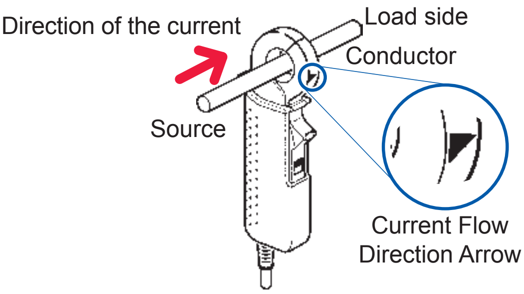
Be sure to read “Wiring” (p. 12).
Connect the current sensors to the measuring objects while checking the **WIRING, wiring settings** screen.



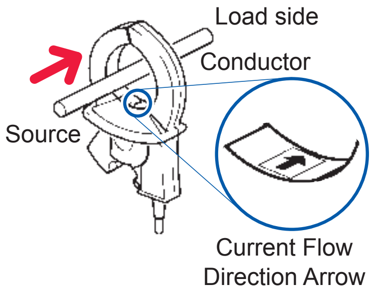
Load current measurement

Make sure that the current flow direction arrow points toward the load side, then clamp the conductor.

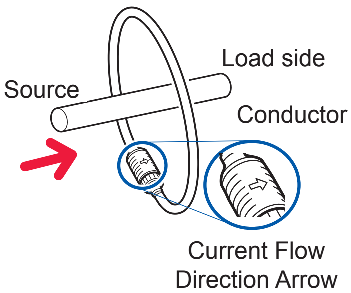
Example:



Model CT7126/CT7131 AC current sensor



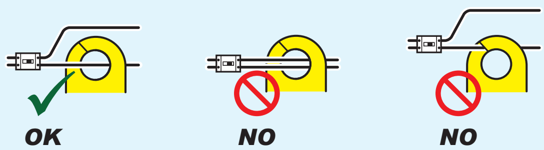
Model CT7136 AC current sensor



CT7044/ CT7045/ CT7046 AC flexible current sensor

IMPORTANT

Attach the clamp around only one line of the conductor.
Single-phase (2-wire) or three-phase (3-wire, 4-wire) cables clamped together will not produce any reading.

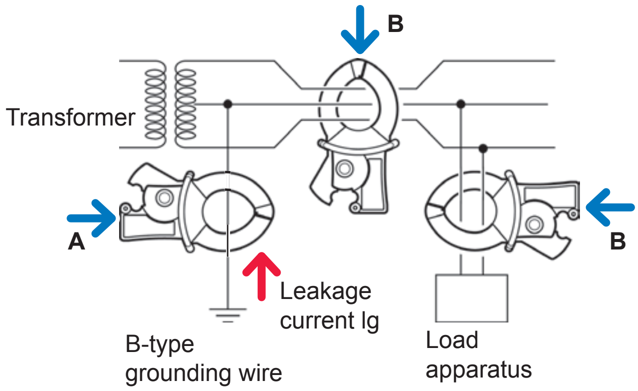


Leakage current measurement

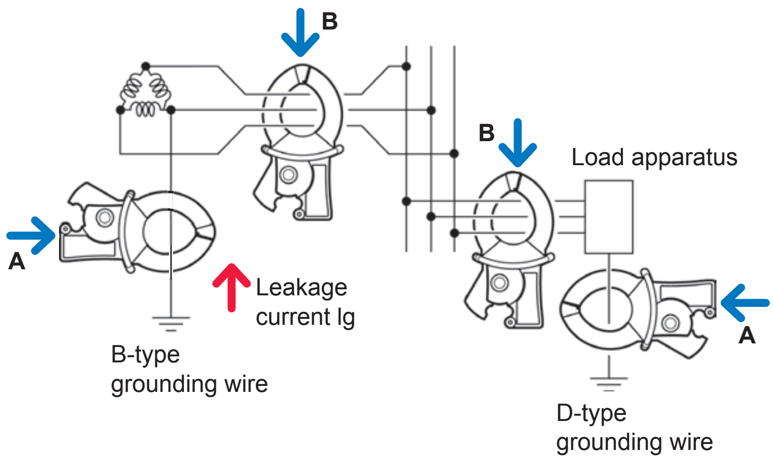
Grounding wire measurement	**Clamp 1 line only. (Diagram A)**
Batch measurement	**Clamp the electrical circuits together. (Diagram B) Clamp 2 wires together in the single phase 2-wire system circuit, and 4 wires in the 3-phase 4-wire system circuit.**

Example:

Single phase 3-wire system circuit



3-phase 3-wire system circuit



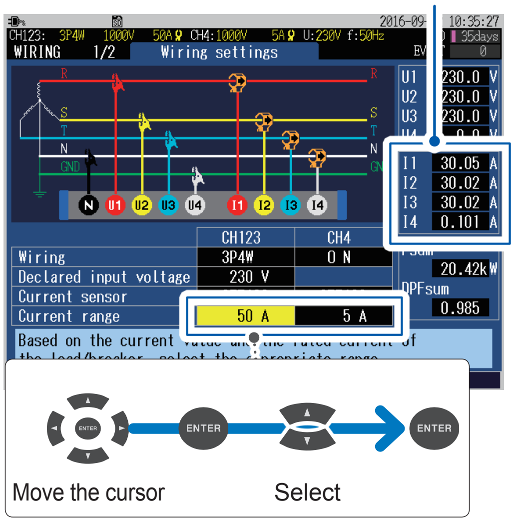
4.8 Configuring Current Range Setting

Check the current value in the **WIRING, wiring settings** screen and select an appropriate current range.

1 **Press the [WIRING] key to display the WIRING, wiring settings screen.**

2 **Check the current value (RMS value) and select the current range.**

Current value (RMS value)



Current sensor			Current range
Optional		Other than the optional	
AC flexible current sensor	CT7044 CT7045 CT7046	CT9667-01* CT9667-02* CT9667-03*	5000A, 500A, 50A
AC leakage current sensor	CT7116	9657-10 9675	5A, 500mA, 50mA
AC current sensor	CT7126	9694 9695-02	50A, 5A, 500mA
	CT7131	9660 9695-03	100A, 50A, 5A
	CT7136	9661	500A, 50A, 5A
AC/DC auto-zero current sensor	CT7731	–	100A, 10A
	CT7736	–	500A, 50A
	CT7742	–	2000A, 1000A, 500A
Clamp on sensor	9669	9669	1000A, 100A

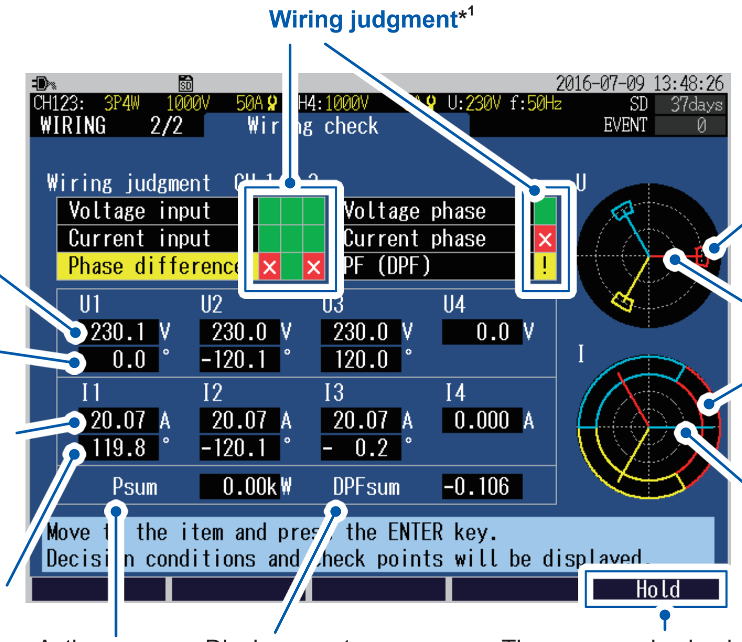
*: Set the range switch of the sensor to 500 A when the **current range** of this instrument is set to **500 A** or **50 A**.

Selecting an appropriate current range

Set the current range based on the anticipated maximum load current that will generate during the measurement. (Refer to the operating status, load rating, breaker rating, and other data to make this determination.)
If the range is too low, then an over-range current will be generated during measurement, and accurate measurement will not be possible.
And if the range is too high, then errors will increase and accurate measurement will not be possible.

4.9 Checking Wiring

Press the **[WIRING]** key to display the **WIRING, wiring check** screen.
This screen is used to check whether the instrument has been connected properly.



*1: The wiring judgment results are displayed.

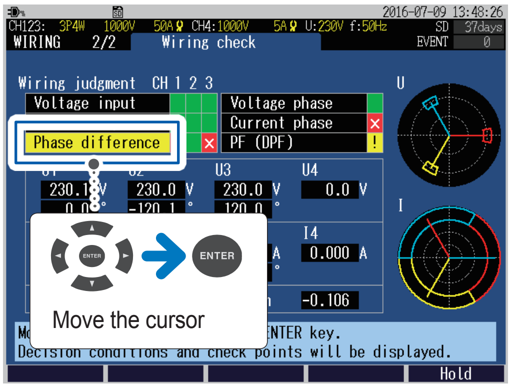
Green	PASS (Normal)
Red (x)	FAIL (Abnormal)
Yellow (!)	CHECK (Confirmation required)

*2: The wiring is normal if the phase vector is within the ‘PASS’ range. (If outside the PASS range, see “Voltage phase” (p. 61), “Current phase” (p. 61))

*3: DPF (Displacement Power Factor) is displayed as the power factor irrespective of the **PF/Q/S** calculation method settings of the **SET UP, measurement settings 2** screen in the **WIRING, wiring check** screen. See “SET UP, Measurement Settings 2 screen” (p. 66) and “Power factor (PF/DPF)” (p. Appx.28).

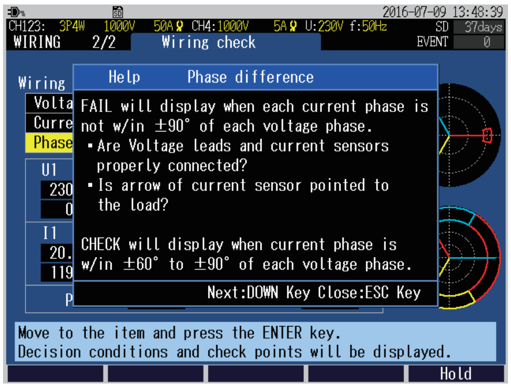
If the wiring judgment result is red (FAIL) or yellow (CHECK)

1 **Select an item to be checked.**



A dialog box with helpful information for fixing the wiring will be displayed.

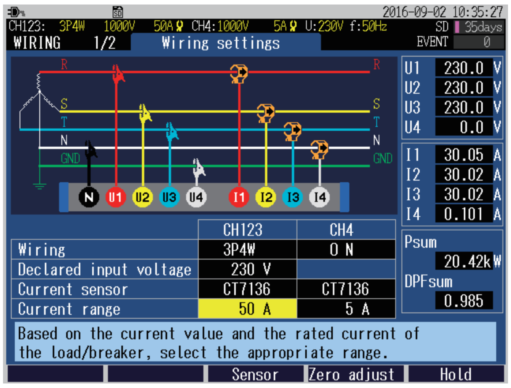
2 **Review its contents.**



(Press the **[ESC]** key to close the dialog box)

3 **Press the [WIRING] key to display the WIRING, wiring settings screen.**

4 **Verify that the actual wiring connections are the same as the ones shown on the screen.**



Correct the wiring if the connections are incorrect.

5 **Once again, press [WIRING] key and confirm the wiring judgment result on WIRING, wiring check confirmation screen.**

Recording can be started even if the wiring judgment result remains red (FAIL) or yellow (CHECK).

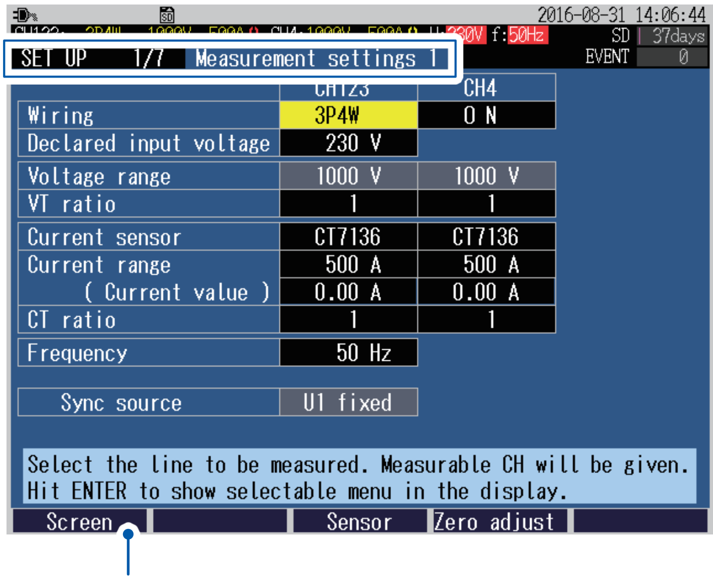
<table>
<tr><th>Wiring judgment items</th><th>Judgment conditions</th><th>Confirmation steps</th></tr>
<tr><td rowspan="2">Voltage input</td><td>To determine the voltage value based on the declared input voltage.
110% < CHECK
90% ≤ PASS ≤ 110%
80% ≤ CHECK < 90%
FAIL < 80%</td><td>• Has the declared input voltage been set correctly?
• Are the voltage cords completely inserted into the voltage input terminals?
• Are the tip clip and cord of the voltage cord completely inserted?
• Is the tip clip of the voltage cord connected to the metal parts of the measurement line?</td></tr>
<tr><td colspan="2">See “4.2 Wiring Method and Declared Input Voltage Settings” (p. 48).
See “4.3 Connecting Voltage Cords to Instrument” (p. 51).
See “4.6 Connecting Voltage Cords to Objects” (p. 55).</td></tr>
<tr><td rowspan="2">Current input</td><td>FAIL will be displayed when input is less than 1% of the current range. CHECK will be displayed when input is less than 10% of the current range.</td><td>Wiring cannot be checked when no current is flowing. Operate the equipment and keep the current flowing in order to check the wiring. If the wiring cannot be checked even if the equipment is operating, as exact diagnosis cannot be done, visually check for proper wiring before measuring.
• Are the current sensors properly inserted into the current sensor input terminals?
• Are the current sensors correctly wired?
• Is the set current range too large for the input level?</td></tr>
<tr><td colspan="2">See “4.4 Connecting Current Sensors and Configuring Current Sensor Settings” (p. 52).
See “4.7 Attaching Current Sensors to Objects” (p. 56).</td></tr>
<tr><td rowspan="2">Voltage phase</td><td>FAIL will be displayed when the voltage phase exceeds the range (exceeds the reference value ±10°).</td><td>• Are the wiring settings correct?
• Are the voltage cords correctly wired?
• The phases may have been incorrectly laid out during wiring. Switch the voltage cords and adjust the connections of the current sensors so that PASS is displayed. To recheck the phases, use a phase detector to confirm that the phases are in the correct sequence.</td></tr>
<tr><td colspan="2">See “4.2 Wiring Method and Declared Input Voltage Settings” (p. 48).
See “4.6 Connecting Voltage Cords to Objects” (p. 55).</td></tr>
<tr><td rowspan="2">Current phase</td><td>FAIL will be displayed when the current phase sequence is incorrect.</td><td>• Are the current sensors connected in the right places? (On both the wiring side, and the input terminal of this instrument)
• Does the arrow of the current sensor point to the load side?</td></tr>
<tr><td colspan="2">See “4.2 Wiring Method and Declared Input Voltage Settings” (p. 48).
See “4.4 Connecting Current Sensors and Configuring Current Sensor Settings” (p. 52).
See “4.7 Attaching Current Sensors to Objects” (p. 56).</td></tr>
</table>

Wiring judgment items	Judgment conditions	Confirmation steps
Voltage and current phase difference	FAIL will be displayed when each current phase is not within 90° with respect to the voltage of each phase.	• Are the voltage cords and current sensors connected in the right places? (On both the wiring side, and the input terminal of this instrument) • Does the arrow of the current sensor point to the load side?
	CHECK appears if current phase is within ±60° to ±90° of each voltage phase.	• Are the voltage cords and current sensors connected in the right places? (On both the wiring side, and the input terminal of this instrument) • Does the arrow of the current sensor point to the load side? • In light loads, power factor may be low and phase difference may be large. Check the wiring and if no problems are observed, proceed with the measurement. • When phase advances too much due to the phase advance capacitor in light loads, power factor may be low and phase difference may be large. Check the wiring and if no problems are observed, proceed with the measurement.
	See “4.3 Connecting Voltage Cords to Instrument” (p. 51) to “4.7 Attaching Current Sensors to Objects” (p. 56).	
Power factor (DPF)	CHECK will be displayed if the power factor is less than 0.5 but more than −0.5.	• Are the current sensors connected in the right places? (On both the wiring side, and the input terminal of this instrument) • Does the arrow of the current sensor point to the load side? • When the load is light, the power factor may be low. Check the wiring and if no problems are observed, proceed with the measurement. • When the phase advances too much due to the use of a phase advance capacitor during a light load, the power factor may be low. Check the wiring and if no problems are observed, proceed with the measurement.
	See “4.4 Connecting Current Sensors and Configuring Current Sensor Settings” (p. 52). See “4.7 Attaching Current Sensors to Objects” (p. 56).	

5 Setting Change (SET UP Screen)

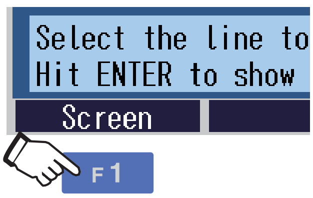
All settings can be changed on the **SET UP** screen.

Press the **[SET UP]** key to display the **SET UP** screen.

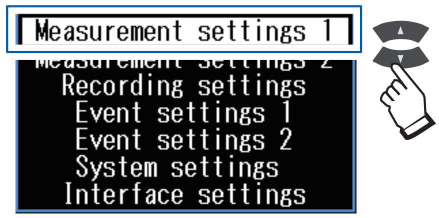


In addition to the **[SET UP]** key, you can switch to the **SET UP** screen from here also.

1



2

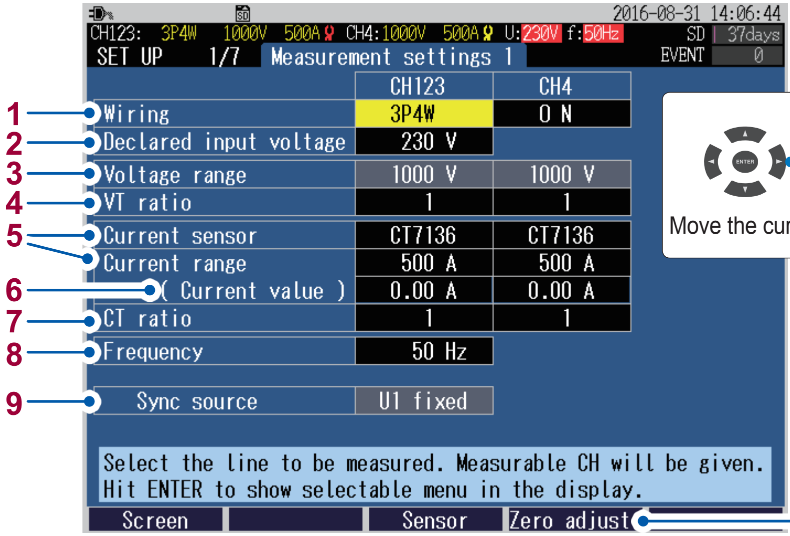


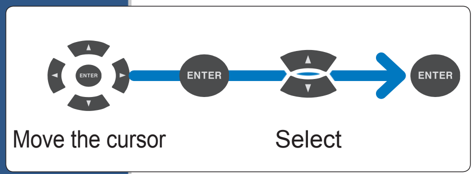
For the **SET UP, Interface Settings** screen, see “12 Communications (USB/LAN/RS-232C)” (p. 137) and “13 External I/O” (p. 147).

5.1 Measurement Settings

SET UP, Measurement Settings 1 screen

Press the **[SET UP]** key to display the **SET UP, measurement settings 1** screen.





See “4.5 Zero Adjustment” (p. 54).

The wiring method, declared input voltage, current sensor and current range can be set on the “**WIRING, Wiring Settings** Screen” or on the “Quick Settings Screen.”
See “4.2 Wiring Method and Declared Input Voltage Settings” (p. 48), and Measurement Guide.

1 Enables you to select the wiring method of CH1 to CH3, and select ON/OFF input for CH4.

CH123	**1P2W**	Single-phase 2-wire line
	1P3W	Single-phase 3-wire line
	1P3W1U	Single-phase 3-wire line (1-voltage measurement)
	3P3W2M	3-phase 3-wire line (2-watt meter method)
	3P3W3M	3-phase 3-wire line (3-watt meter method)
	3P4W	3-phase 4-wire line
	3P4W2.5E	3-phase 4-wire line (2-voltage measurement) (available after the firmware update)
CH4	**ON**	Enables the input to CH4. Voltage: To measure the voltage of a grounded wire. Current: To measure the N wire current of 3P4W or 1P3W. To measure the leakage current.
	OFF	Disables the input to CH4.

2 Enables you to set the declared input voltage for the measurement line. It will be referenced for the event settings (swell, dip, interruption).
See “SET UP, Event Settings 1 screen” (p. 72).

Variable (**50 V** to **800 V** in 1 V increments), **100**, **101**, **110**, **115**, **120**, **127**, **200**, **202**, **208**, **220**, **230**, **240**, **277**, **347**, **380**, **400**, **415**, **440**, **480**, **600**

3 The voltage range is fixed to 1000 V.

4 Enables you to set if an external VT is being used.

Variable (**0.01** to **9999.99**), **1**, **60**, **100**, **200**, **300**, **600**, **700**, **1000**, **2000**, **2500**, **5000**

While taking measurements on the secondary side of a voltage transformer (VT), if you set the VT ratio, you can display the voltage value by converting it to primary-side voltage values.
Example: If the voltage on primary side of a VT is 6.6 kV and the voltage on secondary side is 110 V then the VT ratio = 60 (6600 V / 110 V)
As the voltage range of 1000 V is fixed, it would be multiplied by the VT ratio of 60 to obtain a voltage range of 60 kV.

5 **When connecting the optional current sensor**

If you press the **[F3]** (**sensor**) key, the current sensor and the maximum current range will be set automatically.
Check the current value (RMS value) and select an appropriate current range.

When connecting current sensors other than the optional sensors

The sensor and the range will not be set automatically. See the following table and select the compatible optional current sensor.
Check the current value (RMS value) and select an appropriate current range.

Current sensor			Current range
Optional		Other than the optional	
AC flexible current sensor	CT7044 CT7045 CT7046	CT9667-01* CT9667-02* CT9667-03*	5000A, 500A, 50A
AC leakage current sensor	CT7116	9657-10 9675	5A, 500mA, 50mA
AC current sensor	CT7126	9694 9695-02	50A, 5A, 500mA
	CT7131	9660 9695-03	100A, 50A, 5A
	CT7136	9661	500A, 50A, 5A
AC/DC auto-zero current sensor	CT7731	-	100A, 10A
	CT7736	-	500A, 50A
	CT7742	-	2000A, 1000A, 500A
Clamp on sensor	9669	9669	1000A, 100A

*: Set the range switch of the sensor to 500 A when the **current range** of this instrument is set to **500 A** or **50 A**.

When measuring power lines that use multiple channels

Combine the multiple types of the current sensor.
Example: Use current sensors of the same type from CH1 to CH3 for the 3-phase 4-wire system.

Selecting an appropriate current range

Set the current range based on the anticipated maximum load current that will generate during the measurement. (Refer to the operating status, load rating, breaker rating, and other data to make this determination.)
If the range is too low, then an over-range current will be generated during measurement, and accurate measurement will not be possible.
And if the range is too high, then errors will increase and accurate measurement will not be possible.

6 The present current value will be displayed.

7 Enables you to set if using an external CT.

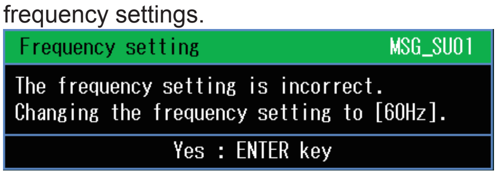
Variable (**0.01** to **9999.99**), **1**, **40**, **60**, **80**, **120**, **160**, **200**, **240**, **300**, **400**, **600**, **800**, **1200**

While taking measurements on the secondary side of a current transformer (CT), if you set the CT ratio, you can display the current value by converting it to primary-side current values.
Example: If the current on primary side is 200 A and the current on secondary side is 5 A then the CT ratio = 40 (200 A / 5 A)
If the current range of 5 A is selected (with the current sensor), it would be multiplied by the CT ratio of 40 to obtain a current range of 200 A.

8 Enables you to select the nominal frequency for the measurement line. It will be referenced for the event settings (frequency).
See “5.3 Event Settings” (p. 72).

50 Hz, **60 Hz**

- After performing a factory reset (default) (p. 77) to reset the instrument to the default settings, when you turn on the power, first set the frequency that matches with the measuring object.
  See “Setting the language, clock, and measurement frequency” (p. 40).
- The **Frequency setting** dialog box will be displayed if the instrument detects voltage input and determines that the frequency differs from the set frequency. Press the **[ENTER]** key to change the frequency settings.

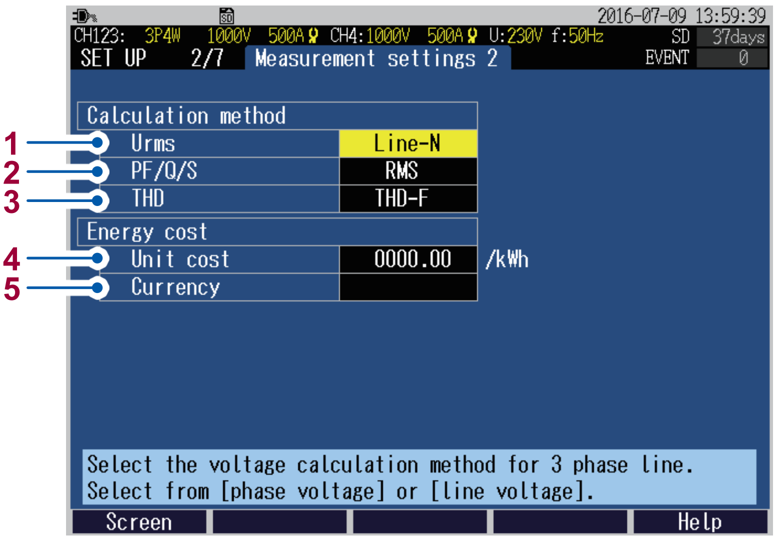


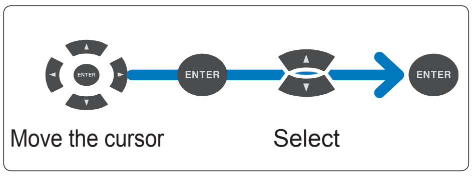
- Measurement of DC does not care that either 50 Hz or 60 Hz is configured.

9 Enables you to sync source referenced for the measurement is fixed to U1.

SET UP, Measurement Settings 2 screen

Press the **[SET UP]** key to display the **SET UP, measurement settings 2** screen.





1 Enables you to select whether to display the RMS voltage of **TREND** screen in the form of line voltage or in phase voltage.

Phase voltage (Line-N), **Line voltage (Line-Line)**

For 1P2W, 1P3W	**Phase voltage**
For 3P3W2M	**Line voltage**
For 3P3W3M, 3P4W, 3P4W2.5E	Can be switched between **phase voltage** and **line voltage** Both the phase voltage and line voltage are stored as a output data. (3P4W2.5E will be available after the firmware update)

2 Enables you to select the method for calculating power factor (PF/DPF), reactive power (Q), and apparent power (S) on the display screen.
Both the RMS calculation and fundamental calculation values are stored as a output data.
See “14.7 Calculation Formula” (p. 175).

RMS value	Uses RMS voltage and RMS current to calculate.
Fundamental	Uses voltage and current fundamentals to calculate. This is the same measurement method used for measuring reactive energy established at commercial-scale utility customers’ facilities.

RMS calculation is generally used in applications such as checking transformer capacity.
Fundamental calculation is used when measuring power factor and reactive power, which are related to the energy cost.

3 Enables you to select the calculation method for calculating the total harmonic distortion (THD) on the display screen and event settings.
Both the THD-F calculation value and THD-R calculation value are taken as output data.

THD-F	Calculates by dividing harmonic components (total of 2nd to 50th orders) with fundamental wave.
THD-R	Calculates by dividing harmonic components (total of 2nd to 50th orders) with RMS value (1st to 50th order).

4 When the unit cost (/kWh) is set, the energy cost is displayed by multiplying the active energy (consumed) WP+ with the energy cost per unit.
See “Unit cost input method” (p. 68).

0.00000 /kWh to **99999.9 /kWh**

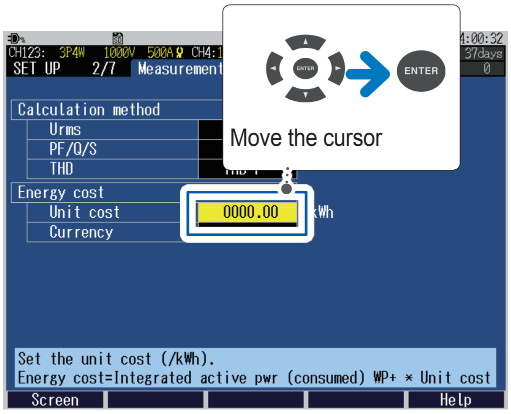
5 Enables you to set the currency.
Set to any 3 alphanumeric characters (example: set **USD** for the US dollar)

5

Setting Change (SET UP Screen)

Unit cost input method

1 **Select the unit cost.**



2 **Change the value.**

When moving the decimal point

**: Move the cursor to the position of decimal point.**

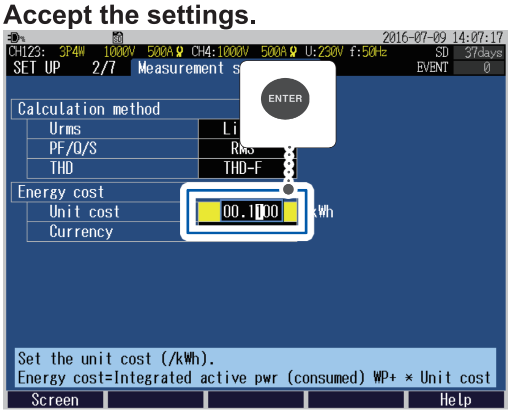
**: Change the location of the decimal point.**

When changing the value

**: Move the cursor to the digit that you wish to change.**

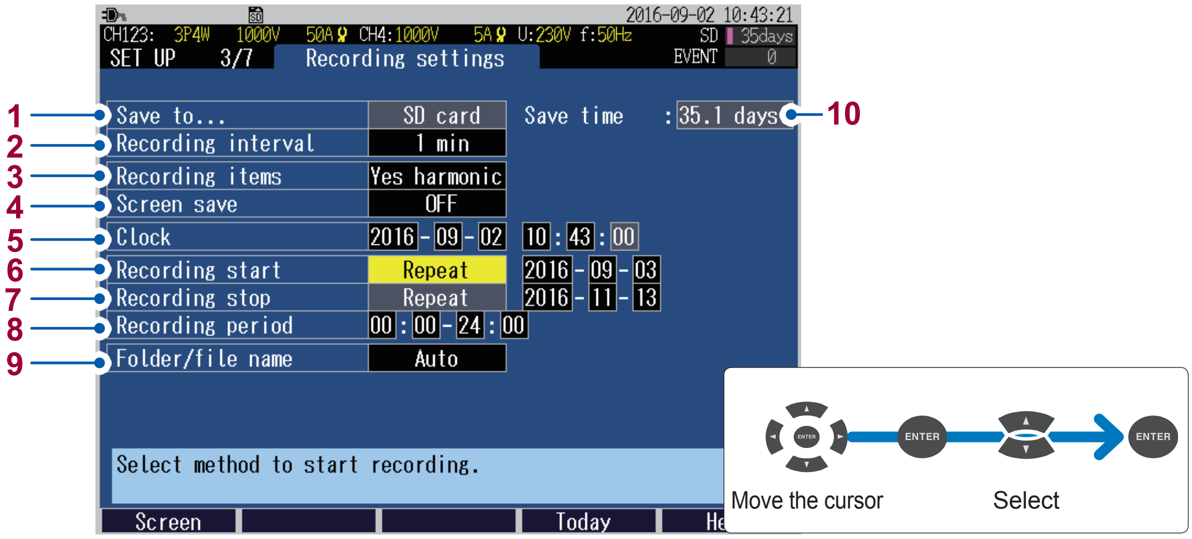
**: Change the value.**

3 **Accept the settings.**



5.2 Recording Settings

Press the **[SET UP]** key to display the **SET UP, recording settings** screen.
Perform the settings regarding recording (storage).
The maximum recording period is up to 1 year and then the recording stops automatically.



1	• The storage destination of measurement data is fixed to the **SD card**. If no SD memory card is inserted or if there is no free space in the SD memory card, data will be stored in the instrument's internal memory (capacity of approx. 4 MB). • No data such as event data but only the setting data and the trend record data are stored in the internal memory. See "File Saving and Operations (FILE Screen)" (p. 115).
2	Enables you to select the recording interval. It will also reflect in the intervals in the trend graph. **150 cycle** (only in the case of 50 Hz), **180 cycle** (only in the case of 60 Hz), **200 ms**, **600 ms**, **1 sec**, **2 sec**, **5 sec**, **10 sec**, **15 sec**, **30 sec**, **1 min**, **2 min**, **5 min**, **10 min**, **15 min**, **30 min**, **1 hour**, **2 hour** • The **150 cycle** (50 Hz) and **180 cycle** (60 Hz) settings provide the recording intervals required for IEC61000-4-30-compliant measurement. • The shortest recording interval of the internal memory is 2 s. If the recording interval of 1 sec or below is set, then the data cannot be stored in the internal memory.

3 Enables you to select the parameters that you wish to record. It will also reflect in the parameters that are displayed on the **TREND** screen.

Yes harmonic	All the parameters are recorded.
No harmonic	Records the parameters other than the harmonic or interharmonic parameters. Records the total harmonic distortion (THD).

The display possible time of the **TREND** screen changes according to the setting of **Recording interval** and **Recording items**.

4 Enables you to select **ON**, for saving the display screen in the BMP format data (screen copy).
Screen copies cannot be saved in the instrument's internal memory.
If the **Recording interval** is set to below **5 min**, then they are saved every 5 min.

ON/**OFF**

5 Enables you to set the date and time.
(The seconds cannot be set. If you press the **[Enter]** key after changing time, the seconds will be set to 00.)

6 Enables you to set the method used to start recording.

Manual	Recording starts immediately after the **[START/STOP]** key is pressed.
Specified time	After the **[START/STOP]** key is pressed, recording starts at the set time. (If the set time has already passed when the key is pressed, “**Interval**” starting method will be used.) **YYYY-MM-DD hh:mm**
Interval time	Recording starts at an even time division based on the **Recording interval**. If the **[START/STOP]** key is pressed at the time “10:41:22” with the time interval set to 10 min, the instrument will enter in the standby state. The recording will start at “10:50:00.” If the set recording interval is of 30 s or less, recording will start from the next zero second.
Repeat	Segments the file every day and repeats the recording. Sets the **Recording period**. If a folder is labeled arbitrarily, data recorded for up to 99 days can be stored. After the **[START/STOP]** key is pressed, recording starts in the **Recording period** of the set start date. (If the set time has already passed when the key is pressed, “**Interval**” starting method is used.) The **Recording intervals** of **1 sec** and above are valid. **YYYY-MM-DD**

See “7.1 Start and Stop of the Recording” (p. 91).

7 Enables you to set the method used to stop the recording.

Manual	Press the **[START/STOP]** key to stop the recording.
Specified time	Recording stops at the set time. (If the set time has already passed when recording starts, recording will be stopped using the “**manual**” method.) **YYYY-MM-DD hh:mm**
Timer	Stops the recording automatically if the set timer time has elapsed. **hhh:mm:ss**
Repeat	Displayed when **Recording start** setting is configured to **Repeat**. Recording is stopped if the **Recording period** of the stop date has passed. The stop method cannot be changed for repeat recording. **YYYY-MM-DD**

See “7.1 Start and Stop of the Recording” (p. 91).

8 **Recording start method** is displayed for the **repeat recording**.
Set the recording period.

hh:mm to **hh:mm**

9	Enables you to set the folder name and file name used to save the data. See “10.2 Folder and File Structure” (p. 118)

Variable	Sets variable folder name in the dialog. (maximum 5 half-width characters) If recording and measurement are performed again without changing the **[Folder/file name]**, sequentially numbered (00 to 99) folders will be automatically created, and the data will be saved there. If Recording start setting is configured to Repeat, data recorded for up to 100 days can be stored because folders are created at daily intervals. Example: “ABCDE00,” “ABCDE01,” and then, “ABCDE02”
Automatic	The folder will be named automatically as “YYMMDDXX.” YYMMDD is the year, month, and date while XX is the serial number (00 to 99).

10	Calculates the save time from the recording settings and displays it. Since the maximum recording time is 1 year, the maximum data storage time is also 1 year. Calculates the save time when there is no event (not occurred). If the event occurs, the save time shortens.

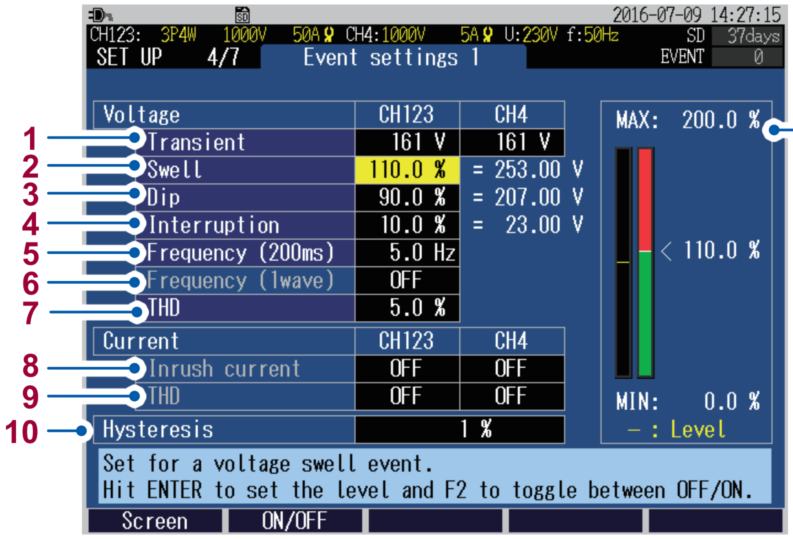
- If the save time of the SD memory card or internal memory is shorter than the specified duration, recording will be started, but only the capacity during save time will be recorded.
- The maximum recording and measurement period is 1 year. Recording will stop after 1 year.

5.3 Event Settings

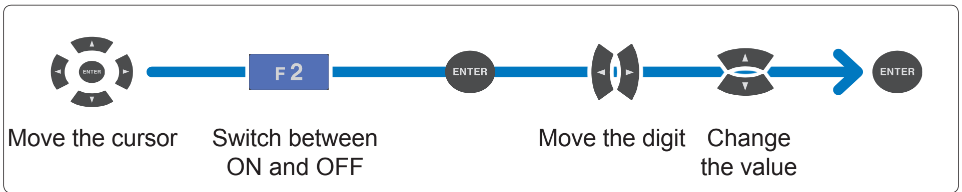
An event will occur using the set threshold value on this screen as the basis.
For more information about events, see “Appx. 3 Explanation of Power Quality Parameters and Events” (p. Appx.4), “Appx. 4 Event Detection Methods” (p. Appx.8).

SET UP, Event Settings 1 screen

Press the **[SET UP]** key to display the **SET UP, event settings 1** screen.



“Reference graph for setting threshold values” (p. 73)



1*1	Enables you to set the threshold value of the voltage transient. **OFF**, **4 V** to **2200 V**
2*1,2	Enables you to set the threshold value of the voltage swell. **OFF**, **0.0%** to **200.0%**
3*1,2	Enables you to set the threshold value of the voltage dip. **OFF**, **0.0%** to **100.0%**
4*1,2	Enables you to set the threshold value of the interruption. **OFF**, **0.0%** to **100.0%**

*1: The actual event threshold value is obtained by multiplying with the VT ratio.
*2: The threshold value is set in terms of % of the declared voltage **Uref** (declared input voltage **Udin** × VT ratio).

5 Enables you to set the threshold value of the frequency (200 ms). (Only U1)

OFF, **0.1Hz** to **9.9Hz**

6 Enables you to set the threshold value of the frequency (1 wave). (Only U1)

OFF, **0.1Hz** to **9.9Hz**

7 Enables you to set the threshold value of the voltage total harmonic distortion.

OFF, **0.0%** to **100.0%**
The value depends on the **THD** settings of the **calculation method** of the **SET UP, Measurement settings 2** screen (**THD-F**/**THD-R**).

8 Enables you to set the threshold value of the inrush current.

5000 A range	**OFF**, **0 A** to **5000 A**
2000 A range	**OFF**, **0 A** to **2000A**
1000 A range	**OFF**, **0 A** to **1000A**
500 A range	**OFF**, **0 A** to **500A**
100 A range	**OFF**, **0 A** to **100A**
50 A range	**OFF**, **0 A** to **50A**
10 A range	**OFF**, **0 A** to **10A**
5 A range	**OFF**, **0 A** to **5A**
500 mA range	**OFF**, **0 A** to **500mA**
50 mA range	**OFF**, **0 A** to **50mA**

The actual event threshold value is obtained by multiplying with the CT ratio.

9 Enables you to set the threshold value of the current total harmonic distortion.

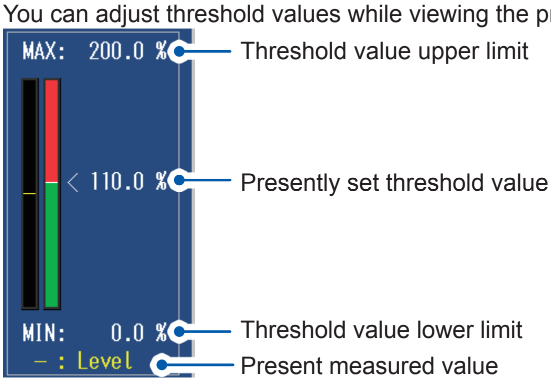
OFF, **0.0%** to **500.0%**
The value depends on the **THD** settings of the **Calculation method** of the **SET UP, Measurement settings 2** screen (**THD-F**/**THD-R**).

10 Enables you to set the hysteresis for the event threshold value to avoid frequent occurrence of events. Hysteresis can be set to all the parameters except frequency.
The frequency is fixed to 0.1 Hz.

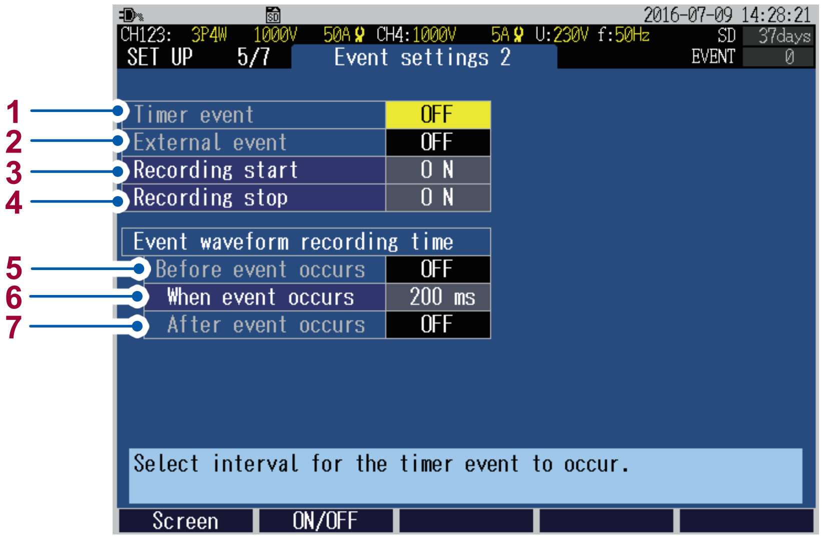
0% to **10%**

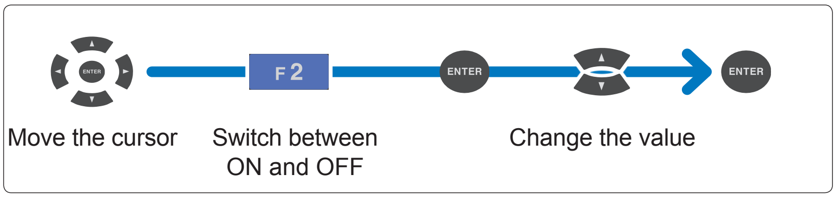
Reference graph for setting threshold values

You can adjust threshold values while viewing the present measured values.



SET UP, Event Settings 2 screen



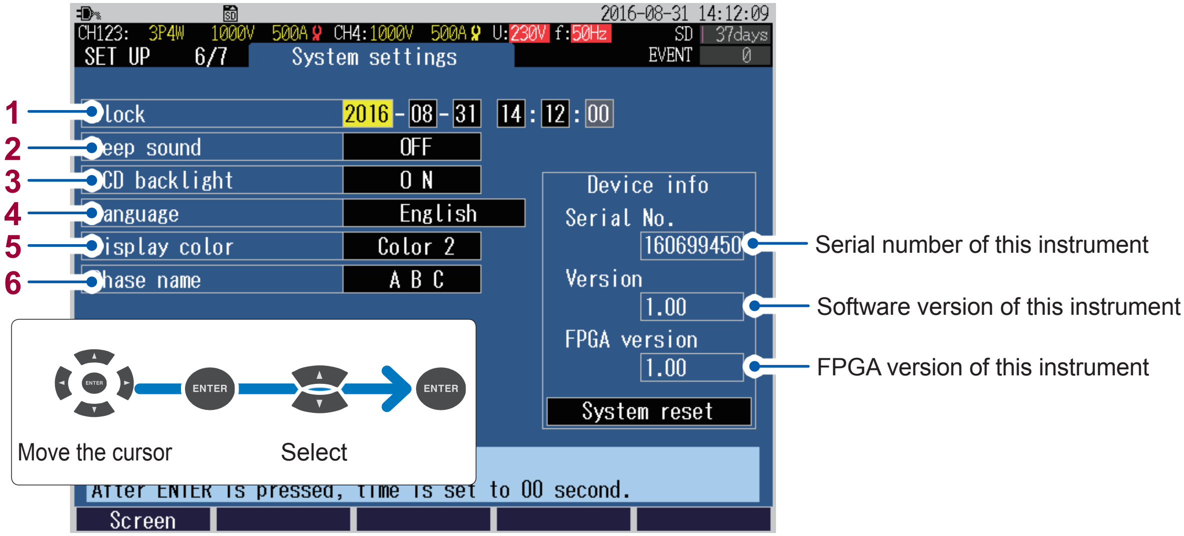


1	Enables you to select the timer event. The timer events are recorded at the set intervals. **OFF**, **1min**, **2min**, **5min**, **10min**, **15min**, **30min**, **1hour**, **2hour**
2	Select **ON** for using an external event. External events occur at the time of short-circuiting the event input terminal (EVENT IN) or of the pulse signal falling and they are recorded. **OFF**, **ON**
3	The recording start event occurs when the recording starts.
4	The recording stop event occurs when the recording stops.
5*1	Enables you to select the event waveform recording time (before-event) before the event occurs. **OFF**, **200ms**, **1sec**
6	The event waveform recording time when the event occurs is fixed to 200 ms.
7*1	Enables you to select the event waveform recording time (after-event) after the event occurs. Only the event which initially occurred is recorded. If another event occurs during the after-event, the after-event of this another event cannot be stored. **OFF**, **200ms**, **400ms**, **1sec**, **5sec**, **10sec**

*1: The event OUT, timer, manual, recording start, and recording stop events are not recorded in the event waveform recording of before-event and after-event. Only the event waveform of 200 ms, when the event occurs, will be saved.
The event waveform is divided at intervals of 200 ms. When the after event is set to 1 sec, five pieces, which is obtained by dividing 1 sec by 200 ms, of the event waveform are saved.
If the before event or the after even set to exceeding 200ms, only the waveform recorded during 200 ms can be observed with the instrument. To observe the entire length of the waveform, use the application software PQ One, which is supplied with the instrument.

5.4 System Settings

Press the **[SET UP]** key to display the **SET UP, System settings** screen.



1	Enables you to set the date and time. (The seconds cannot be set. If you press the **[Enter]** key after changing the value, the seconds will be set to 00.)
2	Select **ON** to enable a beep sound when pressing a key. **ON**, **OFF**
3	Enables you to select whether or not to auto-off the backlight of the display.

Auto OFF	The backlight automatically turns off after 2 min have elapsed since the last key operation.
ON	The backlight is on at all times.

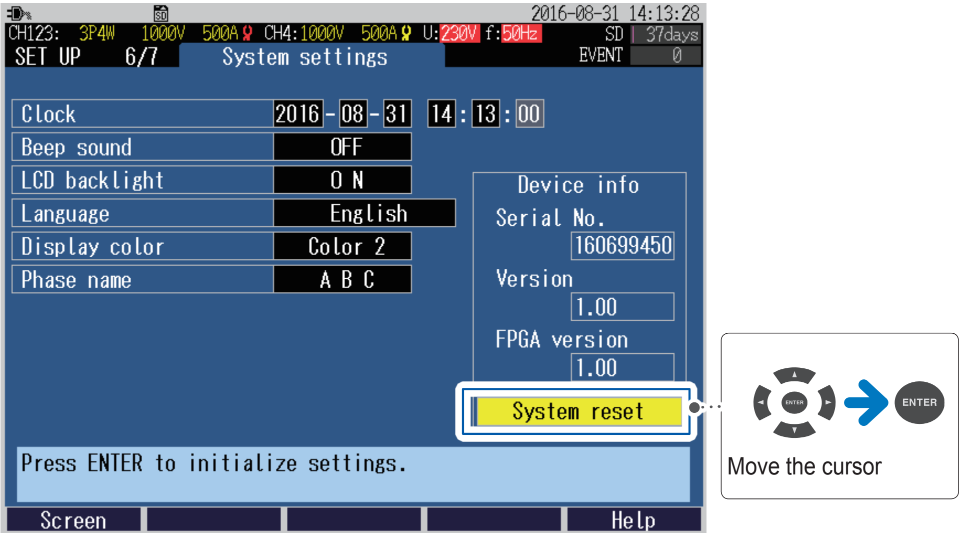
4 Enables you to select the display language.

Japanese		**German**	
English		**French**	
Chinese Simple	(Simplified)	**Italian**	
Chinese Trad	(Traditional)	**Spanish**	
Korean		**Turkish**	

5	Enables you to select the display color. **Color 1**, **color 2**, **color 3**
6	Enables you to select the phase names for the measuring objects displayed on the wiring diagram. **RST**, **ABC**, **L1L2L3**, **UVW**

System reset (Default)

Move the cursor to the **system reset** and press **[ENTER]** key to reset the system settings of this instrument. (Factory settings: p. 78)
Perform if the instrument is operating in an odd or unexpected manner with no clear cause.



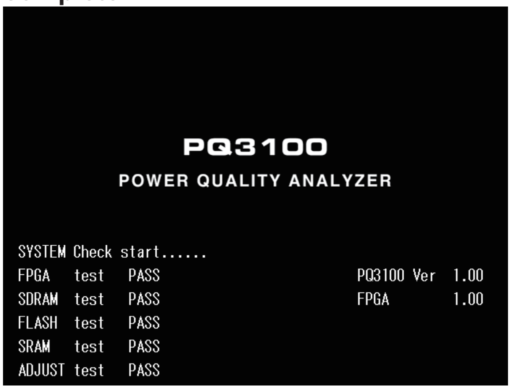
All settings other than the measurement frequency, clock, language, and communication settings (LAN and RS-232C) are initialized to their factory settings. The internal memory will not be erased.

Factory reset (Default)

If you perform the factory reset, all settings, including frequency, language, and communications settings will revert to their factory settings (p. 78). The internal memory will be erased.

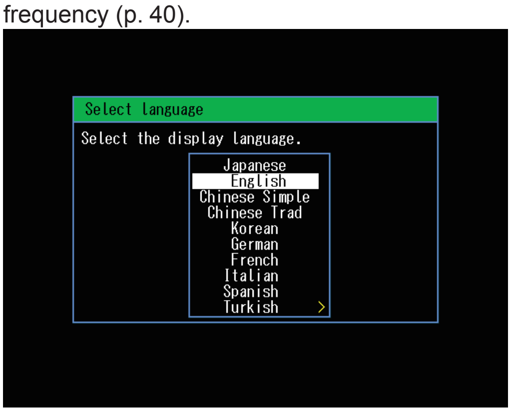
1 **Turn off the instrument. (p. 44)**

2 **Turn on the instrument while holding down the [ENTER] and [ESC] keys, and continue holding them down until the beep sounds after the self-test is complete.**



The factory reset will complete, and the language setting screen will be displayed.

Set the language, clock, and measurement frequency (p. 40).



5

Setting Change (SET UP Screen)

Factory settings

All the default settings are as follows:

*1: Checked parameters (✓) are the parameters that are not initialized in quick set.
*2: Checked parameters (✓) are the parameters that are not initialized during the system reset. These are initialized in the factory reset only.

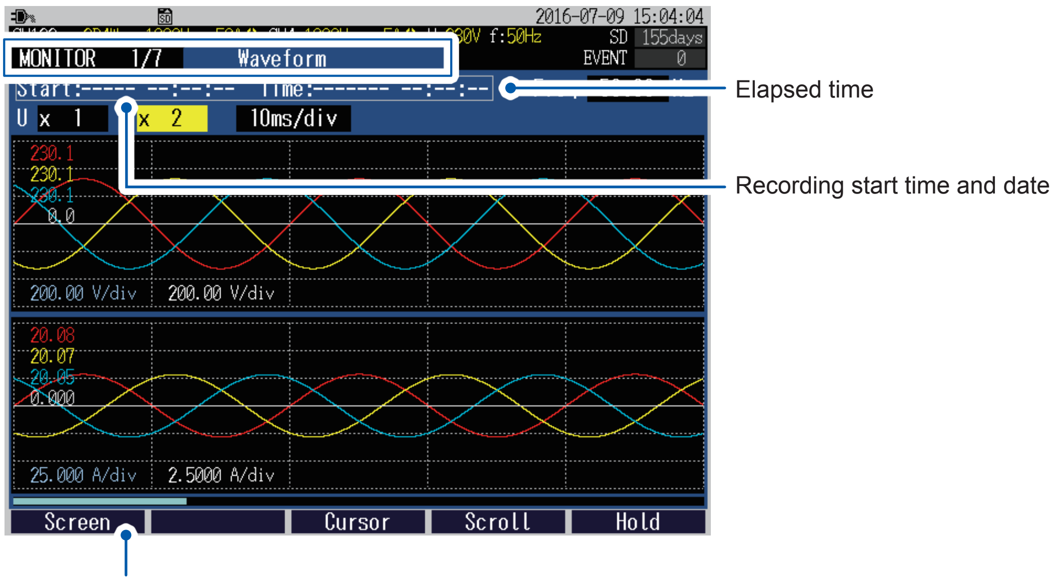
Screens	items	Default values		*1	*2
Measurement settings 1	**Wiring**	**Display Language**: **Japanese**	**CH123**: **3P3W2M** **CH4**: **OFF**		
		Display language: Other than above	**CH123**: **3P4W** **CH4**: **ON**		
	Declared input voltage	**Display Language**: **Japanese**	**200V**		
		Display language: Other than above	**230V**		
	VT ratio	**CH123**: **1** **CH4**: **1**			
	Current sensor	**CH123**: **CT7136** **CH4**: **CT7136**			
	Current range	**CH123**: **500 A** **CH4**: **500 A**			
	CT ratio	**CH123**: **1** **CH4** :**1**			
	Measurement frequency	Select **50 Hz** or **60 Hz** after the factory reset.		✓	✓
Measurement settings 2	**Urms**	**Other than 3P3W**: **Phase voltage** **3P3W**: **Line voltage**			
	PF/Q/S	**RMS value**			
	THD	**THD-F**			
	Harmonics (Available after the firmware update)	**U, I, P: All levels**			
	Energy unit cost	**0000.00/kWh**			
	Energy cost currency	_____			
	Flicker (Available after the firmware update)	**Display Language**: **Japanese**	**ΔV10**	✓	✓
		Display language: Other than above	**Pst,Plt**		
	Filter (Available after the firmware update)	**Display Language**: **Japanese**	**-**	✓	✓
		Display language: Other than above	**230V lamp**		
Recording settings	**Recording interval**	**1min**			
	Recording items	**Yes harmonic**			
	Screen save	**OFF**			
	Recording start method	**Interval time**			
	Recording stop method	**Manual**			
	Folder/ File name	**Automatic**			

Screens	items	Default values		*1	*2
Event settings 1	Transient	CH123: OFF CH4: OFF			
	Swell	OFF			
	Dip	OFF			
	Interruption	OFF			
	Frequency (200 ms)	OFF			
	Frequency (1 wave)	OFF			
	Voltage total harmonic distortion	OFF			
	Inrush current	CH123: OFF CH4: OFF			
	Current total harmonic distortion	CH123: OFF CH4: OFF			
	Hysteresis	1%			
Event settings 2	Timer event	OFF			
	External event	OFF			
	Event waveform recording time Before event occurs	OFF			
	Event waveform recording time After event occurs	OFF			
System settings	Clock	Set at the time of shipment		✓	✓
	Beep sound	ON		✓	
	LCD backlight	Auto OFF		✓	
	Display language	Language selection after factory reset		✓	✓
	Display color	Color 1		✓	
	Phase name	Display Language: Japanese	RST	✓	✓
		Display language: Other than above	ABC		
Interface settings	DHCP (available after the firmware update)	OFF		✓	✓
	IP address	192.168.1.31		✓	✓
	Subnet mask	255.255.255.0		✓	✓
	Default gateway	192.168.1.1		✓	✓
	FTP function (Available after the firmware update)	Undetermined		✓	✓
	Send mail (Available after the firmware update)	Undetermined		✓	✓
	RS-232C baud rate	19,200bps		✓	✓
	External output	Short pulse		✓	✓

6 Verifying the Waveform, Measured Values (MONITOR Screen)

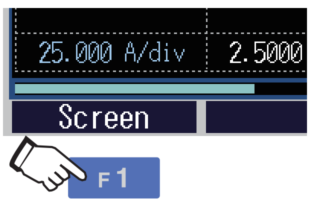
You can view the measured waveforms and measured values on the **MONITOR** screen.

Press the **[MONITOR]** key to display the **MONITOR** screen.

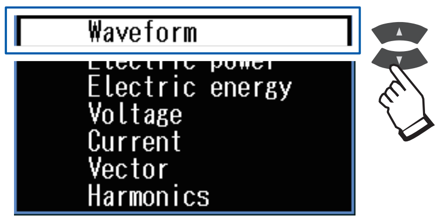


In addition to the **[MONITOR]** key, you can also switch to the **MONITOR** screen by using the **[F1]** (**Screen**) key.

1



2



Fixing the waveform display and measured values

Press the **[F5]** (**Hold**) key to fix the waveform display and measured values.
Press the **[F5]** key again to cancel the fixed waveform display and measured values.

- If a setting is changed while measured values and waveform display are being held, the hold will be canceled.
- The time display is not fixed.

6.1 Verifying the Voltage Waveform and Current Waveform

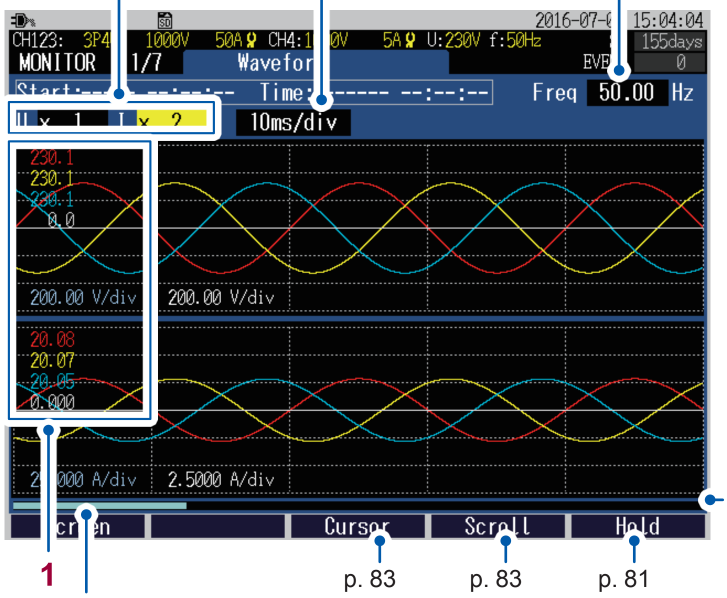
Press the **[MONITOR]** key to display the **MONITOR, Waveform** screen.
The voltage waveforms and current waveforms of up to 4 channels are overlapped and displayed.
The color of waveform is same as the phase color.

Screen display

Zoom factor settings for the horizontal axis (time axis) of the waveform (p. 83)

Zoom factor settings for the vertical axis of the waveform (p. 83)

Frequency (average value for a period of 200 ms)



Scroll bar
Scope of all measurement data

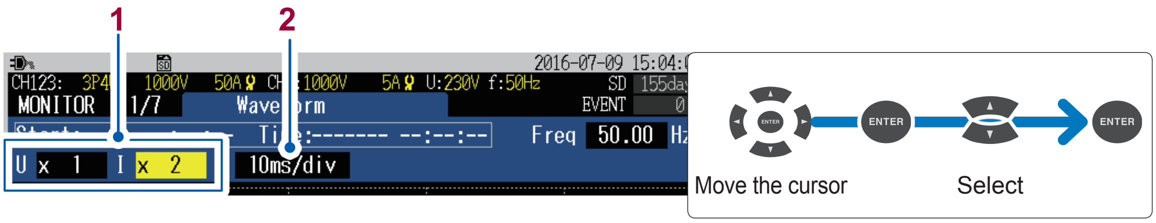
Screen display scope

---

1 When the cursor is OFF: measured values of each channel (RMS value)
At the time of the cursor measurement: cursor measured values of the waveforms of each channel
(Above diagram shows the screen that is displayed when the cursor is OFF)

See “Verifying the measured value and time at the cursor position (cursor measurement)” (p. 83).

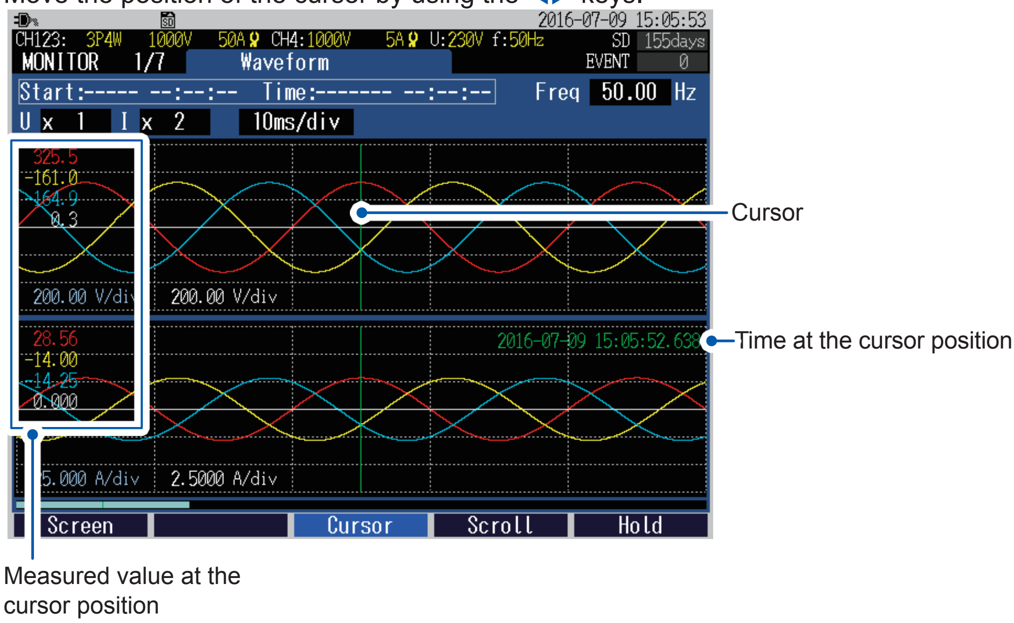
Changing the zoom factor for the vertical axis and horizontal axis (X and Y axis) of the waveform



1	Enables you to set the zoom factor for the vertical axis (Y axis) of the waveform (U: voltage, I: current). **×1/4**, **×1/2**, **×1**, **×2**, **×5**, **×10**, **×20**, **×50**
2	Enables you to set the zoom factor for the horizontal axis (time axis) of the waveform. **10ms/div**, **20ms/div**, **40ms/div**

Verifying the measured value and time at the cursor position (cursor measurement)

If you press the **[F3]** (**Cursor**) key, the measured value and time at the cursor position will also display along with the cursor.
Move the position of the cursor by using the ◀▶ keys.

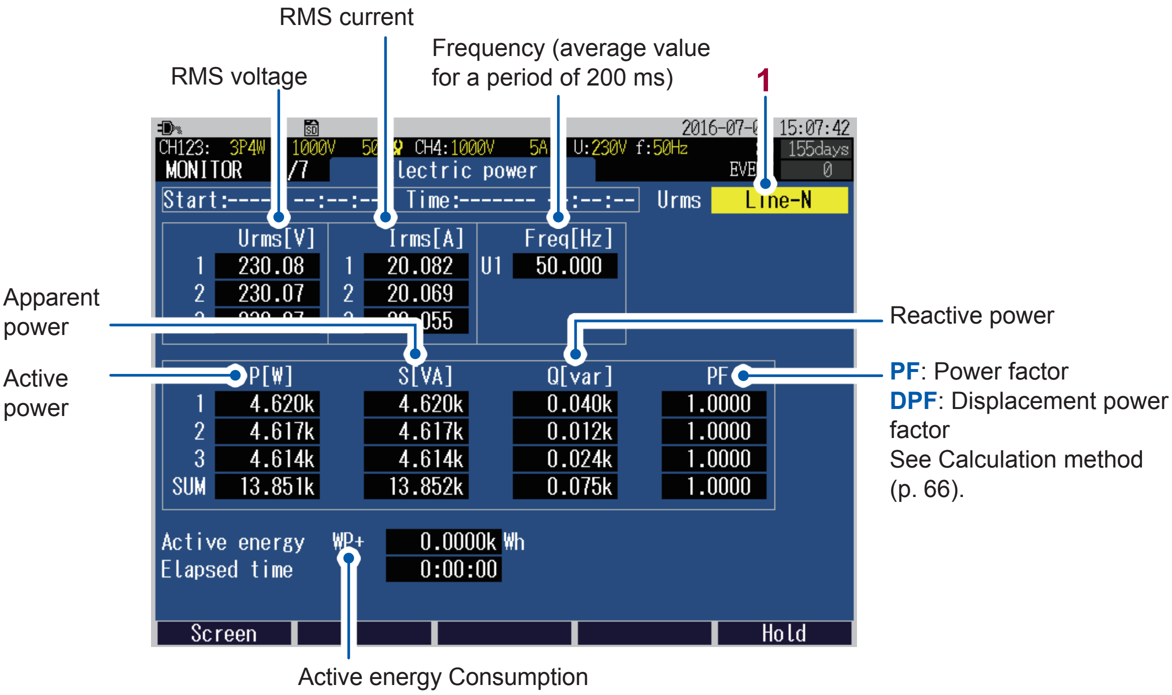


Scrolling the waveform

If the waveform is protruding from the screen, press the **[F4]** (**Scroll**) key to be able to scroll the waveform.
Enables you to scroll the waveform in the vertical and horizontal directions by using the ▲▼◀▶ keys.

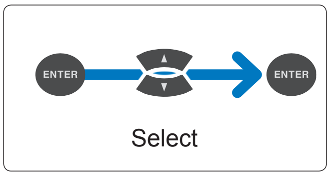
6.2 Verifying the Electric Power (List of Numerical Values)

Press the **[MONITOR]** key to display the **MONITOR, Electric power** screen.



---

1 When the wiring method is 3P3W3M, 3P4W, or 3P4W2.5E (available after the firmware update), the display method of the RMS voltage can be switched (between phase voltage and line voltage).



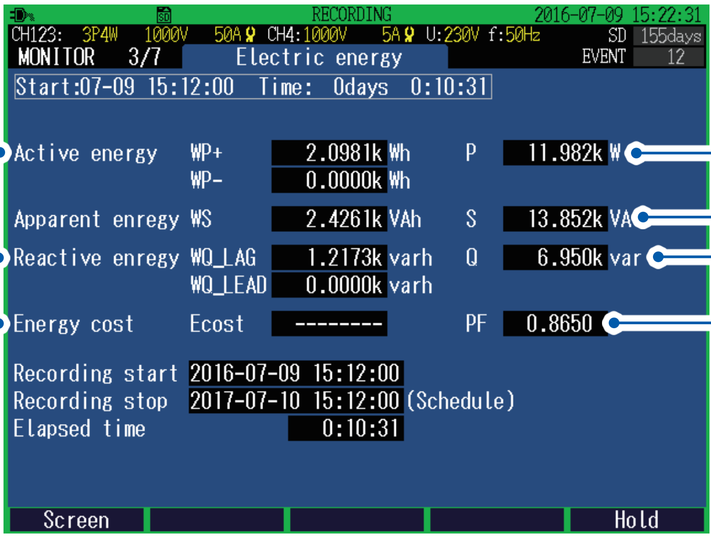
Phase voltage (Line-N), **Line voltage (Line-Line)**

For 1P2W, 1P3W	Fixed to **phase voltage**
For 3P3W2M	Fixed to **line voltage**
For 3P3W3M, 3P4W, 3P4W2.5E	Can be switched between the **line voltage** and **phase voltage**. Both the phase voltage and line voltage are stored as a output data. (3P4W2.5E will be available after the firmware update.)

6.3 Verifying the Electric Energy

Press the **[MONITOR]** key to display the **MONITOR, Electric energy** screen.

1
2
3



Active power

Apparent power

Reactive power

PF: Power factor
DPF: Displacement power factor
(Not displayed for 3-phase 3-wire line)
See Calculation method (p. 66).

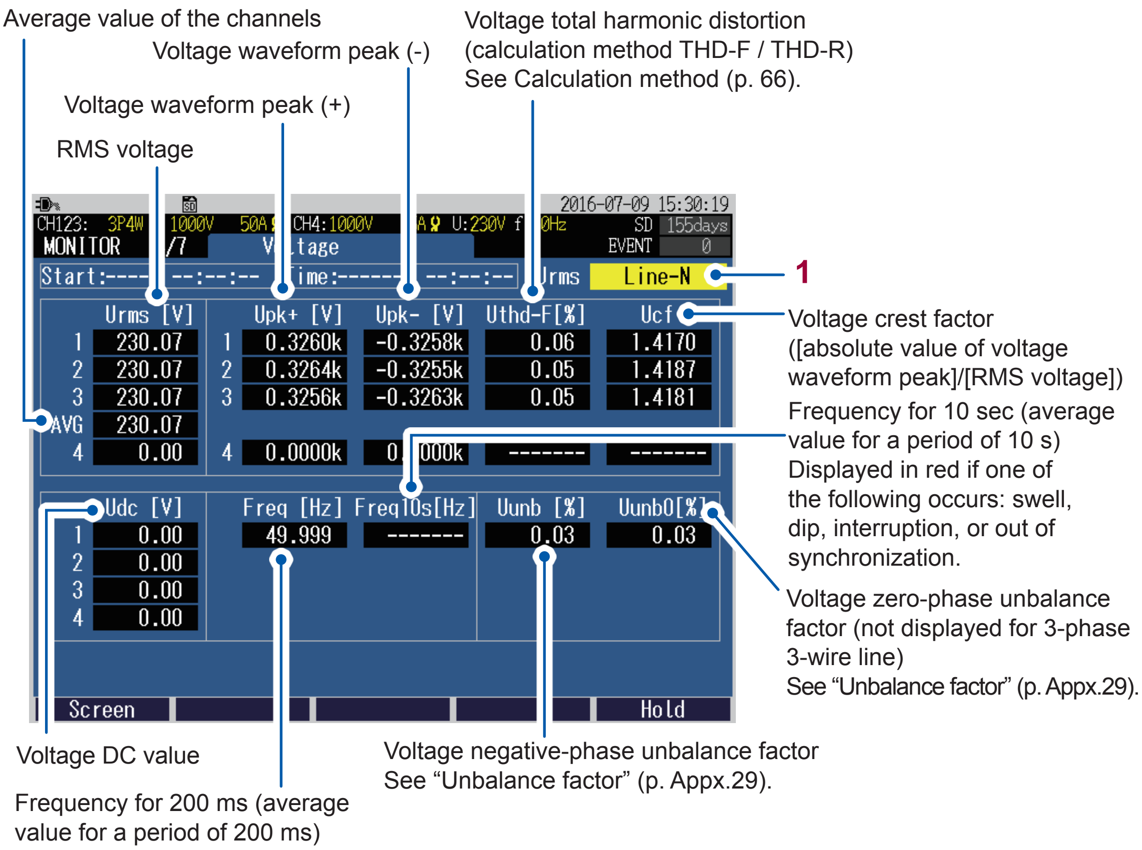
1	Active energy (**WP+**: consumption, **WP-**: regeneration)
2	Reactive energy (**WQ_LAG**: lag, **WQ_LEAD**: lead)
3	Energy cost Value obtained by multiplying the “active energy consumption: **WP+**” by the **energy unit cost*** *: See “SET UP, Measurement Settings 2 screen” (p. 66)

6

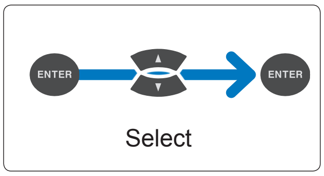
Verifying the Waveform, Measured Values (MONITOR Screen)

6.4 Verifying the Voltage Details

Press the **[MONITOR]** key to display the **MONITOR, Voltage** screen.



1 When the wiring method is 3P3W3M, 3P4W, or 3P4W2.5E (available after the firmware update), the display method of the RMS voltage can be switched (between phase voltage and line voltage).

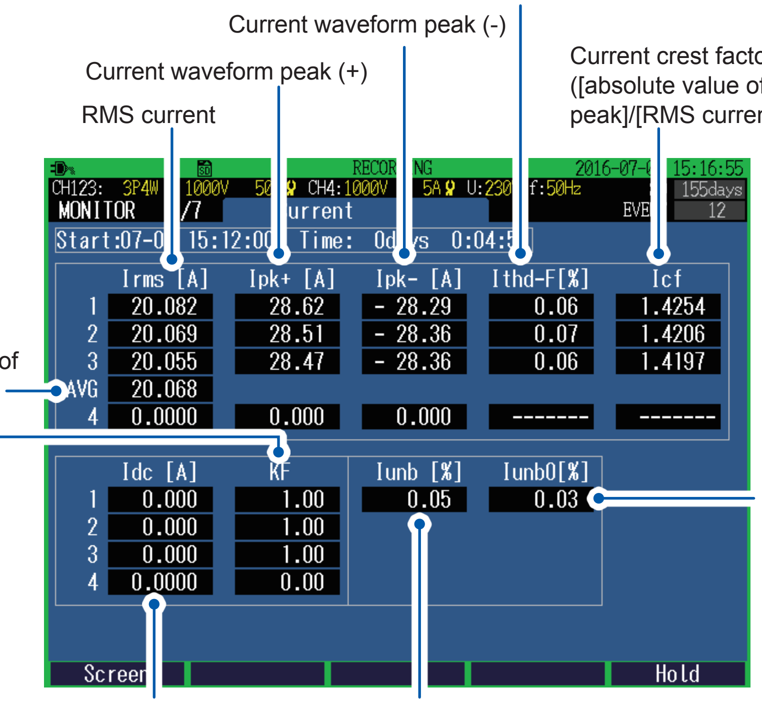


Phase voltage (Line-N), **Line voltage (Line-Line)**

For 1P2W, 1P3W	Fixed to **phase voltage**
For 3P3W2M	Fixed to **line voltage**
For 3P3W3M, 3P4W, 3P4W2.5E	Can be switched between the **line voltage** and **phase voltage**. Both the phase voltage and line voltage are stored as a output data. (3P4W2.5E is available after the firmware update)

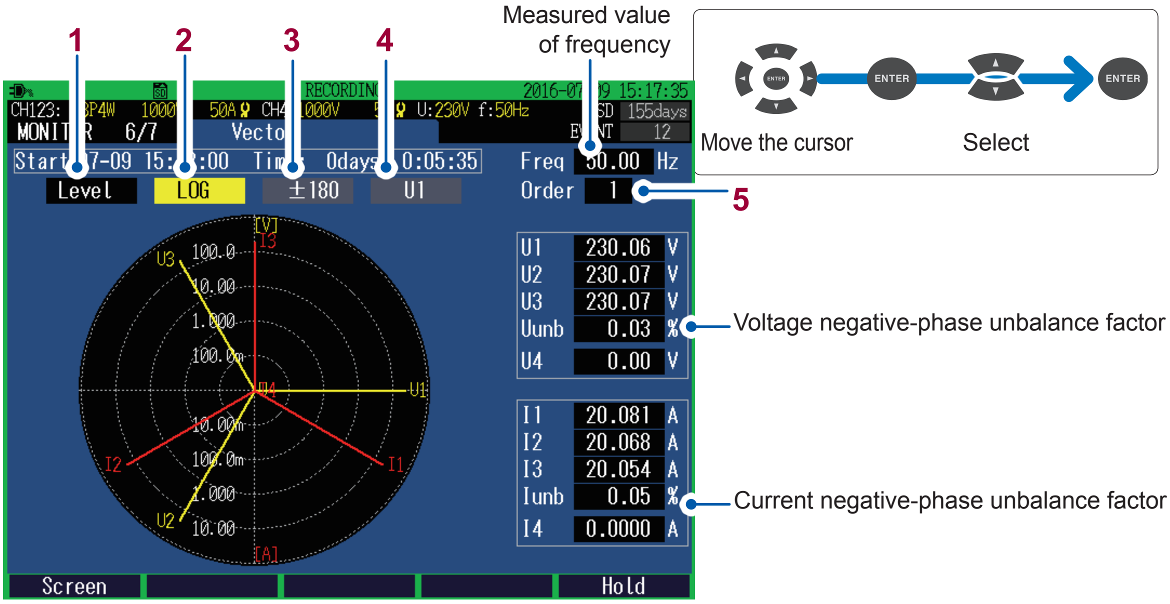
6.5 Verifying the Current Details

Press the **[MONITOR]** key to display the **MONITOR, Current** screen.



6.6 Verifying the Vector

Press the **[MONITOR]** key to display the **MONITOR, Vector** screen.
The voltage and current phase relationships for each harmonic order of the CH1 to CH4 are displayed in the vector diagram.

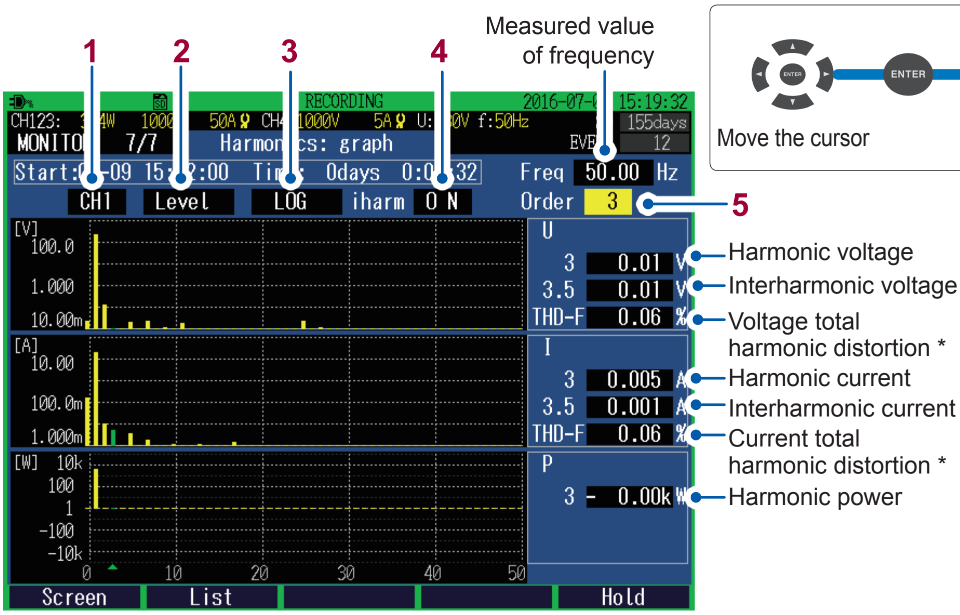


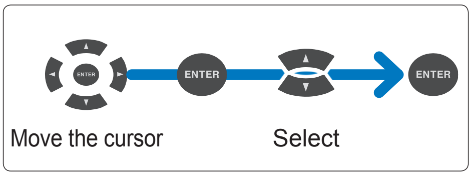
1	Enables you to set the numerical values to be displayed.	
	Level	RMS voltage and RMS current
	% of FND	Takes the fundamental wave component as 100% and shows a harmonic of each order in terms of proportion to the fundamental wave component.
	Phase	The phase angle of each harmonic order when the phase of fundamental wave components of the reference source is expressed in terms of 0°.
2	Enables you to set the display method of the axes.	
	Linear	Linear display
	Log	Logarithmic display (low levels also become easily visible.)
3	Enables you to set at the time of **Phase** display. Set the display method of numbers of phase angle.	
	±180	Lead 0 to 180°, lag 0 to −180°
	Lag360	Lag 0 to 360°
4	Enables you to set when **Lag360** is set. Select the reference (0°)source. **U1**, **I1**, **U2**, **I2**, **U3**, **I3**	
5	Enables you to set the number of harmonic orders to be displayed. The values of the frequency, voltage negative-phase unbalance factor (**Uunb**), and current negative-phase unbalance factor (**Iunb**) remain the same as calculated by using the fundamental wave (1st order). **0** to **50**	

6.7 Verifying the Harmonics Graph and Harmonics Numerical Values

Press the **[MONITOR]** key to display the **MONITOR, Harmonics: graph** screen or **MONITOR, Harmonics: list** screen. You can switch between the harmonics graph and harmonics numerical values by using the **[F2]** key.

MONITOR, Harmonics: graph screen





*: See calculation method (p. 66).
If 0th order (direct current component) of voltage and current is negative, the bar will turn green.

1 Enables you to set the display channel.

CH1 to CH4	The voltage (**U**), current (**I**), and electric power (**P**) of the selected channels are displayed.
ALL	The bar graphs of all the channels (all phases) are displayed. The orders are displayed up to 30th order.
SUM	Only the active power (**P**) is displayed.

2 Enables you to set the parameters to be displayed.

Level	RMS voltage, RMS current, and electric power
% of FND	Takes the fundamental wave component as 100% and shows a harmonic of each order in terms of proportion to the fundamental wave component.
Phase	Voltage, current: The phase angle of each harmonic order when the phases of the fundamental wave components of U1 are expressed in terms of 0° Active power: The power factor of each harmonic order is expressed in terms of angle If the level exceeds 0.01% of the range, the phase is indicated by yellow bars; does not exceed, by gray bars.

3 Enables you to set at the time of **Level** display and **% of FND** display.
Enables you to set the display method of the axes.

Liner	Linear display
Log	Logarithmic display (low levels also become easily visible.)

4 Enables you to set the display of the interharmonics.

ON, **OFF**

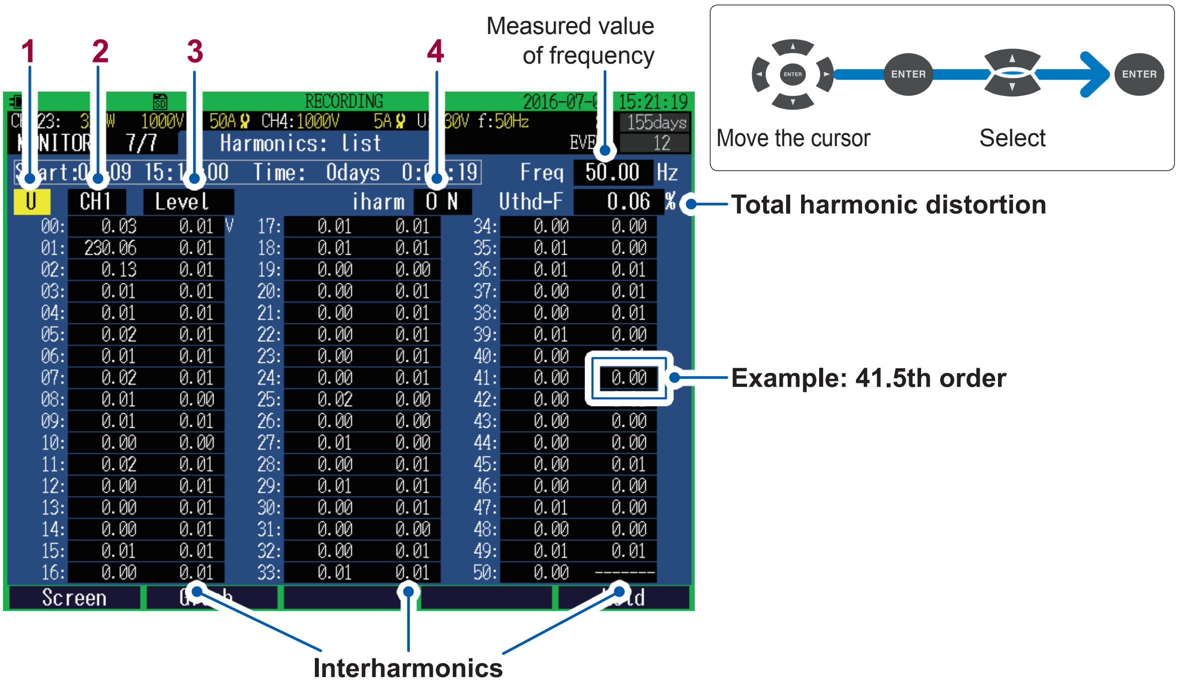
6

Verifying the Waveform, Measured Values (MONITOR Screen)

5 Set the number of harmonic order to be displayed.
The Cursor moves to the selected order.

0 to **50**

MONITOR, Harmonics: list screen



*: See calculation method (p. 66).

1 Enables you to set the display parameters.

U	Voltage
I	Current
P	Active power

2 Enables you to set the display channel.

CH1 to CH4	The voltage (**U**), current (**I**), and active power (**P**) of the selected channels are displayed.
SUM	Only the active power (**P**) is displayed.

3 Enables you to set the parameters to be displayed.

Level	RMS voltage, RMS current, and active power
% of FND	Takes the fundamental wave component as 100% and shows a harmonic of each order in terms of proportion to the fundamental wave component.
Phase	Voltage, current: The phase angle of each harmonic order when the phases of the fundamental wave components of U1 are expressed in terms of 0° Active power: The power factor of each harmonic order is expressed in terms of angle

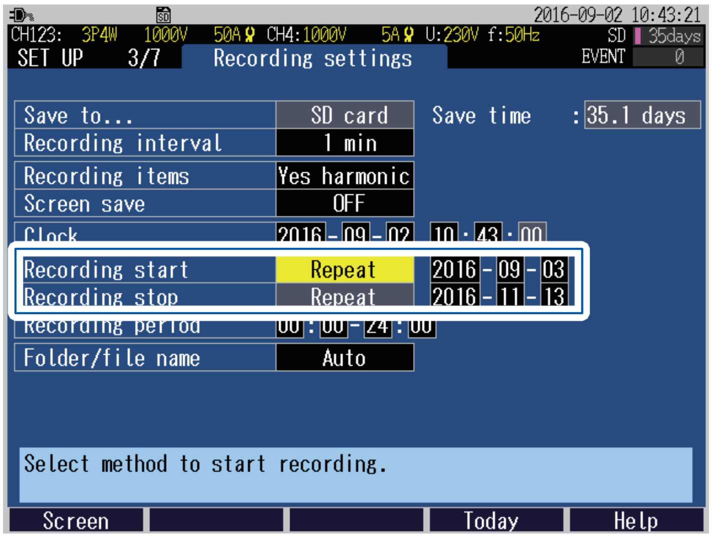
4 Enables you to set the display of the interharmonics.

ON, **OFF**

7 Recording (Save) (SET UP Screen)

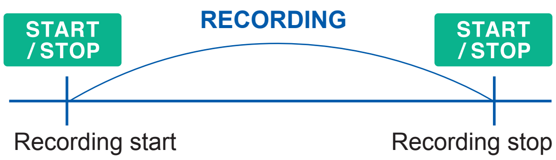
7.1 Start and Stop of the Recording

Press the **[START/STOP]** key to start or stop the recording by the method which is described on the **SET UP, Recording settings** screen (p. 69).
The measurement data is stored to SD memory card. (If no SD memory card is inserted, data will be saved in the instrument's internal memory.)
See "File Saving and Operations (FILE Screen)" (p. 115).



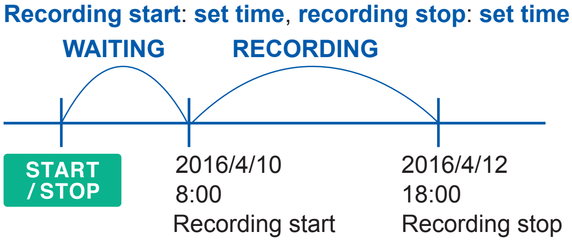
Start and stop the recording manually

Recording start: **manual**, **recording stop**: **manual**



Start and stop recording at the determined time

Recording start: **set time**, **recording stop**: **set time**

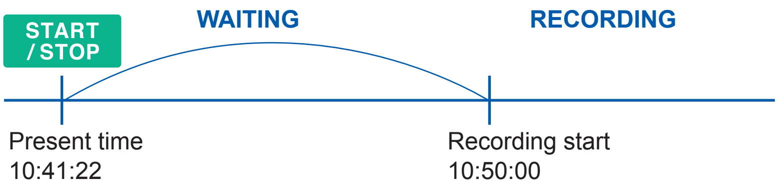


If the set time has already passed when the **[START/STOP]** key is pressed, the recording will be started at an appropriate time punctuation (**Interval**).

Start recording at an appropriate time punctuation

Recording start: **interval**, **recording stop**: **manual** or **set time**

Example: **Recording interval** is set to **10 min**

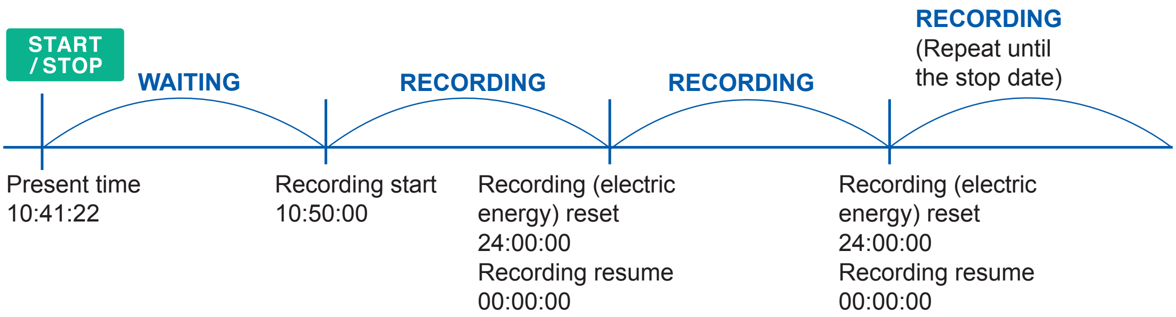


If the recording interval is 30 sec or below, the recording will start at "10:42:00."

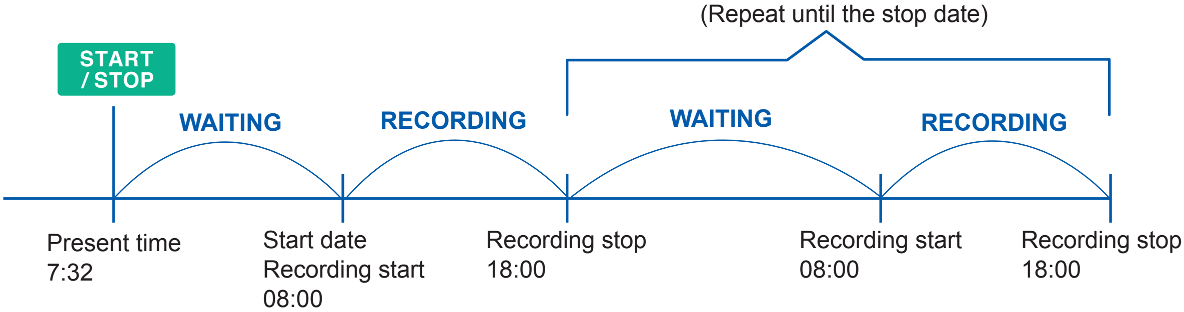
Repeat recording

Recording start: **repeat**, **recording stop**: **repeat**, **recording period**: variable period

Example 1: If the **recording period** is **00:00** to **24:00** and **recording interval** is **10** min.



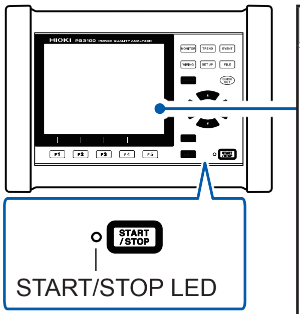
Example 2: If the **recording period** is **08:00** to **18:00**

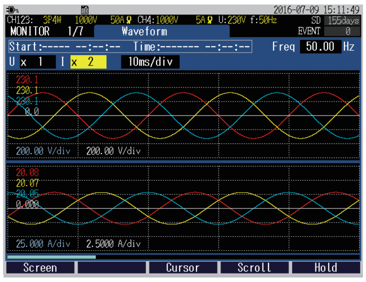
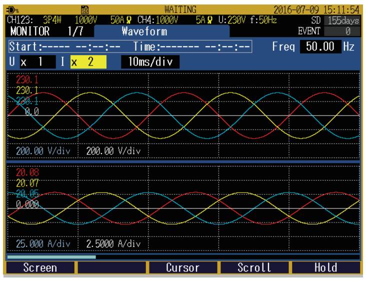
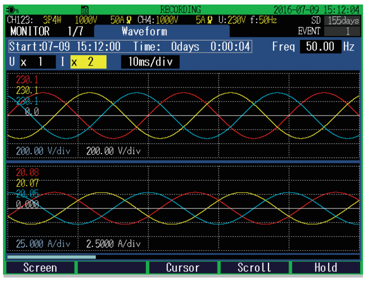


If the set time has already passed when the **[START/STOP]** key is pressed, the recording will start at an appropriate time punctuation (**Interval**).

Status of the recording operation

It can be determined from the background color of the screen and lighting state of the START/STOP LED.



Screen background	Operation status
	**Gray (no character):** (START/STOP LED: Off) • Recording is stopped. • These settings can be changed.
	**Yellow (WAITING):** (START/STOP LED: Blinking) • Recording is in standby. • This screen is shown from the time the **[START/STOP]** key is pressed until the recording actually starts. • During repeated recording, this screen is also displayed when recording is stopped. • These settings can not be changed.
	**Green (RECORDING):** (START/STOP LED: On) • Recording is in progress. • These settings can not be changed.

7.2 Using the Instrument During an Interruption

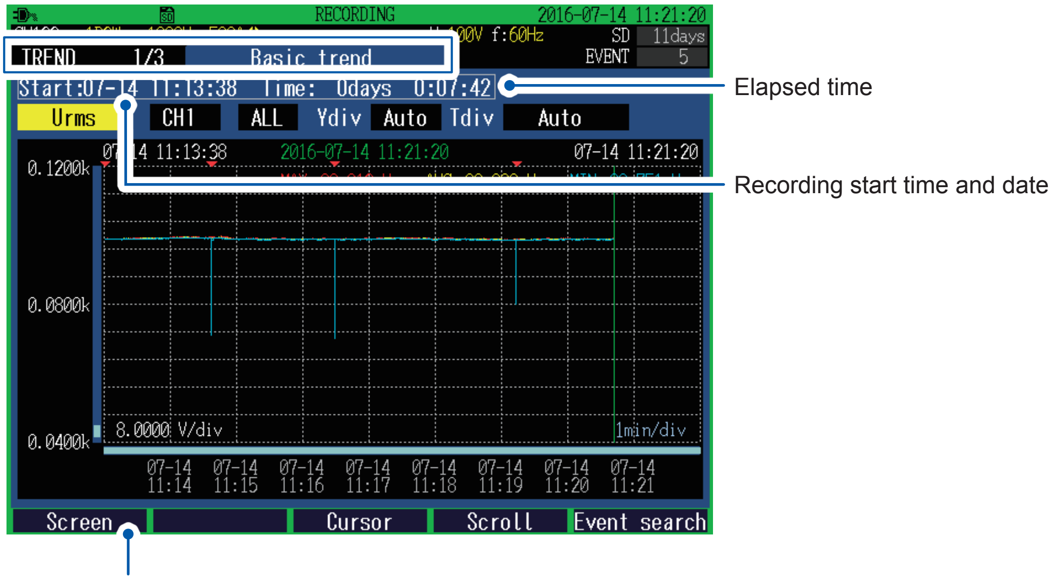
If the supply of power to the instrument is cut off while recording is in progress, measurement operation will stop during the interruption. The setting conditions will be backed up.
When the power supply is restored, the recording will reset once and it will be resumed as a new recording.
If the Model Z1003 Battery pack has been installed, the instrument will automatically switch to battery power in the event of an interruption and continue recording.

IMPORTANT
If the supply of power to the instrument is cut off while accessing the SD memory card, files on the card may be corrupted. Since the SD memory card is accessed frequently when recording with a short recording interval time, file corruption is more likely to occur if an interruption occurs during such use.
It is recommended to avoid such influences of interruptions by using the Model Z1003 Battery pack supplied as an accessory.

8 Verifying the Trends (Fluctuations) in Measured Values (TREND Screen)

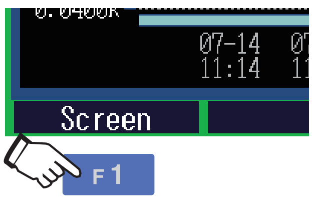
You can view the measured value fluctuations as a time series graph on the **TREND** screen.

Press the **[TREND]** key to display the **TREND** screen.

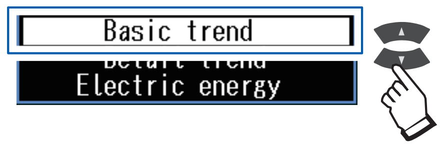


In addition to the **[TREND]** key, you can also switch to the **TREND screen** by using the **[F1]** (**screen select**) key.

1



2

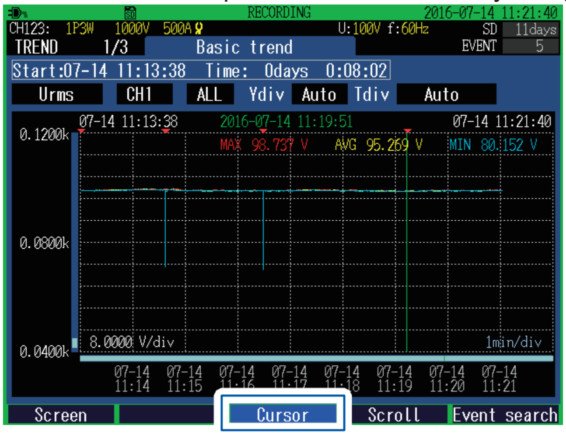


The fluctuation data that can be displayed on this instrument is limited. If the times listed in the following tables exceed, the old time series data is rewritten to the new time series data.

Recording items	Yes harmonic	Recording interval × 530
	No harmonic	Recording interval × 10000

Verifying the measured value and time at the cursor position (cursor measurement)

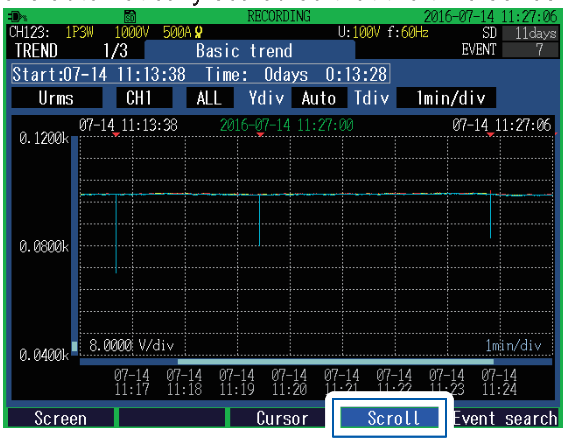
If you press the **[F3]** (**Cursor**) key, the measured value and time at the position of cursor will also be displayed along with the cursor.
You can move the position of the cursor by using the ◀▶ keys.



• When the recording interval is set to **150 cycle** or **180 cycle**, the time is displayed, followed by a small number on the order of milliseconds.
• The time displayed at the time of cursor measurement is based on the CH1 voltage (U1). The time displayed on the event list and the time displayed at the time of cursor measurement may not match.

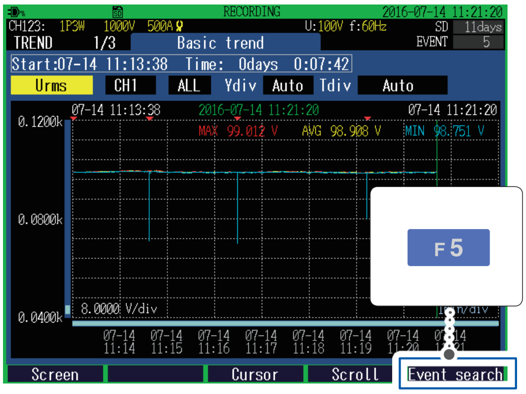
Scrolling the graph

If the graph continues out of the borders of the screen, press the **[F4]** (**scroll**) key to be able to scroll the graph. ▲▼◀▶Use this key to scroll the graph in every direction.
(If the zoom factor for horizontal axis [time axis] is set to Auto, the horizontal and vertical axes are automatically scaled so that the time series graph is entirely displayed on the screen.

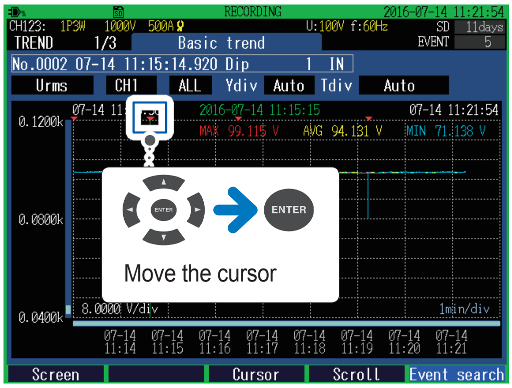


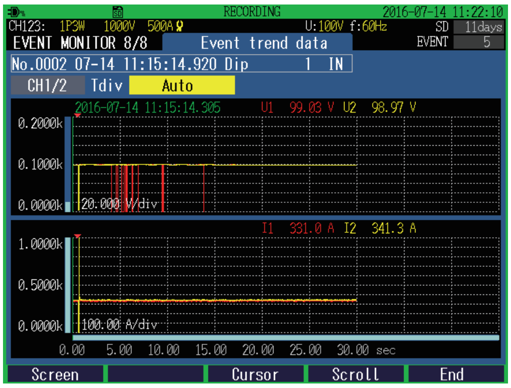
Event search

1



2 **Select an event mark to be checked.**





The screen switches to the **EVENT MONITOR** screen (p. 111).
The waveform* or graph* at the time of event occurrence is displayed.

*: The screen which displays initially varies according to the event items.

For switching the screen display of the EVENT MONITOR screen

Press the **[MONITOR]** key.

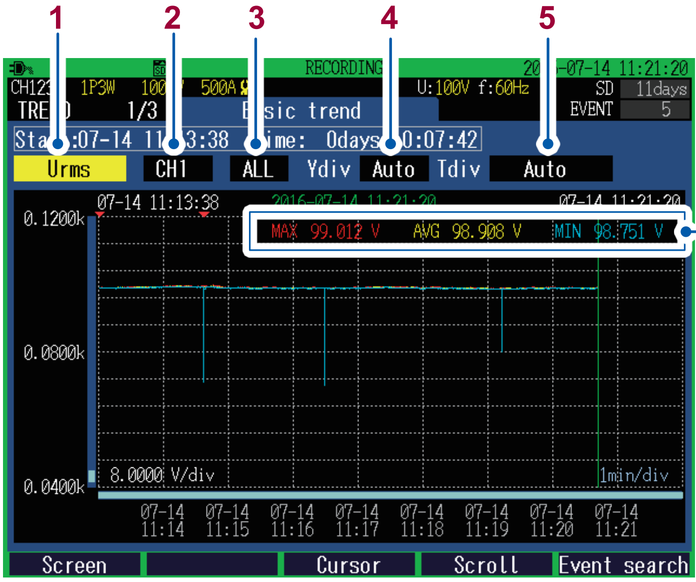
For closing the EVENT MONITOR screen

Press the **[F5]** (**End**) key.

• The recording start event generates when the recording starts and recording stop event generates when the recording stops.

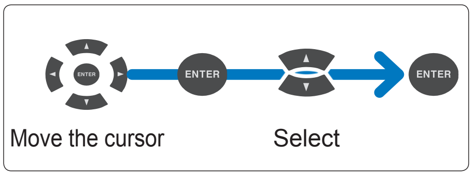
8.1 Verifying the Basic Trend

Press the **[TREND]** key to display the **TREND, Basic trend** screen.
This screen is used to check fluctuation width of maximum, minimum and average values between recording intervals.
(The maximum, minimum, and average values are calculated incessantly after every 200 ms.)



MAX: Maximum value
AVG: Average value
MIN: Minimum value

The latest measured values are displayed when the cursor is disabled, while the measured values at the position of cursor are displayed during the cursor measurement.
(The figure on the left illustrates the screen that is displayed when the cursor is disabled.)



1 Enables you to set the display parameters.

Freq	Frequency (200 ms)
Freq10s	Frequency (10 sec)
Urms	RMS voltage (200 ms)
Upk+	Voltage waveform peak (+)
Upk-	Voltage waveform peak (-)
Udc	Voltage DC value
Ucf	Voltage crest factor
Uthd	Voltage total harmonic distortion (calculation method THD-F / THD-R)
Uunb	Voltage negative-phase unbalance factor
Uunb0	Voltage zero-phase unbalance factor
Irms	RMS current (200 ms)
Ipk+	Current waveform peak (+)
Ipk-	Current waveform peak (-)
Idc	Current DC value
Icf	Current crest factor
Ithd	Current total harmonic distortion (calculation method THD-F / THD-R)
Iunb	Current negative-phase unbalance factor
Iunb0	Current zero-phase unbalance factor
P	Active power
S	Apparent power
Q	Reactive power
PF/DPF	Power factor/displacement power factor
KF	K factor

2 Enables you to set the display channel.
The channel which can be set differs according to the display items and wiring settings.

3 Set the type of graph to be displayed.
The type that can be set differs according to the display items.

MAX	The maximum value during the recording interval is displayed.
AVG	The average value during the recording interval is displayed.
MIN	The minimum value during the recording interval is displayed.
ALL	The maximum, average, and minimum values during the recording interval are displayed.

4 Set the zoom factor for the vertical axis of the graph.

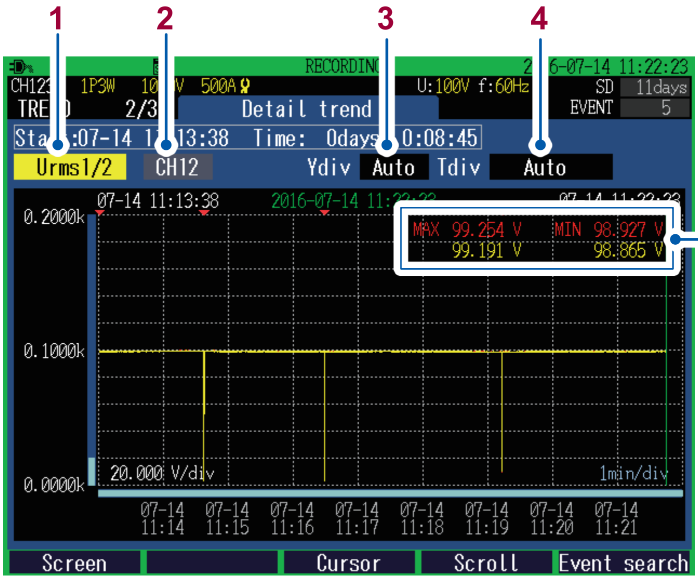
Auto, **×1**, **×2**, **×5**, **×10**, **×25**, **×50**

5 Set the zoom factor for the horizontal axis (time axis) of the graph.

The horizontal axis (time axis) which can be set, differs according to the recording intervals.

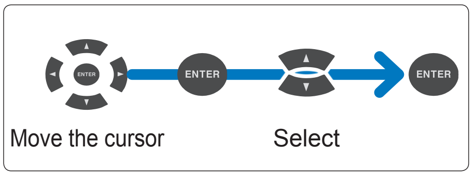
8.2 Verifying the Detail Trend

Press the **[TREND]** key to display the **TREND, Detail Trend** screen.
You can check the fluctuation range of the maximum value and minimum value during the recording intervals.
(The fluctuation range of the maximum and minimum value is calculated per wave or per half wave.)



MAX: Maximum value
MIN: Minimum value

The latest measured values are displayed when the cursor is disabled, while the measured values at the position of cursor are displayed during the cursor measurement (The figure on the left illustrates the screen that is displayed when the cursor is disabled).



1 Enables you to set the display parameters.

Urms1/2	RMS voltage refreshed each half-cycle	Calculation over a 1-cycle time, refreshed each half-cycle See “RMS voltage refreshed each half-cycle” (p. Appx.11).
Irms1/2	RMS current refreshed each half-cycle	Calculation over a 1-cycle time, refreshed each half-cycle
Inrush	Inrush current	Calculation over each half-cycle time See “Inrush current” (p. Appx.13).
Freq_wav	Frequency (1 wave)	Calculation over each 1-cycle time See “Frequency (1 wave)” (p. Appx.12).

2 Enables you to set the display channel.
The channel which can be set differs according to the display items and wiring settings.

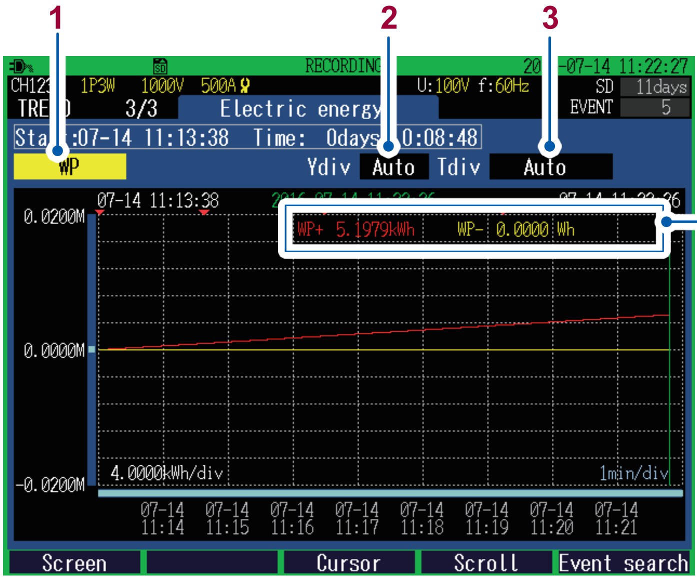
3 Set the zoom factor for the vertical axis of the graph.

Auto, **×1**, **×2**, **×5**, **×10**, **×25**, **×50**

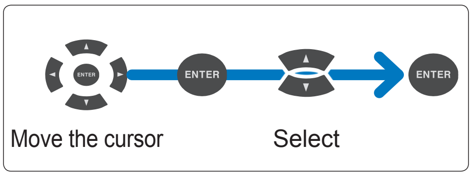
4 Set the zoom factor for the horizontal axis (time axis) of the graph.
The horizontal axis (time axis) which can be set, differs according to the recording intervals.

8.3 Verifying the Electric Energy

Press the **[TREND]** key to display the **TREND, Electric energy** screen.
This screen is used to check electric energy trends for each recording interval.
Since all the items are updated after every 1 s, the data is updated after every 1 s, when the recording interval is below 1 s.



The latest measured values are displayed when the cursor is disabled, while the measured values at the position of cursor are displayed during the cursor measurement.
(The figure on the left illustrates the screen that is displayed when the cursor is disabled.)



1 Enables you to set the display parameters.

WP	Active electric energy (**WP+**: consumption, **WP-**: regeneration)
WQ	Reactive electric energy
WS	Apparent electric energy
Ecost	Energy Cost

2 Set the zoom factor for the vertical axis of the graph.

Auto, **×1**, **×2**, **×5**, **×10**, **×25**, **×50**

3 Set the zoom factor for the horizontal axis (time axis) of the graph.
The horizontal axis (time axis) which can be set, differs according to the recording intervals.

8.4 Verifying the Demand (Available after the firmware update)

Press the **[TREND]** key to display the **TREND, Demand** screen.

8.5 Verifying the Harmonic Trend (Available after the firmware update)

Press the **[TREND]** key to display the **TREND, Harmonic trend** screen.

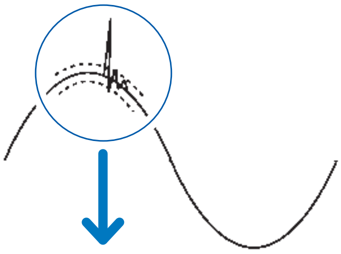
8.6 Verifying the Flicker (Available after the firmware update)

Press the **[TREND]** key to display the **TREND, Flicker** screen.

9 Checking Events (EVENT Screen)

The **EVENT** screen is used to view the list of events that have occurred and trend data of the events. (Event statistics process: Version upgrade supported)

For more information on events, see “Appx. 3 Explanation of Power Quality Parameters and Events” (p. Appx.4).



Each time an event occurs, the event is added to the **[Event list]** screen.

- When making measurements using events, ensure that event settings has been enabled by using the **Event Setting** screen in **SET UP** mode.
- The maximum number of events that can be displayed is 9999. Depending on the repeated recording setting, events for up to 9999 × days (up to one year) can be recorded.

Save items (event waveform, event trend data) change depending on the event items.

Event waveform ▶ Approx. 200 ms waveform data
(Data sampled at 200 kS/s reduced to 12.5 kS/s)

Transient waveform (available after the firmware update) ▶ Approx. 3 ms waveform data
(Data sampled at 200 kS/s)

Event trend data ▶ RMS (one or half wave) data, 0.5 s before an event and 29.5 s after an event

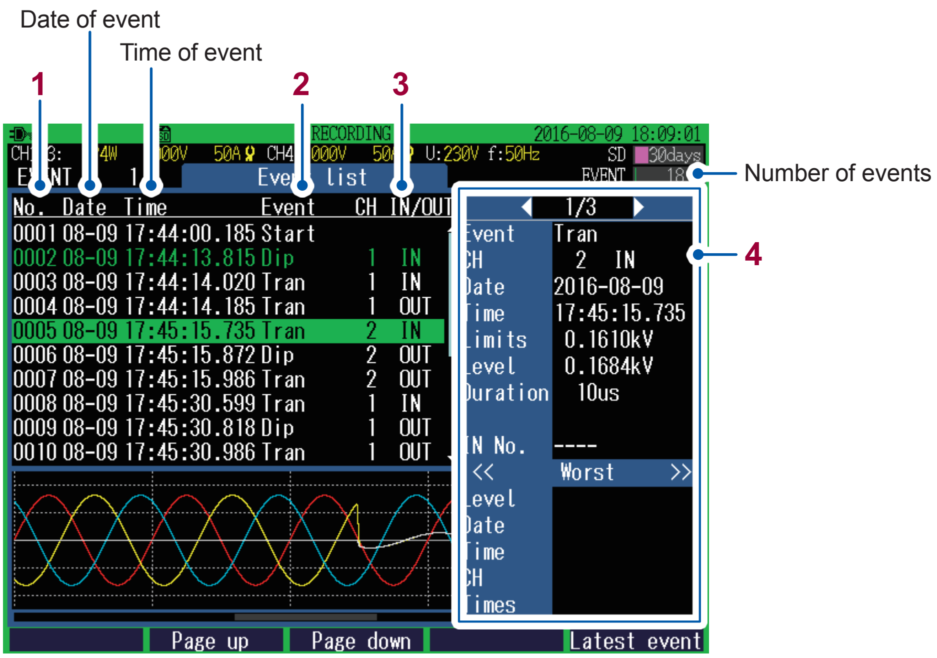
Event parameter	Screen display	IN/OUT	Measurement Items	Saved data	
				Event waveform	Event trend data
Transient overvoltage	**Tran**	IN/OUT	All instantaneous values • Frequency • Voltage • Current • Power • Power factor • Unbalance factor • Harmonic voltage • Harmonic current • Harmonic power • Voltage total harmonic distortion • Current total harmonic distortion	✓*1	—
Swell	**Swell**	IN/OUT		✓	✓*2 • RMS voltage refreshed each half-cycle (One wave calculation per half wave) • RMS current refreshed each half-cycle (One wave calculation per half wave)
Dip	**Dip**	IN/OUT		✓	✓*2 • RMS voltage refreshed each half-cycle (One wave calculation per half wave) • RMS current refreshed each half-cycle (One wave calculation per half wave)
Interruption	**Intrpt**	IN/OUT		✓	✓*2 • RMS voltage refreshed each half-cycle (One wave calculation per half wave) • RMS current refreshed each half-cycle (One wave calculation per half wave)
Frequency (200 ms)	**Freq**	IN/OUT		✓	—
Frequency (1 wave)	**Freq_wav**	IN/OUT		✓	—
Voltage total harmonic distortion	**Uthd**	IN/OUT		✓	—
Inrush current	**Inrush**	IN/OUT		✓	✓*2 RMS inrush current (Half wave calculation)

Event parameter	Screen display	IN/OUT	Measurement Items	Saved data	
				Event waveform	Event trend data
Current total harmonic distortion	**Ithd**	IN/OUT	All instantaneous values • Frequency • Voltage • Current • Power • Power factor • Unbalance factor • Harmonic voltage • Harmonic current • Harmonic power • Voltage total harmonic distortion • Current total harmonic distortion	✓	—
Timer event	**Timer**	—		✓	—
External event	**Ext**	—		✓	—
Manual event	**Manu**	—		✓	—
Pre-event recording	**Before**	—		✓	—
Post-event recording	**After**	—		✓	—
Recording start	**Start**	—		✓	—
Recording stop	**Stop**	—		✓	—

✓: Saved, -: Not saved
*1: Transient waveforms are also saved.
*2: Saved only for Event IN. If a number of Events IN occur continuously, no event trend data may be present.

9.1 Checking Event List

Press the **[EVENT]** key to display **EVENT**, **Event list** screen.
Events can be checked on the list. The events are sorted in the order of occurrence.



1	Event No. • Number of listed events is all events from No.1 through No. 9999. • The first event to occur (the starting recording event) is assigned No. 1, and subsequent events are assigned numbers in order as they occur.		
2	Event item See “Appx. 2 Event Item” (p. Appx.3).		
3	**IN**	Event occurrence	
	OUT	Event end	
4	Event list details (Details of the selected event numbers are displayed)		
	Event	Event item	
	Event CH	**CH**	Event channel (**CH1**/**CH2**/**CH3**/**CH4**/**sum**)
		IN	Event occurrence
		OUT	Event end
		UP	For frequency events, the list indicates up (when the reading is greater than the threshold value).
		DOWN	For frequency events, the list indicates down (when the reading is less than the threshold value).
	Date	Date of event	

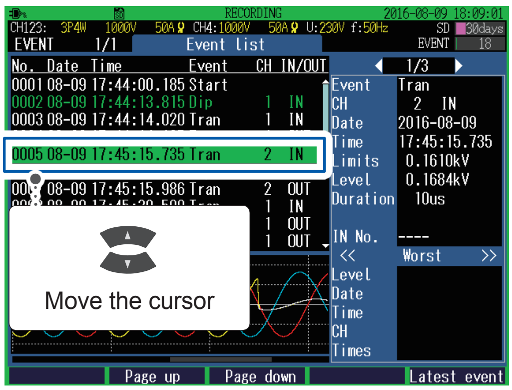
4 Time		Time of event
Threshold		Threshold value with event (measured value)
Measured value		Measured value when an event was detected If a transient overvoltage event occurred, the transient width is also displayed.
Duration		Indicates the period after which the reading returned after the threshold value was exceeded, or the period from IN to OUT.
IN No.		Event No. of IN for Event OUT
Worst*	Level	Worst measured value during event period
	Date	Indicates the date on which the worst value was detected.
	Time	Indicates the time at which the worst value was detected.
	CH	Channel on which the worst value was detected (**CH1**/**CH2**/**CH3**/**CH4**/**sum**)
	Times	Number of transient overvoltage detected from the transient overvoltage event IN to the transient overvoltage event OUT (up to **999999 Times**)

*: Indicates the worst measured value during event period. For example in the case of voltage drop due to DIP, the lowest voltage is the worst value.

• An SD card is required to be inserted to display the Event list details.
• Event data with characters colored in green include event trend data. (p. 112)
• When events with multiple differing parameters occur during the same approximately 200 ms period, they are displayed together as a single event. A list of the multiple parameters is displayed in the “Event list details” at the right.
• When two event IN items occur simultaneously, they will be displayed according to the priority. Two event OUT items occurring simultaneously are treated in the same manner.

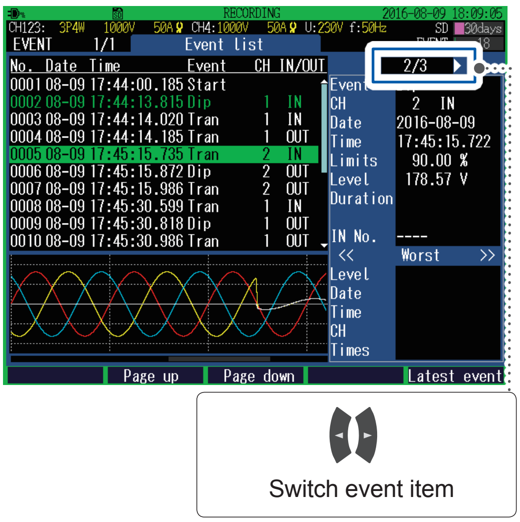
Checking event details

1 **Select an event No.**



[F2] (**Page up**) key, **[F3]** (**Page down**) key:
Cursor position can be changed for each page.
[F5] (**Latest Event**) key:
You can move the cursor to the latest event.

2 **When more than one event has occurred simultaneously, change the event item to check the event list details.**



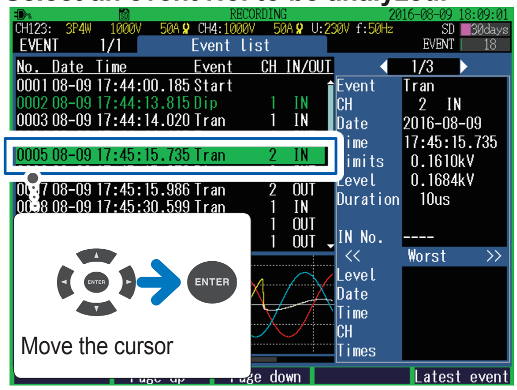
An SD card is required to be inserted to refresh the displayed details

9.2 Checking Event Status

Use the following procedure to display the **EVENT MONITOR** screen. Waveforms and measured values of the event can be checked.

1 **Press the [EVENT] key to display EVENT, Event list screen.**

2 **Select an event No. to be analyzed.**

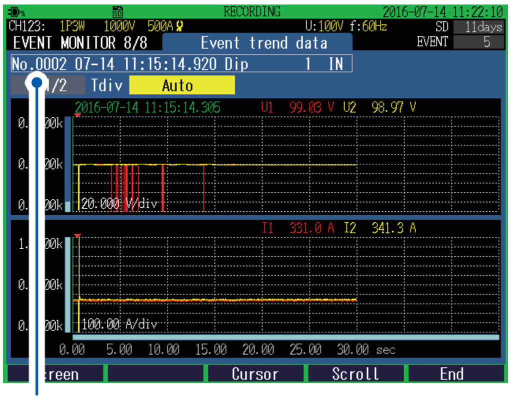


The display will switch to the **EVENT MONITOR** screen to show waveforms and a graph when the event occurred.

The screen displayed initially depends on the event items.

3 **Use the [MONITOR] key to switch the screen.**

EVENT MONITOR, Event trend data Screen



Event number, time and date, and type

[F3] (**Cursor**) key:
Cursor, and measurement value of the cursor position and the time are displayed.
◀▶ You can move the cursor to the latest event.

[F4] (**Scroll**) key:
If the waveforms do not fit on the screen, the graph can be scrolled with this key. ▲▼◀▶Use this key to scroll the graph in every direction.

To exit the EVENT MONITOR screen:

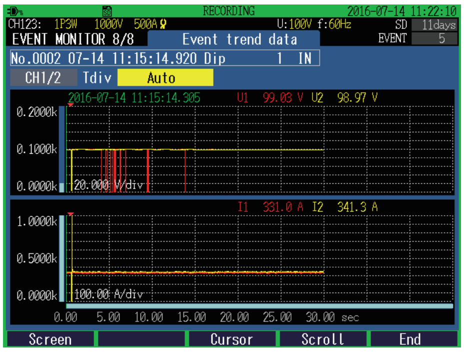
Press the **[F5]** (**End**) key.

Switching event monitor screen

When event monitor is displayed, **[EVENT]** and **[MONITOR]** keys are lit.

Display/switch screen: **[MONITOR]** key

Event trend data screen (p. 112)



Event trend data is shown in a time series graph.
(This graph appears only for swell, dip, interruption, and inrush current Event IN.)

Waveform screen (p. 82)*

Voltage and current waveforms of CH1 through CH4 are displayed.

Electric power screen (p. 84)*

RMS voltage, RMS current, frequency, power, power factor, active energy (consumption) and elapsed time are displayed.

Electric energy screen (p. 85)*

Electric energy, energy cost, start time, stop time, elapsed time, power and power factor are displayed.

Voltage screen (p. 86)*

Measured values related to voltage are displayed.

Current screen (p. 87)*

Measured values related to current are displayed.

Vector screen (p. 88)*

Phase relationship between voltage and current is displayed in a vector diagram.

Harmonics screen (p. 89)*

Harmonic voltage, harmonic current, and harmonic power from 0 to 50th order are displayed.

Zoom screen (p. 91) (available after the firmware update)*

Enlarged view of 6 user-selected items are available.

Transient waveform screen (p. 113) (available after the firmware update)

Transient waveforms are also saved.
(Displayed only if a transient overvoltage event occurred.)

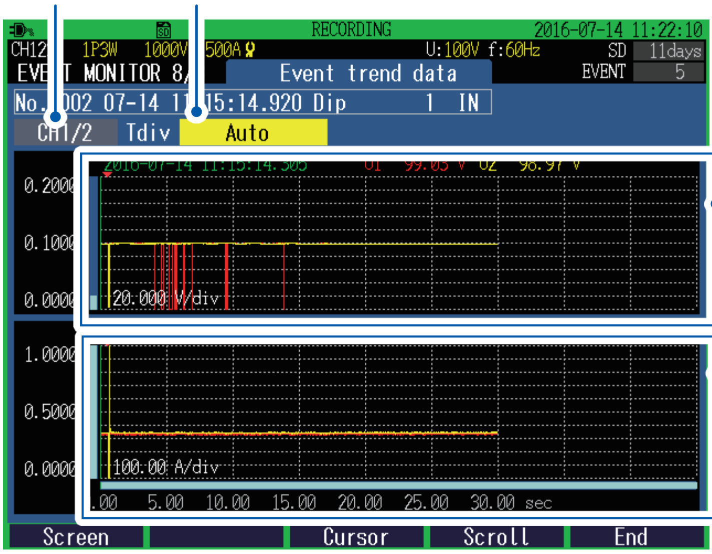
*: Data for every 200 ms on an event is displayed.

Checking trend data on event

Event trend data of swell, dip, interruption, and inrush current event for 30 s (0.5 s before Event IN, 29.5 s after Event IN) is displayed in a time series graph.

How to display the EVENT MONITOR screen: p. 110

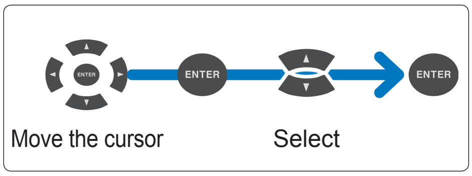
1 2



Voltage trend data on a swell, dip, or interruption event (Urms1/2)

- Current trend data on a swell, dip, or interruption event (Irms1/2)

  or
- Current trend data on an inrush current event (Inrush)



1	Enables you to set the display channel. **CH1**/**2**/**3** (depending on the wiring settings), **CH4** (when the wiring settings are enabled)	
2	Set a horizontal axis zoom factor for the graph. **Auto**, **0.10sec/div**, **0.25sec/div**, **0.50sec/div**, **1.00sec/div**, **2.50sec/div**, **5.00sec/div**	

- The event trend data appears only for swell, dip, interruption, and inrush current Event IN.
- Even if another event occurred during event trend data recording (30 s), the event trend data for the event will not be saved.

Checking transient waveforms during an event (Available after the firmware update)

10 File Saving and Operations (FILE Screen)

The instrument can save the following data on an SD memory card or in its internal memory.

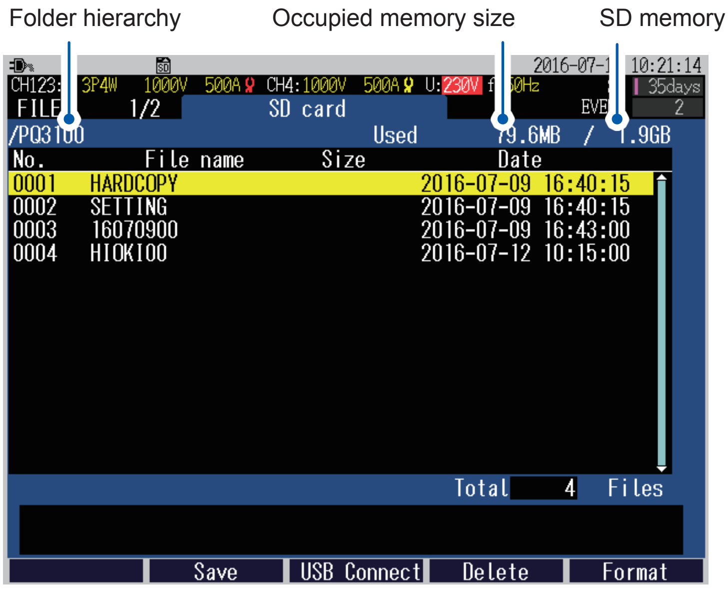
File contents	Extension	Format	SD memory card	Internal memory
Screen copy data	BMP	Binary	✓	—
Setting data	SET	Binary	✓	✓
Trend record data	ITV	Binary	✓	✓
Flicker/trend record data (available after the firmware update)	FLC	Binary	✓	✓
Event list	EVL	Binary	✓	—
Event data	EVT	Binary	✓	—
Event trend data	WDU	Binary	✓	—
Event statistics data (available after the firmware update)		Binary	✓	—

✓: Saved, —: Not saved

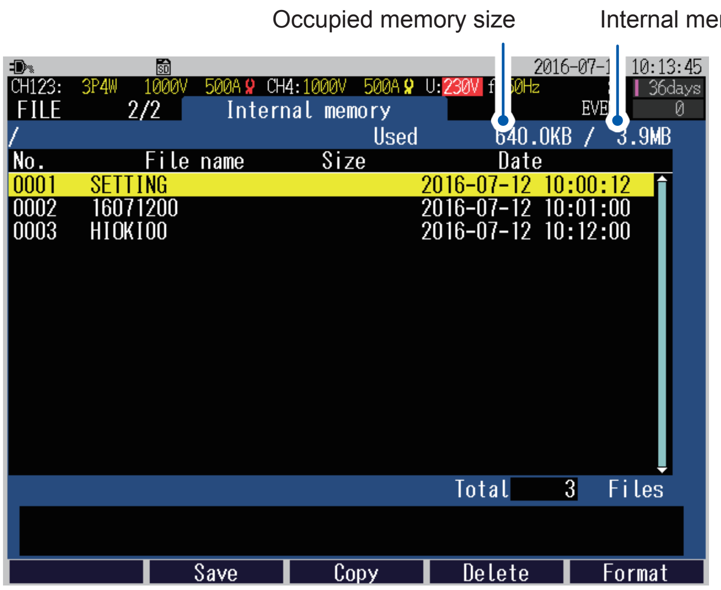
10.1 Viewing and Using FILE Mode Screen

Press the **[FILE]** key to display the **FILE** screen.

FILE, SD card screen



FILE, Internal memory screen

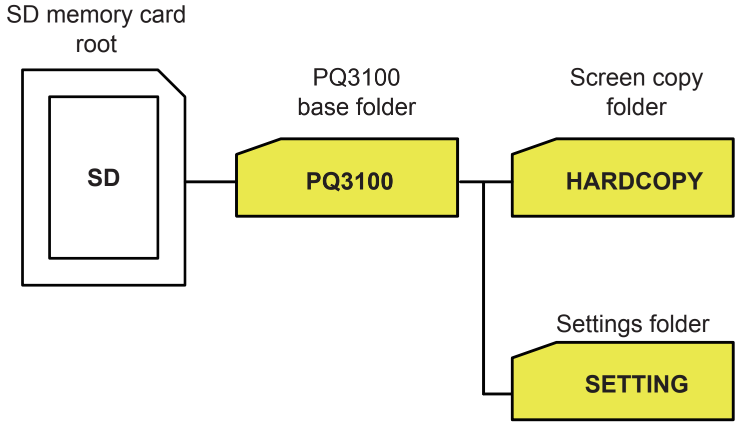


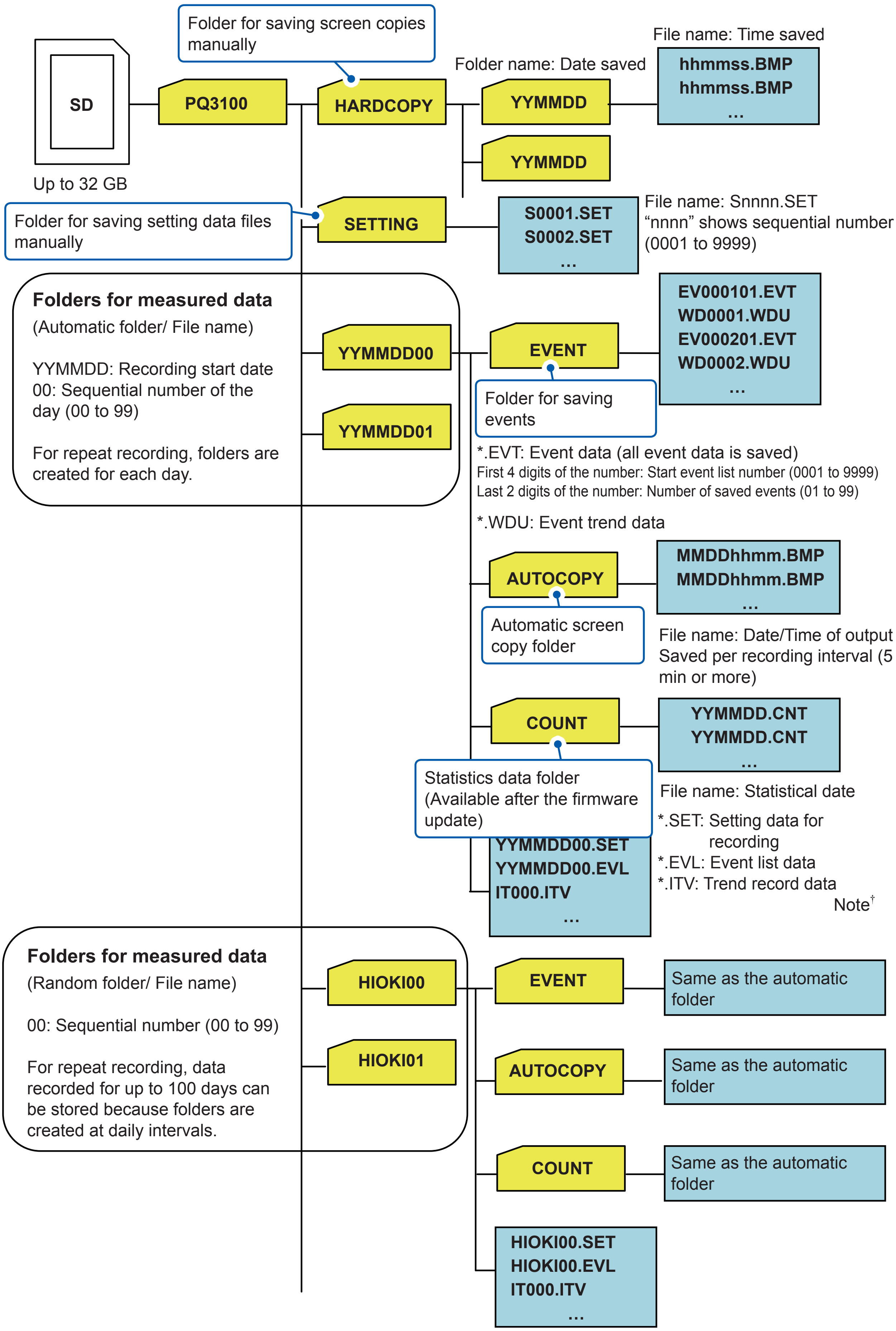
Keys	Description
	Navigates within the folder hierarchy.
	Selects folders and files.
ENTER	Navigates to lower hierarchy when a folder is selected.
F1 (**Load**)	Loads setting data (p. 123). Loads measured data (p. 124).
F1 (**Remove SD**)	Enables the state which allows the removal of the SD memory card during recording (p. 127).
F2 (**Save**)	Saves setting data (p. 122).
F3 (**USB Connect**)	**FILE, SD card** screen The USB cable is used to connect the instrument with a computer (mass storage connection) and copy data from an SD memory card to the computer (p. 131).
F3 (**Copy**)	**FILE, Internal memory** screen Copies data selected from the internal memory to the SD memory card (p. 125).
F4 (**Delete**)	Deletes selected folders/files (p. 125).
F5 (**Format**)	Formats the SD memory card or the internal memory (p. 126).

10.2 Folder and File Structure

SD memory card

The **PQ3100** base folder is required for the instrument to save data on the SD memory card. If the **PQ3100** base folder does not exist on the SD memory card, it will be created automatically when a file is created.





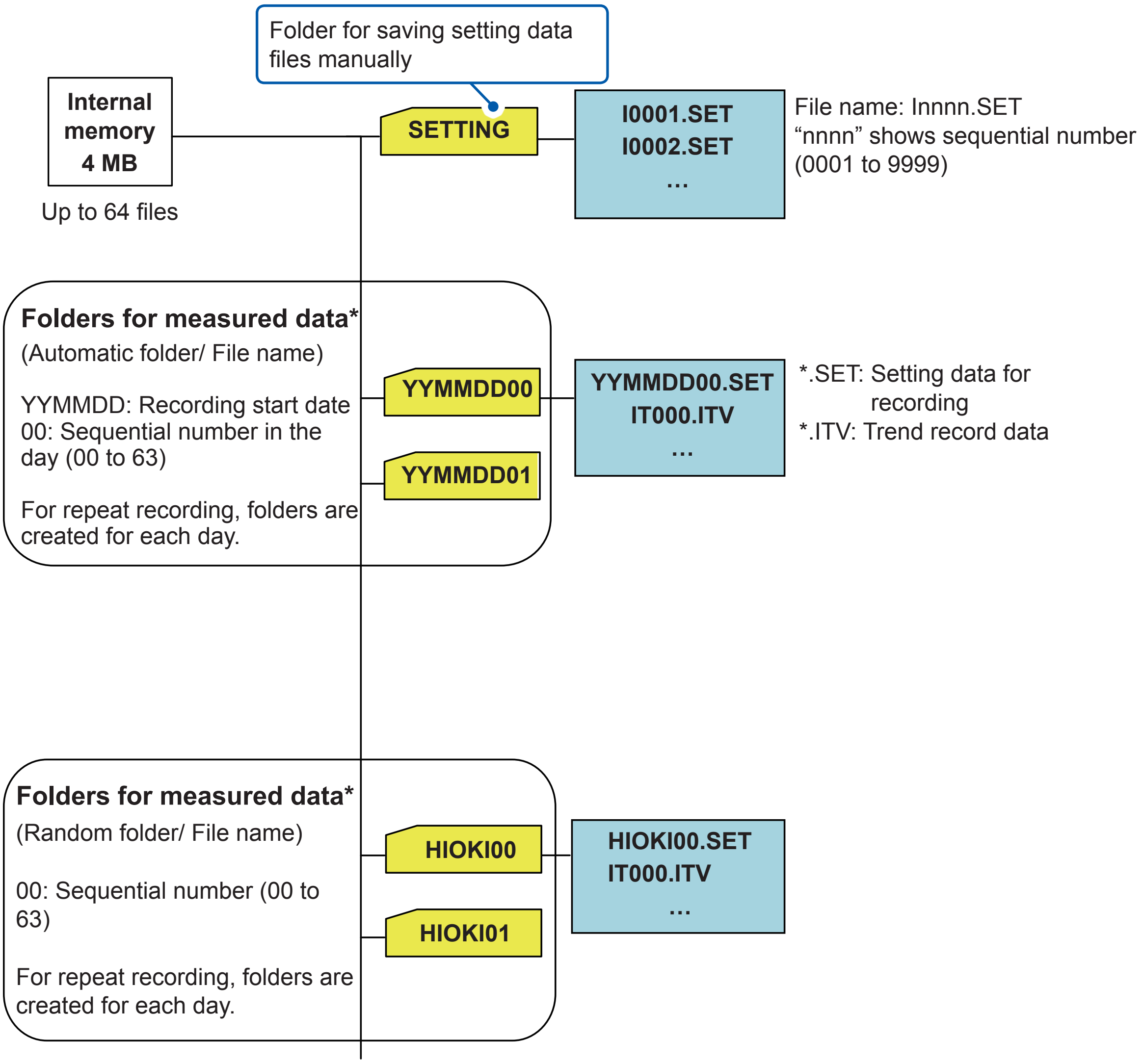
† If the file size exceeds 100 MB or the SD memory card is inserted or ejected, the file is divided. (Up to 1000 files)

File Saving and Operations (FILE Screen)

10

Internal memory

If no SD memory card is inserted or if there is no free space in the SD memory card, data will be stored in the instrument's internal memory. Only the setting data and the trend record data are stored in the internal memory.
Event data and screen hard copies can be stored in only an SD memory card. After the recording is terminated, if an SD memory card is inserted before the instrument is turned on or a new recording starts, the data stored in the internal memory will be moved to the SD memory card.



*: When 64 files are created, no further recording is available.

10.3 Screen Hard Copy

The screen currently being displayed can be saved in BMP format on the SD memory card.

1 **Verify that an SD memory card has been inserted into the instrument (SD appears on the screen).**

2 **Display the screen you wish to save.**

3 **Press the [COPY] key.**

Screen copy data is saved in the **/PQ3100/HARDCOPY** folder of the SD memory card.

If no SD memory card has been inserted, screen copy data cannot be saved.

Checking images (Available after the firmware update)

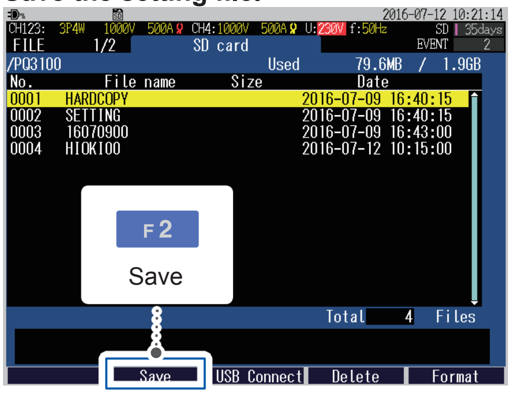
10.4 Saving Setting Files

Present setting state can be saved.
Either SD memory card or internal memory can be used to save the setting files.

1 **Verify that an SD memory card has been inserted before saving data to it.**
(appears on the screen)

2 **Press the [FILE] key to display the FILE, SD card screen or FILE, Internal memory screen.**

3 **Save the setting file.**



Sample screen: **FILE, SD card** screen

The setting file will be saved.

Save to folder

On the **FILE, SD card** screen:
/PQ3100/SETTING

On the **FILE, Internal memory** screen:
/SETTING

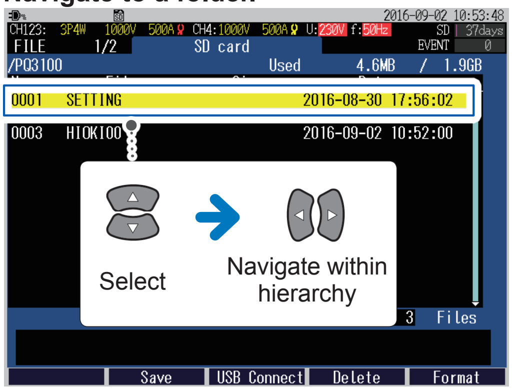
10.5 Loading Setting Files

Loading a setting file allows you to restore the instrument to the state when the settings were saved.
Settings related to LAN cannot be loaded.

1 **Verify that an SD memory card has been inserted before loading data from it.**
( appears on the screen)

2 **Press the [FILE] key to display the FILE, SD card screen or FILE, Internal memory screen.**

3 **Navigate to a folder.**

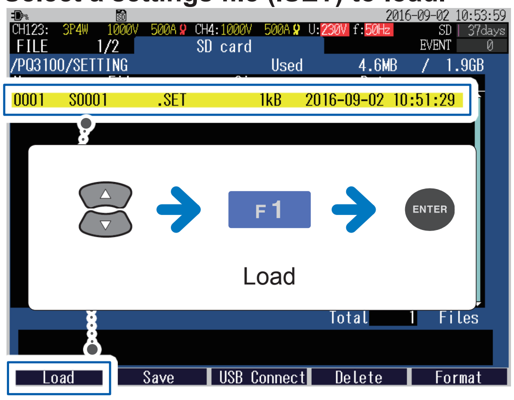


SD memory card:
/PQ3100/SETTING

Internal memory:
/SETTING

The measured data save folder also has the setting file used during the measurement.

4 **Select a settings file (.SET) to load.**



The setting file will be loaded to the instrument.

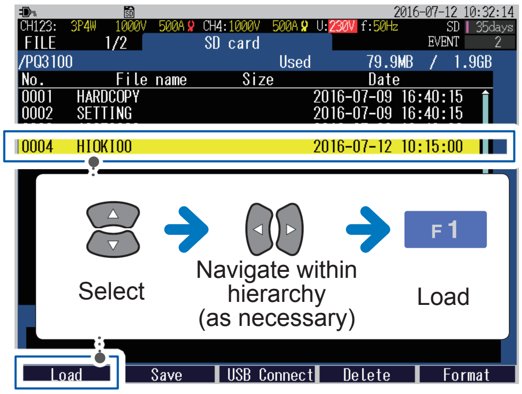
10.6 Loading Measured Data

The measured data in the SD memory card and internal memory can be loaded to the instrument to check the measured values.

1 **Verify that an SD memory card has been inserted before loading data from it.**
(appears on the screen)

2 **Press the [FILE] key to display the FILE, SD card screen or FILE, Internal memory screen.**

3 **Select a folder to load.**



Folder for the measured data
SD memory card:
/PQ3100/YYMMDDXX or
/PQ3100/HIOKI (desired folder name)**XX**
Internal memory:
/YYMMDDXX or
/HIOKI (desired folder name)**XX**

Screen sample:
/PQ3100/HIOKI00 folder on the **FILE, SD card** screen

The measured data will be loaded to the instrument.

After the loading is complete, the **EVENT, Event list** screen is displayed.

The data that has been loaded will be retained until a new recording is started or the power is turned off.

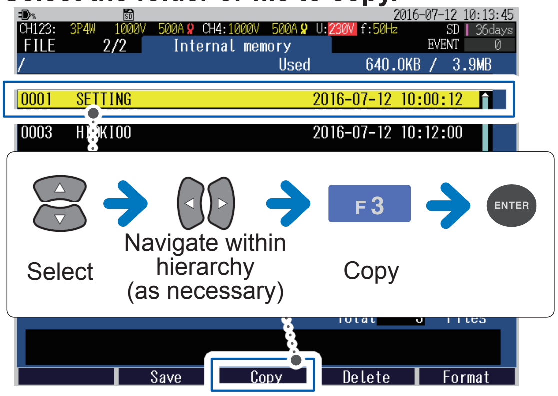
10.7 Copy from the Internal Memory to SD Memory Card

This section describes how to copy folders and files of the internal memory to the SD memory card.

1 **Verify that an SD memory card has been inserted into the instrument (appears on the screen).**

2 **Press the [FILE] key to display the FILE, Internal memory screen.**

3 **Select the folder or file to copy.**



The folders or the files will be copied to the SD memory card.

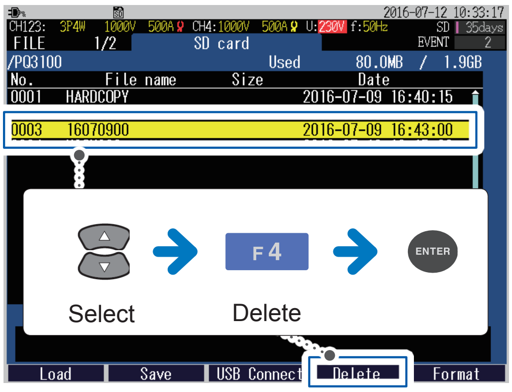
10.8 Deleting Folders and Files

This section describes how to delete folders and files stored on the SD memory card or in the instrument's internal memory.

1 **Verify that an SD memory card has been inserted before deleting folders or files from it. (appears on the screen)**

2 **Press the [FILE] key to display the FILE, SD card screen or FILE, Internal memory screen.**

3 **Select the folder or file to delete.**



Sample screen: **FILE, SD card** screen

The folders or the files will be deleted.

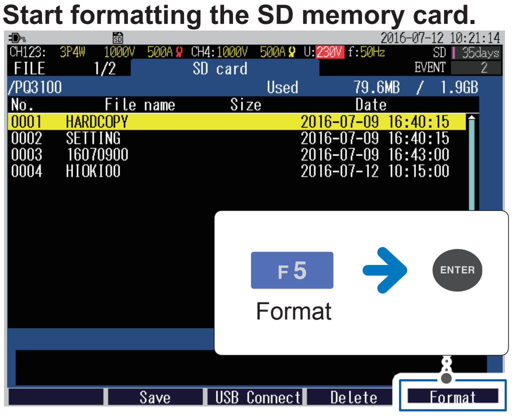
10.9 Formatting SD Memory Card (Deleting All Files)

An SD memory card and the internal memory can be formatted.

1 **Verify that an SD memory card has been inserted before formatting it.**
(The icon SD appears on the screen)

2 **Press the [FILE] key to display the FILE, SD card screen or FILE, Internal memory screen.**

3 **Start formatting the SD memory card.**



Sample screen: **FILE, SD card** screen

The SD memory card / the internal memory is formatted and the PQ3100 master folder is in it (p. 118).

- Be sure to use the instrument to format SD memory cards. The instrument can only save data to SD memory cards that have been initialized with the dedicated SD format (The format of Hioki's optional SD memory cards is dedicated SD format).
- Using a computer to format the card may reduce the card's performance.

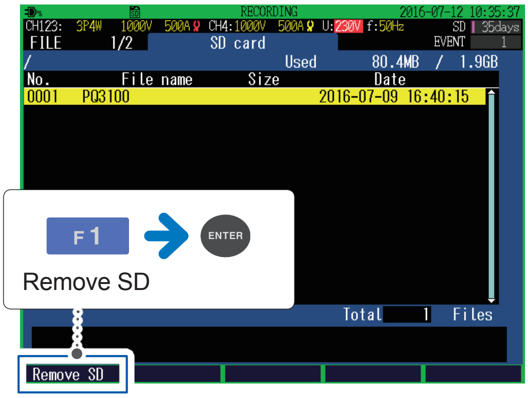
10.10 Removing SD Memory Card during Recording

Removing an SD memory card while recording data to the card may damage the data. To remove the SD memory card safely during recording, saving data to the SD memory card can be stopped.

Only when the recording interval is set to 2 s or more, the SD memory card can be removed.

1 **Press the [FILE] key to display the FILE, SD card screen.**

2 **Execute card removal.**



The SD memory card can be removed.

Procedure after removal

1. After all data in the SD memory card is copied to a computer or a similar device, insert the SD memory card into the instrument.
   If the SD memory card is returned to its original state by deleting the stored data or another SD memory card is inserted, a measurement data folder is newly created. A measurement data folder that differs from the previously created folder will cause the application software PQ One, which is supplied with the instrument, not to recognize both of the measurement data to be the same.
   To analyze the data stored in the SD memory card that was previously ejected and the one stored in the card that is subsequently inserted, considering both of the data as equal, insert the SD memory card with the original data left in it.

2. Check that the SD memory card is recognized.
   (The icon  appears on the screen)

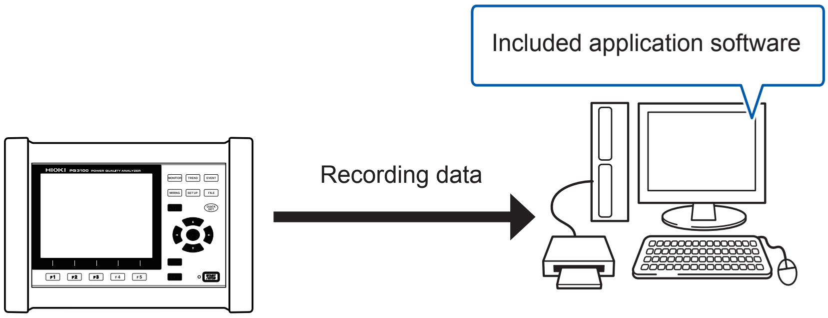
   Trend record data will be divided and a new file will be created.

Saving operation when an SD memory card is removed during a recording

Only trend record data (p. 115) will be backed up in the internal memory with the recording interval time that has been set. When an SD memory card is inserted into the instrument while recording is stopped, backup data will be automatically moved to the SD memory card (the data will be divided and saved as a new file).

11 Analysis (with Computer)

This section describes how to load data recorded with the instrument onto a computer and analyze the data using the supplied application software, PQ One.
Refer to Application Software Instruction Manual (CD).



File contents	Extension	Format	Supported software	
			Application software	Other than application software
Screen copy data	BMP	Binary	—	Graphics software
Setting data	SET	Binary	✓	—
Trend record data	ITV	Binary	✓	
Flicker/trend record data (Available after the firmware update)	FLC	Binary	✓	
Event list	EVL	Binary	✓	
Event data	EVT	Binary	✓	
Event trend data	WDU	Binary	✓	

✓: Supported, —: Not supported

The data measured by the instrument is written in binary format and cannot be directly read using spreadsheet software such as Microsoft Excel®. When the measured data is read using the appropriate application software and output in CSV format, the data can be read using spreadsheet software (available after the firmware update).

11.1 Copying Files

The following methods are available to copy data saved to a computer.

Method	SD memory card	Internal memory	Reference
Use an SD memory card reader	✓	—	p. 130
The SD memory card is recognized as a removable disk by connecting the instrument to a computer with a USB cable	✓	—	p. 131
Copy the data from the internal memory to the SD memory card and copy the data from the SD memory card	—	✓	p. 125

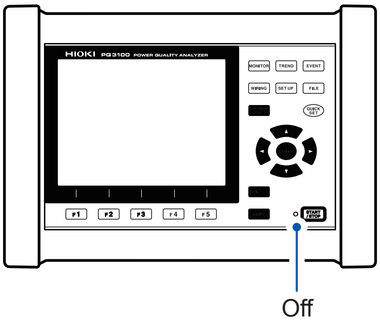
✓: Supported, —: Not supported

Use of SD Memory Cards

Be sure to read “Using SD Memory Cards” (p. 10) before use.

Screen sample: Windows 10

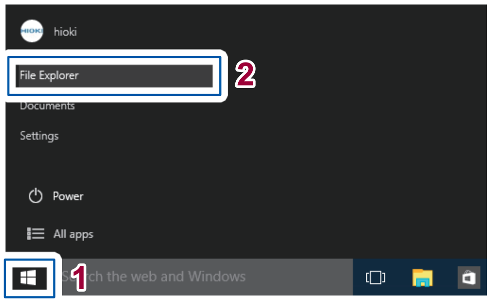
1 **Verify that recording has stopped.**



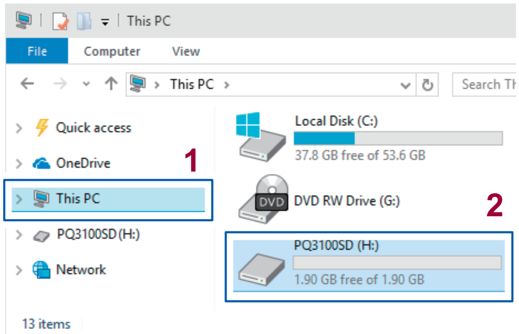
2 **Eject the SD memory card from the instrument.**

3 **Insert the SD memory card into the SD memory card slot on the computer.**

4 **Click the Start button, and then, click File Explorer to start Explorer.**



5 **Click This PC, and then, double-click PQ3100SD.**



If the SD memory card was not formatted with the instrument, then **Removable Disk** will be displayed.

6 **Copy the necessary folders to the any folder on the computer.**

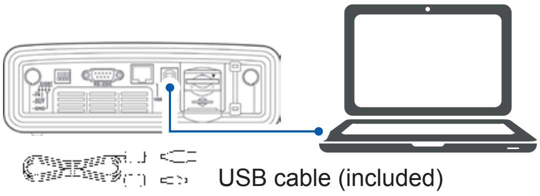
Use of USB Cable

Be sure to read "Using USB Connector (USB Cable)" (p. 12) before use.
The USB cable included is used to connect the instrument with a computer and copy data from the SD memory card to the computer.

1 **Turn on the computer.**

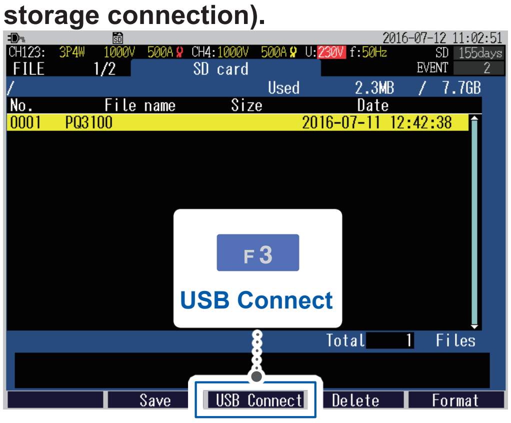
2 **Turn on the instrument. (p. 44)**

3 **Connect the instrument and computer with the USB cable.**



4 **Press the [FILE] key to display the FILE, SD card screen.**

5 **Change the mode to USB Connect (mass storage connection).**



After the mode is changed to USB Connect, the following message appears on the instrument screen.

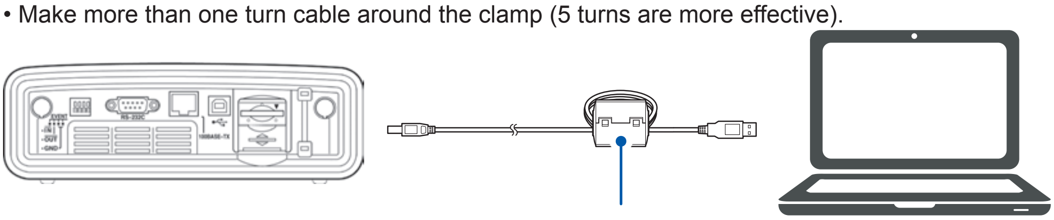
USB connected
To cancel
Cancel: ESC key

6 **Copy the necessary folders to the any folder on the computer.**

- Data on the instrument's SD memory card cannot be accessed (to delete files, change filenames, etc.) from the computer.
- The USB connection is not possible if the SD memory card is not inserted.

The effects of electromagnetic interference such as noise from an external source may cause communications errors when using a USB connection. If you encounter such errors, wind the USB cable around a commercially available ferrite clamp as shown in the figure below before connecting the instrument with the computer.

The effectiveness of the clamp can be increased as follows:
- Attach the clamp as close as possible to the connector of the computer.
- Make more than one turn cable around the clamp (5 turns are more effective).



Ferrite clamp (commercially available)

The ferrite clamp (segmented core) shown in the figure is the product of NEC Tokin. (Model: ESD-SR-250)

Disconnecting the USB cable from the computer

To disconnect a USB cable connected to the instrument from a computer which is ON:

1. **Press the [ESC] key to terminate the USB connection.**
   Alternately, eject the disk by using the **[Safely Remove Hardware and Eject Media]** icon on the computer.

2. **Disconnect the USB cable from the computer.**

11.2 Use of Application Software PQ One (Included)

What can be done with the application software

The application software PQ One (included) is used for analyzing the data from the instrument (binary-format) on a computer.

Displays and analyzes measurement data
Event statistics function allows analyzing measured data in detail.
Checking event status daily or hourly allows detecting events with higher frequency at specific a time or on a specific day of the week.

Easily creates the required graphs
Adjusting the display period of the trend graph when the output is good, and integrating the trend data for 3 phases to a single graph is possible.

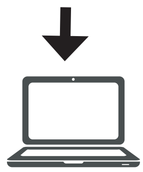
Generates measurement data reports
Contents displayed on the screen can be output without any modifications. No complicated report settings are required, and the required reports can be created.

Displays measurement data in EN50160 mode (available after the firmware update)

Converts measurement data to CSV format (available after the firmware update)
Any range of measurement data can be converted to CSV format.
The converted files can be used in spreadsheet programs.

Judges anomalies based on the ITIC (CBEMA) curve* (available after the firmware update)
*: The ITIC Curve is commonly used in America, and is a standard for evaluating voltage anomalies by specifying a range of acceptable tolerance. A “User-Defined Curve” can be optionally defined for voltage anomaly evaluation.

Refer to the Application Software Instruction Manual (CD) for details.



Installation

Contents of included CD

Language	File description	
English	PQONE_Manual_Eng.pdf	Instruction Manual (English)
	Setup.exe	PQ One Installer (English)
	Setup_Eng.msi	
Japanese	PQONE_Manual_Jpn.pdf	Instruction Manual (Japanese)
	Setup.exe	PQ One Installer (Japanese)
	Setup_Jpn.msi	

The latest version can be downloaded from our website.

How to use Instruction Manual

The Instruction Manual is provided in PDF format.
The Adobe Reader must be installed on your computer to view the Instruction Manual. (Adobe Reader can be downloaded from the Adobe website.)
To request a paper copy of the user manual, contact an authorized Hioki distributor or reseller. You can purchase the manuals.

Operating environment

Operating System (OS)	Windows 7, Windows 8.1, Windows 10
Display	Resolution 1280 × 768 dots or more
CD-ROM drive	Used for installation

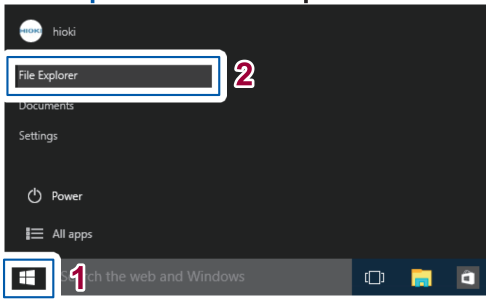
Installation procedure

Screen sample: Windows 10

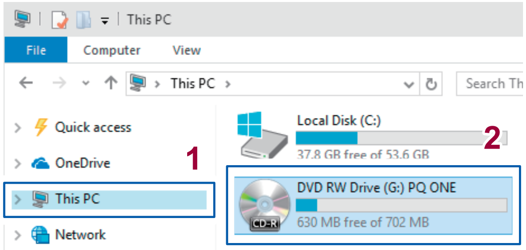
1 **Start the computer.**
Administrator authority may be required for the installation.

2 **Set the included CD to the CD-ROM drive.**

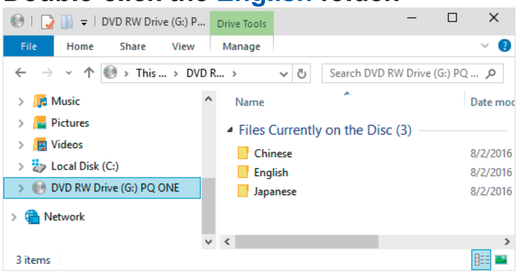
3 **Click the Start button, and then, click File Explorer to start Explorer**



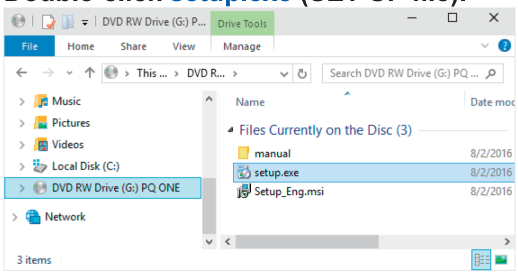
4 **Click This PC, and then, double-click CD-ROM drive.**



5 **Double-click the English folder.**



6 **Double-click setup.exe (SET UP file).**



(The extension may not be displayed.)
After the installer starts, follow the instruction to proceed with the installation.

12 Communications (USB/LAN/RS-232C)

This instrument includes the USB, LAN, and RS-232C as standard interfaces.

Capabilities	USB	LAN	RS-232C	Reference
Recognizing the SD memory card as a removable disk and copying the data to computer.	✓	—	—	p. 131
Remote control of the instrument through an internet browser	—	✓	—	p. 142
Configuration of the settings, acquiring the measurement data, and downloading the data from the computer voluntarily, can be done by using communication command.	—	✓	✓	Contact Hioki.

✓: Supported, —: Not supported

12.1 Preparing for LAN Communications

To use LAN communications, you must perform the following tasks:
- Configure LAN settings in the instrument. (See the following “Settings”)
- Build a network environment. (p. 139)
- Connect the instrument and a computer with a LAN cable. (p. 140)

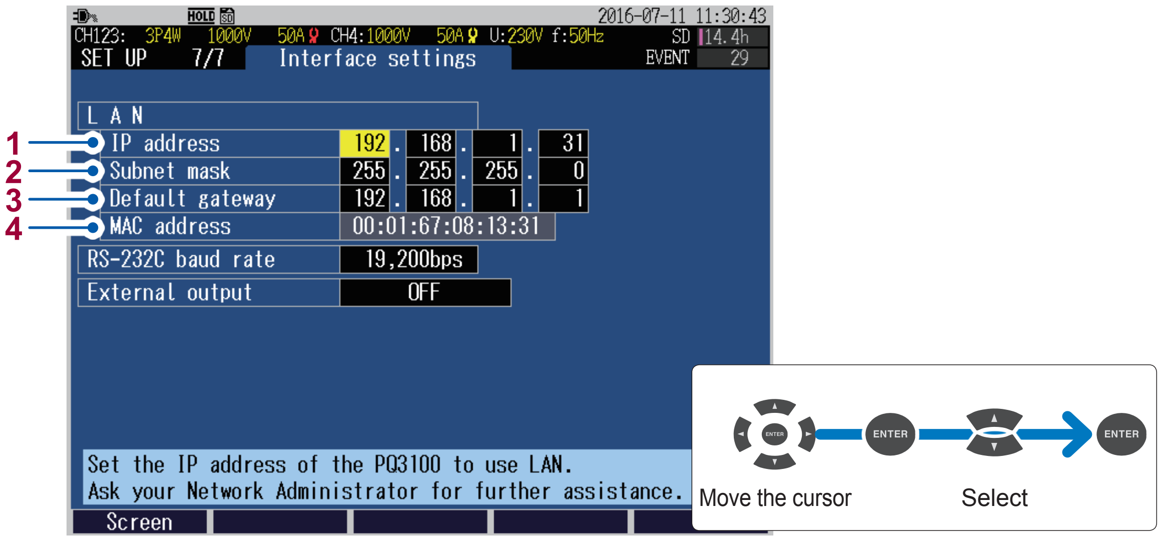
Settings (SET UP Screen)

IMPORTANT
- Be sure to perform these settings before connecting to a network. Changing settings while connected to the network can cause the overlapping of the IP addresses with other devices on the LAN, and incorrect address information may be presented to the LAN.
- After configuring the LAN settings, be sure to turn the instrument off and then turn it back on. If this is not performed, the changed LAN setting will not be enabled and communication will not be possible.

1 **Press the [SET UP] key to display the SET UP, Interface settings screen.**

2 **Set the items of LAN.**

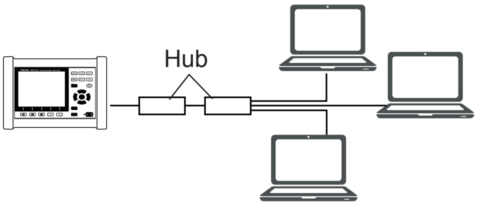
3 **Turn on the instrument once again.**



1	This address is for identifying each device connected to a network. Each network device must be set to a unique address. This instrument is IP version 4, so the IP address is indicated by the four decimals separated by three periods, for example, “192.168.0.1.”
2	This setting is used to distinguish the IP address of the network from the addresses of individual network devices. Normally, it is indicated by the value containing four decimals separated by three periods, for example, “255.255.255.0.”
3	When the computer and instrument are on different networks, specify the IP address of the device which serves as a gateway. If the computer and instrument are connected one-to-one, and no gateway is used, set “0.0.0.0” on this instrument.
4	A MAC address is assigned as a device-specific address, so it cannot be changed.

Example of establishing a network environment

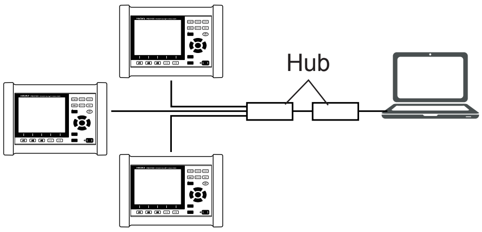
(1) Connecting the instrument to an existing network



To connect to an existing network, the network system administrator (IT department) has to assign the settings beforehand.
The settings must not overlap with another device.
Obtain assignments from the administrator (IT department) for the following items, and write them down.

IP address	___.___.___.___
Subnet mask	___.___.___.___
Default gateway	___.___.___.___

(2) Connecting multiple instruments to a single computer using a hub

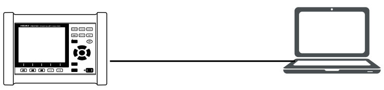


When building a local network with no outside connection, it is recommended to use the following private IP addresses.

Example: When building the network using network addresses 192.168.1.0/24 (192.168.0.1 to 192.168.1.255)

IP address	Computer: 192.168.1.1 Instrument (first): 192.168.1.2 Instrument (second): 192.168.1.3 Instrument (third): 192.168.1.4 In this way, assign the addresses in order.
Subnet mask	255.255.255.0
Default gateway	Computer :___.___.___.___ Instrument : 0.0.0.0

(3) Connecting one instrument to a single computer using the Model 9642 LAN cable.



When connecting one instrument to a single computer using the conversion connector supplied with the Model 9642 LAN cable, variable IP address can be set but it is recommended to use private IP addresses.

Example: When building the network using network addresses 192.168.1.0/24 (192.168.0.1 to 192.168.1.255)

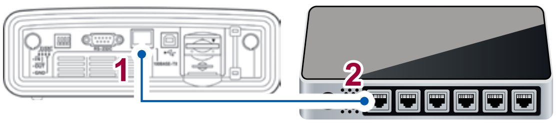
IP address	Computer : 192.168.1.1 Instrument : 192.168.1.2 (Set to a different IP address than the computer.)
Subnet mask	255.255.255.0
Default gateway	Computer : ___.___.___.___ Instrument : 0.0.0.0

Connection

Be sure to read “Connecting the Instrument to an External Device” (p. 13).

(1) When connecting the instrument to an existing network, or when connecting the multiple instruments to a single computer using a hub

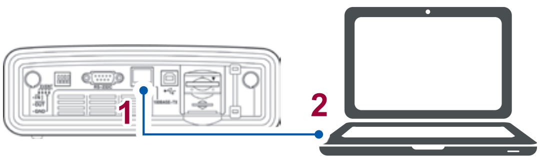
Required items		
☐ Model 9642 LAN cable (option) 	or	☐ A 100BASE-TX-compatible straight cable (up to 100 m, commercially available). For 10BASE communication, a 10BASE-T-compliant cable may also be used.



LAN interface A 100BASE-TX connector of the hub

(2) When connecting one instrument to a single computer

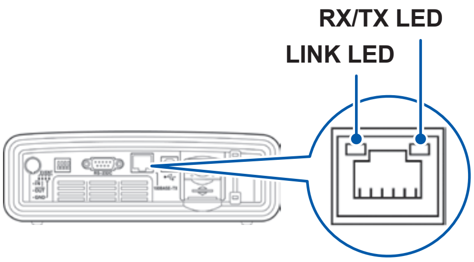
Required items		
☐ Model 9642 LAN cable (option) 	or	☐ A 100BASE-TX-compatible cross cable or straight cable (up to 100 m, commercially available)



LAN interface A 100BASE-TX connector of the computer

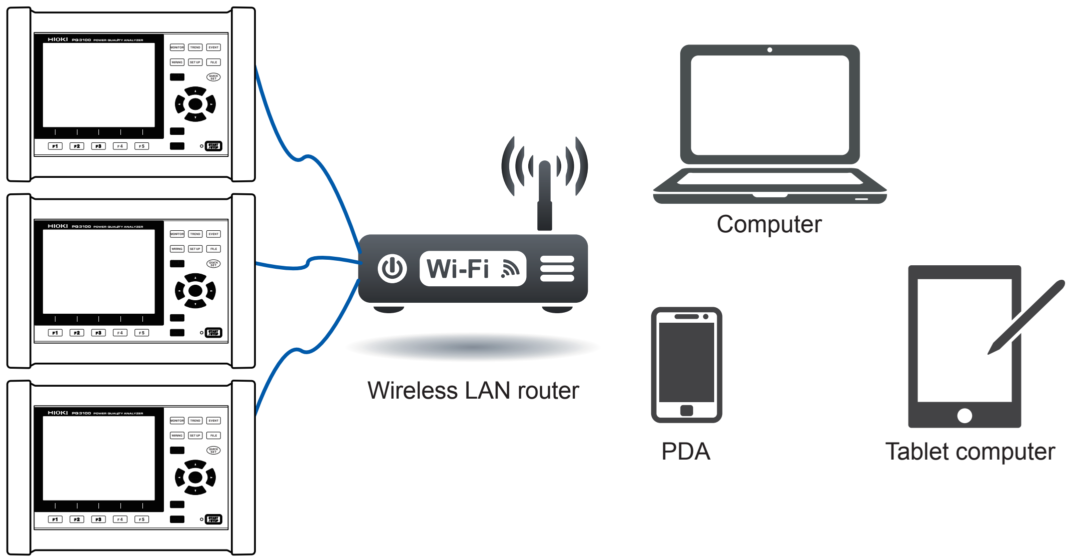
Since this instrument is equipped with the function to automatically differentiate between the straight and cross cable, a straight cable may also be used for communication. If you are unable to establish communications with the computer due to a problem such as compatibility, try a cross conversion cable (Model 9642 accessory).

Verifying the Transmission and Reception



The RX/TX LED blinks during the transmission or reception of data. The LINK LED lights up, when the communication with the connected device is possible.

Example of Remote Control Using Wireless LAN



12.2 Remote Control of the Instrument through the Internet Browser (LAN Communications Only)

This instrument includes a standard HTTP server function that supports the remote control through the Internet browser on a computer. The instrument's display screen and control panel are emulated in the browser. Operating procedures are the same as on the instrument.

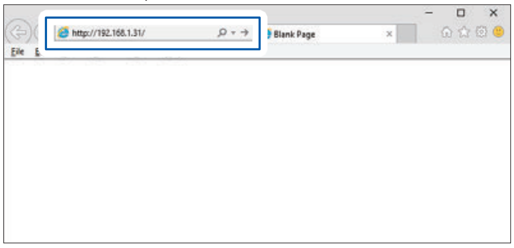
The preparations for LAN communication are necessary. (p. 138).

Preparations

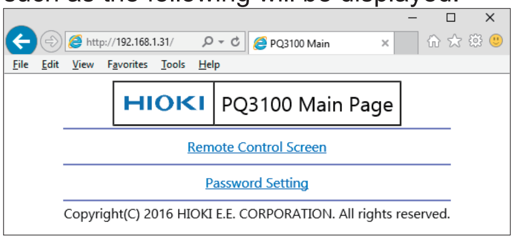
1 **Launch the Internet browser.**

2 **In the address bar, enter "http://" followed by the IP address configured in the instrument.**

For example, if the instrument's IP address is 192.168.1.31, enter as follows.



When the browser has successfully connected to the instrument, a main page such as the following will be displayed.



- It is recommended to use Microsoft Internet Explorer version 9 or later.
- Unintended operations may occur if remote control is attempted from multiple computers simultaneously. Use one computer at a time for remote control.
- Set the browser security level to "Medium" or "Medium-high." Or enable the active scripting settings.
- Remote control can be performed even if the instrument's key lock is active.

If no HTTP screen is displayed

(1) Verify the settings of the Internet browser.

1 **On the Internet Explorer settings, click Tools-Internet Options.**

2 **On the Advanced tab, enable the "Use HTTP1.1" and disable the "Use HTTP1.1 through proxy connections."**

3 **Under LAN settings on the Connections tab, disable the Proxy server settings.**

(2) Verify the LAN settings.

1 **Check the instrument's LAN settings and the computer's IP address.**
See "Settings (SET UP Screen)" (p. 138).

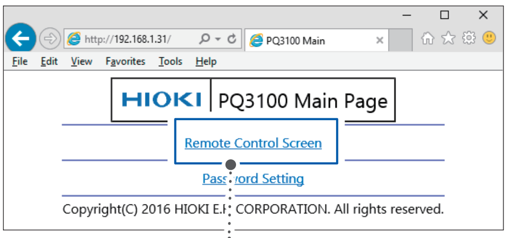
2 **Verify that the LINK LED on the LAN interface is on and that the WEB mark is being shown on the instrument's screen.**
See "Connection" (p. 140) and "1.6 On screen indicators" (p. 35).

3 **Under LAN settings on the Connections tab, disable the Proxy server settings.**

> **IMPORTANT**
> After configuring the LAN settings, be sure to turn the instrument off and on. If this is not performed, the changed LAN setting will not be enabled and communication will not be possible.

Remote operation

1



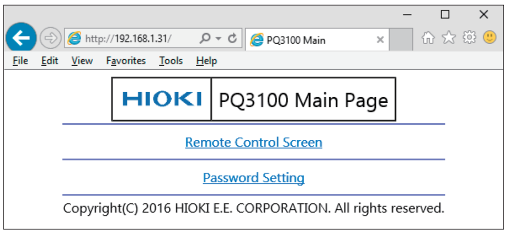
2 **(If the password has already been set)**

If no password has been set or the password has been set to "0000" (four zeros), this screen will not be displayed. The default password is "0000."

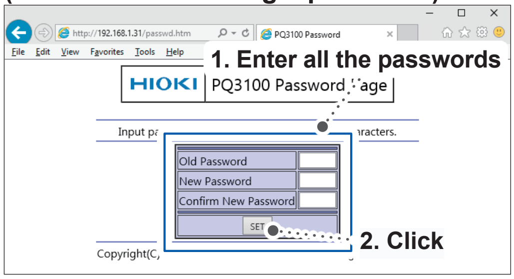
The same screen and control panel being displayed on the instrument will be displayed on the browser.

Restrict the access (password settings)

1



2 **(In the case of setting a password)**



Enter up to four alphanumeric characters.
When setting a password for the first time, enter "0000" (four zeros) in the **Old Password** box.
When changing the password for the second or subsequent times, enter the previously set password.

If you forget your password

Perform "Factory reset (Default)" (p. 77) on the instrument to reset the password to its default figures of "0000." The password cannot be initialized by remote control.

12.3 RS-232C Communication Preparations

To use RS-232C communications, you must perform the following tasks.

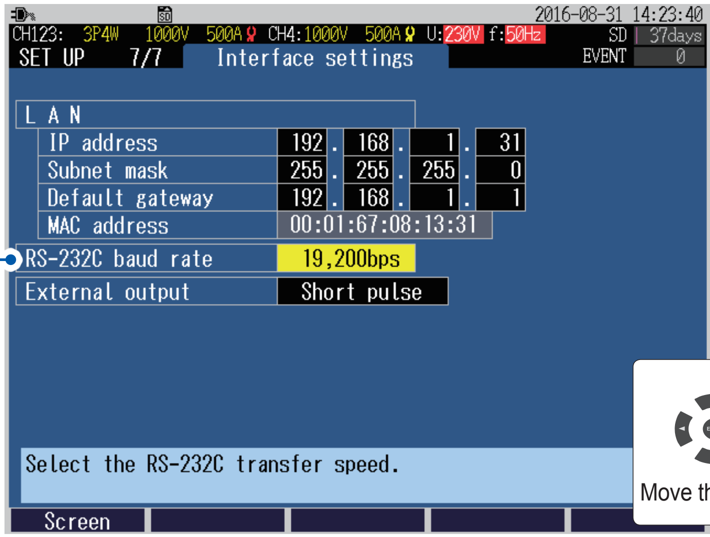
- Configure the settings of RS-232C on the instrument.
- Connect the instrument and a computer with a RS-232C cable (p. 174).

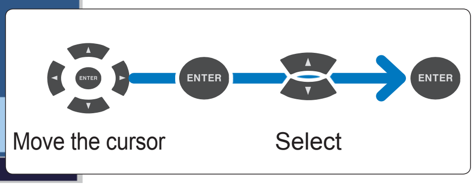
Settings (SET UP screen)

Be sure to read “Connecting the Instrument to an External Device” (p. 13).

1 **Press the [SET UP] key to display the SET UP, Interface settings screen.**

2 **Configure the settings of RS-232C interface.**

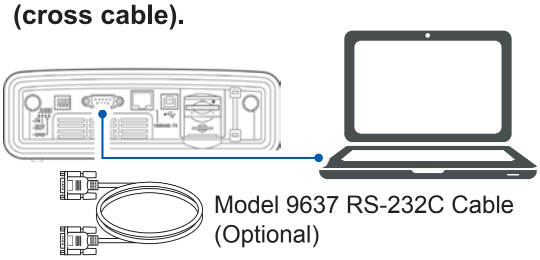




1	Select the baud rate. **19,200bps**, **38,400bps**

Connection

1 **Connect the instrument and computer with the Model 9637 RS-232C Cable (cross cable).**

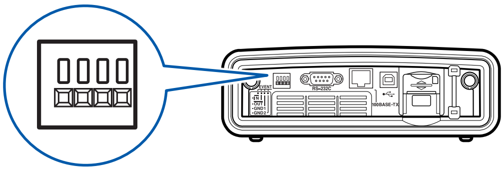


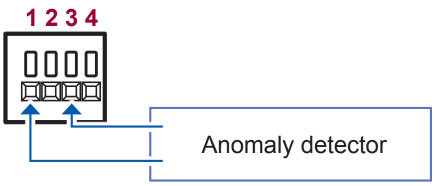
2 **Turn on the computer.**

3 **Turn on the instrument. (p. 44)**

13 External I/O

External I/O terminals are used to allow event signal input from an external device and to output a signal to external device when an event occurs.

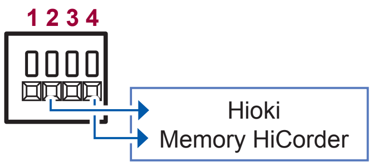




External devices are connected to **1** “Event input terminal” (EVENT IN)” and **3** “Ground terminal for event input (non-isolated) (GND1).”

When you connect the detection signal of an anomaly detector such as an over-current relay to the event input terminal, an event will occur when there is an anomaly operation.

See “13.1 Event Input” (p. 148).



External devices are connected to **2** “Event output terminal” (EVENT OUT)” and **4** “Ground terminal for event output (non-isolated) (GND2).”

The anomalies occurring in the instrument will be informed to the external device.
When you connect the event output terminal to a trigger input terminal on a waveform recording device such as the Hioki Memory HiCorder, you can record waveforms on the Memory HiCorder when an event occurs.

See “13.2 Event Output” (p. 149).

To use the external I/O terminals, you must perform the following tasks:

To use event input

- Check how to use event input terminal
- Set the external event to ON (p. 74)
- Use cables to connect the instrument with the external device (p. 151)

To use event output

- Check how to use the event output terminal
- Set the external event output (p. 150)
- Use cables to connect the instrument with the external device (p. 151)

13.1 Event Input

Event input function is used to enable recording of the voltage and current waveforms and measured values of an external event.
This function is useful to analyze power anomalies that may occur when other electronic/electrical devices are started.
By inputting a signal to the event input terminal (EVENT IN) externally, you can make the instrument determine that an external event has occurred when that event was input.

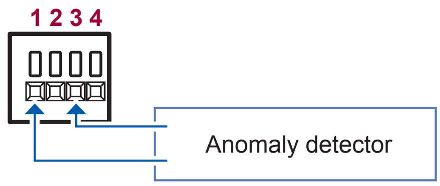
Setting

External event (p. 74) must be set to **ON**.

Signal input methods

External devices are connected to **1** “Event input terminal” (EVENT IN)” and **3** “Ground terminal for event input (non-isolated) (GND1).”

Short the terminals **1** and **3** or input a pulse signal to the terminal **1**.
Event input is recognized when the terminal is shorted (active LOW) or the pulse signal is fell.

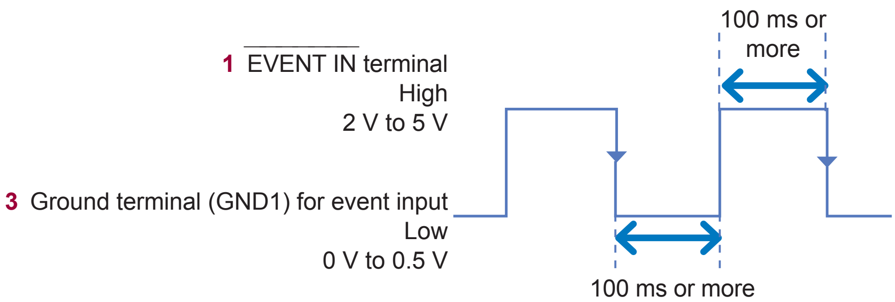


See “13.4 Connection” (p. 151).

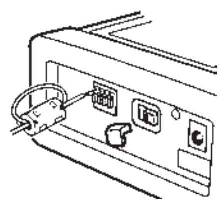
Specifications

Input voltage range	High level: 2 V to 45 V Low level: 0 V to 0.5 V
Maximum input voltage between terminals	45 V
Maximum rated voltage to earth	Non-isolated (GND is shared by the instrument)

Timing chart



- **3** “Ground terminal for event input (GND1)” is shared by GND of the instrument and is not isolated. Isolate as required for input (**4** “Ground terminal for event output (GND2)” is isolated).
- Use a single route for the wires connected to the event input terminal as any other cables bound together with them may cause malfunction due to external noise.
- Longer wires may cause malfunction due to external noise. Wind the wires around a ferrite clamp as shown in the figure before connection (position the ferrite clamp as near the terminal block as possible).



13.2 Event Output

Outputs a signal to the external device synchronized with an event in the instrument showing that there is an event.

Application

(1) Connect a warning device.

This is a good way to output warnings when events such as an interruption occurs.

(2) Connect to the trigger input terminal of a Memory HiCorder.

The instrument allows recording waveforms of an event for 200 ms to 11.2 s (1 s before event, 200 ms during the event, and 10 s after event) (see **Event waveform recording time before Event**, **Event waveform recording time after Event** (p. 74)). Use a Memory HiCorder with the instrument to record waveforms for a longer period.

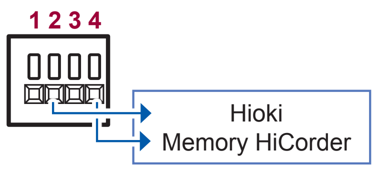
Setting

See “13.3 External Event Output Settings (SET UP Screen)” (p. 150).

Signal output method

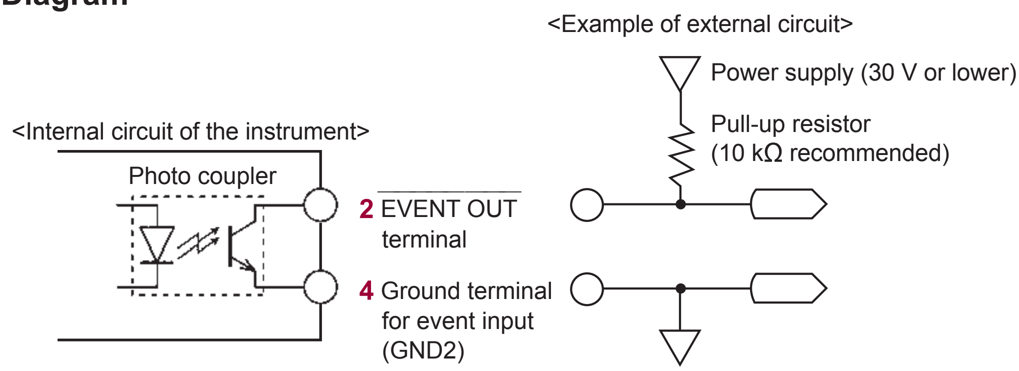
2 “Event output terminal” (EVENT OUT)” and 4 “Ground terminal for event output (non-isolated) (GND2)” are connected to an external device.

2 and 4 are isolated from the internal circuit of the instrument. Connect terminal 2 to an external power supply through a pull-up resistor as shown in the following circuit diagram.
If an event occurs in the instrument, a pulse signal is output.



See “13.4 Connection” (p. 151).

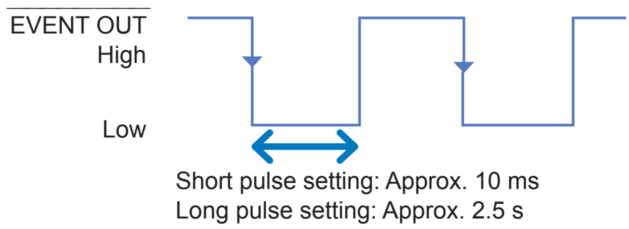
Circuit Diagram



Specifications

Output signal	Open collector output Isolated with a photo coupler Active Low	Maximum input current	5 mA
Maximum input voltage	30 V	Pulse width	Low level Short pulse: Approx. 10 ms Long pulse: Approx. 2.5 s

Timing chart

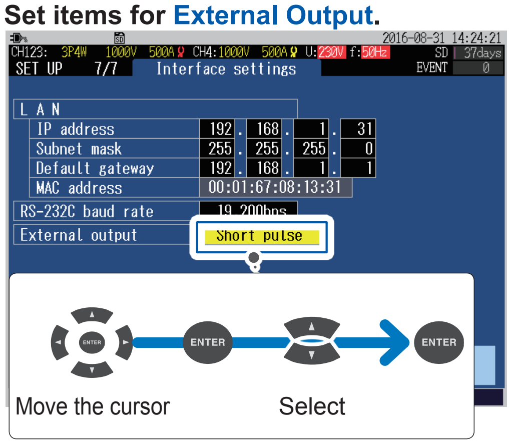


13.3 External Event Output Settings (SET UP Screen)

Set when using the external I/O terminal to connect the instrument to an external device.

1 **Press the [SET UP] key to display the SET UP, Interface settings screen.**

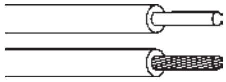
2 **Set items for External Output.**



OFF	External output is disabled.
Short pulse	A short pulse (approx. 10 ms) is output on recording start and stop, or during Event IN.
Long pulse	A long pulse (approx. 2.5 s) is output only during Event IN. Set this function to be combined with the 2300 Remote Measurement System or a sequencer. Low period is retained for approx. 2.5 s during Event IN. If another Event IN occurs during the Low period, the Low period for is retained for another approx. 2.5 s.
ΔV10 alarm	(Available after the firmware update) This setting can be selected only when the [Flicker] setting is **ΔV10** (p. 66). If the **ΔV10 alarm** is set, also set the threshold value (**0.00 V** to **9.99 V**). Output will be set to low when the set threshold value is exceeded.

13.4 Connection

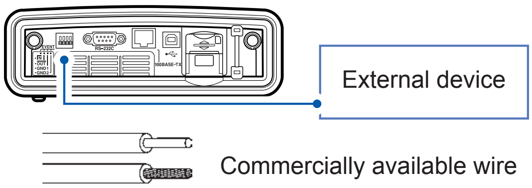
Be sure to read “Using External I/O Terminals” (p. 13) before start.

Required items	
☐ Wires	
☐ Slotted screwdriver • Shaft diameter ϕ3 mm • Blade width: 2.6 mm	

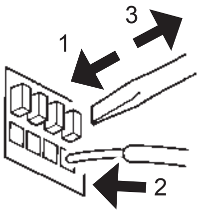
Recommended wire

Single wire:	ϕ0.65 mm (AWG22)
Stranded wire:	0.32 mm^2 (AWG22)
Strand diameter:	ϕ0.12 mm or more
Acceptable limits	
Single wire:	ϕ0.32 mm to ϕ0.65 mm (AWG28 to AWG22)
Stranded wire:	0.08 mm^2 to 0.32 mm^2 (AWG28 to AWG22)
Strand diameter:	ϕ0.12 mm or more
Standard insulation stripping length:	9 mm to 10 mm

1 **Use cables to connect the instrument with the external device.**



Wire connection procedure



1. Press the terminal button down using a tool, such as a slotted screwdriver.
2. While the button is pressed, insert the wire into the electric wire connection hole.
3. Press the button.

   The electric wire is locked in place.

2 **Turn on the external device.**

3 **Turn on the instrument. (p. 44)**

13

External I/O

14 Specifications

14.1 General Specifications

Operating environment	Indoor use, pollution degree 2, altitude up to 3000 m (9843 ft.) At an altitude of above 2000 m (6562 ft.), the measurement categories are lowered to 1000 V CAT II, 600 V CAT III.
Operating temperature and humidity	Temperature: −20°C to 50°C (−4°F to 122°F) When communicating via LAN or USB: 0°C to 50°C (32°F to 122°F) When using the external control terminal: 0°C to 50°C (32°F to 122°F) When running on battery: 0°C to 50°C (32°F to 122°F) When charging battery: 10°C to 35°C (50°F to 95°F) Humidity: 80% RH or less (no condensation)
Storage temperature and humidity	−30°C to 60°C (−22°F to 140°F), 80% RH or less (no condensation) When the instrument is not in use for an extended period, remove the battery pack from the body and store in an environment of −20°C to 30°C (−4°F to 86°F).
Dust-proofness, Water-proofness	IP30 (EN 60529)
Applicable standards	Safety EN 61010 EMC EN 61326 Class A
Compliance standards	Harmonics IEC 61000-4-7:2002 + A1:2008, IEC 61000-2-4 Class 3 Power quality IEC 61000-4-30:2015 Class S, EN 50160, IEEE 1159
Power supply	• Z1002 AC Adapter Rated supply voltage: 100 V to 240 V AC (Voltage fluctuations of ±10% for the rated supply voltage are taken into account.) Rated supply frequency: 50 Hz/60 Hz Anticipated transient overvoltage: 2500 V Maximum rated power: 80 VA (including AC adapter), 35 VA (main unit only) • Z1003 Battery Pack (Ni-MH 4500 mAh) Rated supply voltage: 7.2 V DC
Recharge function	Charges the battery regardless of whether the instrument is on or off. Charging time 5 hours 30 min at a maximum (at 23°C, as a referential)
Continuous operating time	When Z1003 Battery Pack is used (at 23°C, as a referential) Approx. 8 hours (fully charged, continuous operation, with LCD backlight turned off automatically and sensors not involving AC/DC sensors used)
Backup battery	Approx. 10 years (at 23°C, as a referential) For backup clock and setting conditions (Lithium battery)
Maximum recording period	1 year (366 days)
Maximum recording events	9999 events
Clock function	Auto-calendar, leap-year correcting, 24-hour clock
Real-time clock accuracy	±0.5 s per day (when main unit is on, within operating temperature and humidity range)
Display refresh rate	Approx. 0.5 s
Display	6.5-inch TFT color LCD (640 × 480 dots)
Interface	SD memory card, USB, LAN, RS-232C, external I/O
Dimensions	Approx. 300W × 211H × 68D mm (11.81″W × 8.31″H × 2.68″D) (excluding protrusions)
Body	Strap can be attached.
Mass	Approx. 2.5 kg (88.2 oz.) (with Z1003 Battery Pack installed)
Product warranty period	3 years

Accessories	See “Accessories” (p. 2).
Options	See “Options” (p. 3).

14.2 Input Specifications/Output Specifications/ Measurement Specifications

1. Basic specifications

Number of channels	Voltage: 4 channels Current: 4 channels
Input Terminal Specifications	Voltage: Plug-in terminal (Safety terminal) Current: Special connector (Hioki PL14)
Current sensor power supply	For AC/DC Auto-Zero Current Sensor, AC Flexible Current Sensor +5 V±0.25 V, −5 V±0.25 V, supply current up to 30 mA per channel
Wiring	Single-phase 2-wire: 1P2W Single-phase 3-wire: 1P3W Single-phase 3-wire 1-voltage measurement: 1P3W1U 3-phase 3-wire 2-watt meter measurement: 3P3W2M 3-phase 3-wire 3-watt meter measurement: 3P3W3M 3-phase 4-wire: 3P4W 3-phase 4-wire 2.5E: 3P4W2.5E (available after the firmware update) In addition to one of the avobe, input CH4.
Input method	Voltage: Isolated input (U1, U2, U3, U4 and N terminal have a common differential input, and U1, U2, U3, U4 and N terminal are internally non-isolated) Current: Isolated input through a current sensor
Input resistance	Voltage input section: 5 MΩ ± 20% Current input section: 200 kΩ ± 20%
Maximum input voltage	Voltage input section: 1000 V AC/DC, 2200 V peak Current input section: 1.7 V AC/DC, 2.4 V peak
Maximum rated voltage to earth	Voltage input section: 1000 V AC (Measurement category III), 600 V AC (Measurement category IV), and anticipated transient overvoltage 8000 V Current input section: Depends upon the current sensor being used
Measurement method	Digital sampling, zero-cross synchronized calculation method
Sampling frequency	200 kHz
A/D converter resolution	16 bits
Display range	Voltage: 2 V to 1300 V Current: 0.4% to 130% of range Power: 0.0% to 130% of range Measurement items other than the above: 0% to 130% of range
Zero display range	RMS voltage: Lower than 2 V If the RMS voltage is 0 V, the voltage DC value, harmonic voltage (all orders), power value, harmonic active power (all orders), and reactive power (all orders) are made to be zero. RMS current: Less than 0.4% f.s. If the RMS current is 0 A, the current DC value, harmonic current (all orders), power value, harmonic active power (all orders), and reactive power (all orders) are made to be zero.
Effective measurement range	• Voltage AC: 10 V to 1000 V The peak voltage is ±2200 V. DC: 5 V to 1000 V • Current 5% to 120% of range The peak current is ±400% of range. • Power 5% to 120% of range (with both voltage and current within effective measuring range) See separate specifications for harmonic measurement

2. Measurement items

(1) Item detected at a sampling frequency of 200 kHz with no gaps

	Notation	1P2W	1P3W	1P3W1U	3P3W2M	3P3W3M	3P4W
Transient overvoltage	Tran	1, 4	1, 2, 4	1, 4	1, 2, 4	1, 2, 3	1, 2, 3, 4

(2) Items measured each 1 cycle with no gaps

	Notation	1P2W	1P3W	1P3W1U	3P3W2M	3P3W3M	3P4W
Frequency (1 wave)	Freq_wav	U1					

(3) Item measured over 1 cycle with no gaps, commencing at a fundamental zero crossing, and refreshed each half-cycle

	Notation	1P2W	1P3W	1P3W1U	3P3W2M	3P3W3M	3P4W
RMS voltage refreshed each half-cycle	Urms1/2	1, 4	1, 2, 4	1, 4	1, 2, 3, 4	12, 23, 31	1, 2, 3, 4
Swell	Swell	1	1, 2	1	1, 2, 3	12, 23, 31	1, 2, 3
Dip	Dip	1	1, 2	1	1, 2, 3	12, 23, 31	1, 2, 3
Interruption	Intrpt	1	1, 2	1	1, 2, 3	12, 23, 31	1, 2, 3
RMS current refreshed each half-cycle	Irms1/2	1, 4	1, 2, 4		1, 2, 3, 4		

(4) Items measured over half-cycle with no gaps

	Notation	1P2W	1P3W	1P3W1U	3P3W2M	3P3W3M	3P4W
Inrush current	Inrush	1, 4	1, 2, 4		1, 2, 3, 4		

(5) Items measured over the approximately 200-ms (10/12-cycle for 50 Hz / 60 Hz, respectively) aggregation with no gaps

<table>
<tr><th></th><th>Notation</th><th>1P2W</th><th>1P3W</th><th>1P3W1U</th><th>3P3W2M</th><th>3P3W3M</th><th>3P4W</th></tr>
<tr><td>Frequency (200 ms)</td><td>Freq</td><td colspan="6">U1</td></tr>
<tr><td>Frequency (10 sec)</td><td>Freq10s</td><td colspan="6">U1</td></tr>
<tr><td>Voltage waveform peak</td><td>Upk+, Upk−</td><td>1, 4</td><td>1, 2, 4</td><td>1, 4</td><td>1, 2, 3, 4</td><td>12, 23, 31</td><td>1, 2, 3, 4</td></tr>
<tr><td>Current waveform peak</td><td>Ipk+, Ipk−</td><td>1, 4</td><td colspan="2">1, 2, 4</td><td colspan="3">1, 2, 3, 4</td></tr>
<tr><td>RMS voltage (phase)</td><td rowspan="2">Urms</td><td rowspan="2">1, 4</td><td rowspan="2">1, 2, AVG, 4</td><td rowspan="2">1, 4</td><td>—</td><td>1, 2, 3, AVG</td><td>1, 2, 3, AVG, 4</td></tr>
<tr><td>RMS voltage (line)</td><td>1, 2, 3, AVG, 4</td><td>12, 23, 31, AVG</td><td>12, 23, 31, AVG, 4</td></tr>
<tr><td>Voltage DC</td><td>Udc</td><td>1, 4</td><td>1, 2, 4</td><td>1, 4</td><td>1, 2, 3, 4</td><td>12, 23, 31</td><td>1, 2, 3, 4</td></tr>
<tr><td>Voltage CF</td><td>Ucf</td><td>1, 4</td><td>1, 2, 4</td><td>1, 4</td><td>1, 2, 3, 4</td><td>12, 23, 31</td><td>1, 2, 3, 4</td></tr>
<tr><td>RMS current</td><td>Irms</td><td>1, 4</td><td colspan="2">1, 2, AVG, 4</td><td colspan="3">1, 2, 3, AVG, 4</td></tr>
<tr><td>Current DC</td><td>Idc</td><td>1, 4</td><td colspan="2">1, 2, 4</td><td colspan="3">1, 2, 3, 4</td></tr>
<tr><td>Current CF</td><td>Icf</td><td>1, 4</td><td colspan="2">1, 2, 4</td><td colspan="3">1, 2, 3, 4</td></tr>
<tr><td>Active power</td><td>P</td><td>1</td><td colspan="3">1, 2, SUM</td><td colspan="2">1, 2, 3, SUM</td></tr>
<tr><td>Active energy</td><td>WP+, WP−</td><td>1</td><td colspan="5">SUM</td></tr>
</table>

<table>
<tr><th></th><th>Notation</th><th>1P2W</th><th>1P3W</th><th>1P3W1U</th><th>3P3W2M</th><th>3P3W3M</th><th>3P4W</th></tr>
<tr><td>Energy cost</td><td>Ecost</td><td>1</td><td colspan="5">SUM</td></tr>
<tr><td>Reactive power</td><td>Q</td><td>1</td><td colspan="3">1, 2, SUM</td><td colspan="2">1, 2, 3, SUM</td></tr>
<tr><td>Reactive energy</td><td>WQ_LAG, WQ_LEAD</td><td>1</td><td colspan="5">SUM</td></tr>
<tr><td>Apparent power</td><td>S</td><td>1</td><td colspan="2">1, 2, SUM</td><td colspan="3">1, 2, 3, SUM</td></tr>
<tr><td>Apparent energy</td><td>WS</td><td>1</td><td colspan="5">SUM</td></tr>
<tr><td>Power factor / displacement power factor</td><td>PF/DPF</td><td>1</td><td colspan="3">1, 2, SUM</td><td colspan="2">1, 2, 3, SUM</td></tr>
<tr><td>Voltage negative-phase unbalance factor</td><td>Uunb</td><td colspan="3">—</td><td colspan="3">SUM</td></tr>
<tr><td>Voltage zero-phase unbalance factor</td><td>Uunb0</td><td colspan="5">—</td><td>SUM</td></tr>
<tr><td>Current negative-phase unbalance factor</td><td>Iunb</td><td colspan="3">—</td><td colspan="3">SUM</td></tr>
<tr><td>Current zero-phase unbalance factor</td><td>Iunb0</td><td colspan="5">—</td><td>SUM</td></tr>
<tr><td>Harmonic voltage</td><td>Uharm</td><td>1, 4</td><td>1, 2, 4</td><td>1, 4</td><td>1, 2, 3, 4</td><td>12, 23, 31</td><td>1, 2, 3, 4</td></tr>
<tr><td>Harmonic current</td><td>Iharm</td><td>1, 4</td><td colspan="2">1, 2, 4</td><td colspan="3">1, 2, 3, 4</td></tr>
<tr><td>Harmonic power</td><td>Pharm</td><td>1</td><td colspan="2">1, 2, SUM</td><td>SUM</td><td colspan="2">1, 2, 3, SUM</td></tr>
<tr><td>Interharmonics voltage</td><td>Uiharm</td><td>1, 4</td><td>1, 2, 4</td><td>1, 4</td><td>1, 2, 3, 4</td><td>12, 23, 31</td><td>1, 2, 3, 4</td></tr>
<tr><td>Interharmonics current</td><td>Iiharm</td><td>1, 4</td><td colspan="2">1, 2, 4</td><td colspan="3">1, 2, 3, 4</td></tr>
<tr><td>Harmonics voltage phase angle</td><td>Uphase</td><td>1, 4</td><td>1, 2, 4</td><td>1, 4</td><td>1, 2, 3, 4</td><td>12, 23, 31</td><td>1, 2, 3, 4</td></tr>
<tr><td>Harmonics current phase angle</td><td>Iphase</td><td>1, 4</td><td colspan="2">1, 2, 4</td><td colspan="3">1, 2, 3, 4</td></tr>
<tr><td>Harmonic voltage-current phase difference</td><td>Pphase</td><td>1, 4</td><td colspan="2">1, 2, SUM</td><td>SUM</td><td colspan="2">1, 2, 3, SUM</td></tr>
<tr><td>Voltage total harmonic distortion rate</td><td>Uthd-F/ Uthd-R</td><td>1, 4</td><td>1, 2, 4</td><td>1, 4</td><td>1, 2, 3, 4</td><td>12, 23, 31</td><td>1, 2, 3, 4</td></tr>
<tr><td>Current total harmonic distortion rate</td><td>Ithd-F/Ithd-R</td><td>1, 4</td><td colspan="2">1, 2, 4</td><td colspan="3">1, 2, 3, 4</td></tr>
<tr><td>K factor</td><td>KF</td><td>1, 4</td><td colspan="2">1, 2, 4</td><td colspan="3">1, 2, 3, 4</td></tr>
</table>

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Specifications

3. Accuracy specifications

Conditions of guaranteed accuracy	Guaranteed accuracy period: 1 year Guaranteed accuracy period from adjustment made by Hioki: 1 year Temperature and humidity for guaranteed accuracy: 23°C±5°C (73°F±5°F), 80% RH or less Warm-up time: at least 30 min Power supply frequency range: 50 Hz/60 Hz ± 2 Hz Power factor=1, common-mode voltage 0 V, specified after zero-adjustment For AC measurement, add the following conditions: Input of 10 V rms or more in the standard channel (U1) Frequency Range: When the measurement frequency is set to 50 Hz: 40 Hz to 58 Hz When the measurement frequency is set to 60 Hz: 51 Hz to 70 Hz
Temperature coefficient	0.1% f.s./°C
Effect of common mode voltage	Within ±0.2% f.s. (1000 V rms AC, 50 Hz/60 Hz, between voltage input and the instrument case)
Effect of external magnetic	Within 1.5% f.s. (in a magnetic field of 400 A rms/m AC, 50 Hz/60 Hz)

4. Transient overvoltage measurement specifications Tran

Measurement method	Detected using the sampled waveform from which the fundamental wave component (50 Hz/60 Hz) (detected once for every waveform of fundamental voltage)
Displayed items	Transient voltage value: Peak value of a waveform from which the fundamental component is eliminated obtained over a 3-ms time Transient width: Period during which threshold value is exceeded (up to 2 ms) **Worst** Maximum transient voltage value: The maximum of peak values of a waveform from which the fundamental component is eliminated obtained during the period from transient IN to transient OUT (leaving channel information) Transient period: Period from transient IN to transient OUT Transient count within the period: Number of transients occurring during period from transient IN to transient OUT (The number of transients includes ones occurring across every channel; however, transients occurring simultaneously on multiple channels are counted as one) (RMS transient: For testing purposes)
Measurement range	± 2.200 kV peak
Measurement band	5 kHz (−3 dB) to 40 kHz (−3 dB), specified at 20 V rms
Minimum detection width	5 μs
Measurement accuracy	±5.0% rdg. ±1.0% f.s. (specified at 1000 V rms, 15 kHz)
Event threshold	2200.0 V Set as an absolute value relative to the peak value (crest value) of the waveform from which the fundamental component is eliminated.
Event IN	In the state that the transient voltage is detected for the first time during the 200-ms aggregation period Event occurrence time represents the time when a peak value exceeds the threshold value. The detected peak voltage and transient width are displayed.
Event OUT	The lead of the 200-ms aggregation period in which no transient overvoltages were detected on any one of the channels, following the transient event IN state. The transient period (difference between the IN time and OUT time) is indicated.
Multiple-phase system treatment	Begins when a transient overvoltage is detected for any one of the U1 to U4 channels and ends when no transient overvoltage is detected for every channels.
Saved waveforms	Event waveforms

5. Frequency cycle measurement specifications Freq_wav

Measurement method	Reciprocal method Frequency calculated from the reciprocal of the accumulated time over a 1-cycle time on U1 (reference channel)
Displayed items	Frequency obtained over a 1-cycle time, maximum deviation between event IN and event OUT
Measurement range	70.000 Hz
Measurement accuracy	±0.200 Hz or less (at an input of between 50 V and 1100 V)
Event threshold	Specified in deviation, 0.1 Hz to 9.9 Hz, 0.1 Hz increments
Event IN	Start time when the waveform exceeds the positive threshold value or falls below the negative threshold value
Event OUT	Start time when the waveform falls below the value calculated by subtracting 0.1 Hz from the positive threshold value in the negative direction or exceeds the one calculated by adding 0.1 Hz to the negative threshold value in the positive direction. Frequency hysteresis corresponds to 0.1 Hz.
Multiple-phase system treatment	None
Saved waveforms	Event waveforms

6. RMS voltage refreshed each half-cycle measurement specifications Urms1/2

Measurement method	RMS voltage calculated using data obtained over a 1-cycle time refreshed each half-cycle Line voltage is used for 3-phase 3-wire (3P3W3M) wiring, while phase voltage is used for 3-phase 4-wire wiring.
Displayed items	RMS voltage refreshed each half-cycle
Measurement range	1000.0 V
Measurement accuracy	During 10 V to 660 V input: ±0.3% of declared voltage (at a declared input voltage of 100 V or more, but at an input of 10% to 150% for the declared input voltage) Other than above: ±0.2% rdg.±0.1% f.s.

7. RMS current refreshed each half-cycle measurement specifications Irms1/2

Measurement method	RMS current calculated using data obtained over a 1-cycle time refreshed each half-cycle (synchronized with voltage of same channel).
Displayed items	RMS current refreshed each half-cycle
Measurement range	Depends on the current sensor in use
Measurement accuracy	± 0.2% rdg. ± 0.1% f.s. + (current sensor accuracy) (Note: While using 2000 A range of Model CT7742, f.s. tolerance should be 2.5 times the value)

8. Swell measurement specifications Swell

Measurement method	Detected when the RMS voltage refreshed each half-cycle exceeds the threshold value.
Displayed items	Swell height: Maximum value for RMS voltage refreshed each half-cycle [V] Swell duration: Period from when a swell is detected on any one of U1, U2, or U3 to when a measured value fall below the value obtained by subtracting the hysteresis from the threshold value
Measurement range	1000.0 V
Measurement accuracy	Same as for RMS voltage refreshed each half-cycle Duration: Within a half-cycle time from the starting time and another half-cycle until the end time
Event threshold	Percentage with respect to declared input voltage
Event IN	When a RMS voltage refreshed each half-cycle exceeds the threshold value
Event OUT	When a RMS voltage refreshed each half-cycle falls below the value calculated by subtracting the hysteresis from the threshold value
Multiple-phase system treatment	Begins when a swell is detected in any one of the channels among U1 to U3, and ends when no swell is detected in every channels.
Saved waveforms	Event waveforms
Trend Data	The data of RMS voltage refreshed each half-cycle and RMS current refreshed each half-cycle obtained in the period between 0.5 sec prior to the EVENT IN and 29.5 sec after the EVENT IN are saved.

9. Dip measurement specifications Dip

Measurement method	Detected when the RMS voltage refreshed each half-cycle falls below the threshold value.
Displayed items	Dip depth: Minimum value of the RMS voltage refreshed each half-cycle [V] Dip duration: Period from the time a U1 to U3 dip is detected until the reading exceeds the value obtained by adding the hysteresis to the threshold value.
Measurement range	1000.0 V
Measurement accuracy	Same as for RMS voltage refreshed each half-cycle Duration: Within a half-cycle time from the starting time and another half-cycle until the end time
Event threshold	Percentage with respect to declared input voltage
Event IN	When the RMS voltage refreshed each half-cycle falls below the threshold value
Event OUT	When the RMS voltage refreshed each half-cycle exceeds the value calculated by adding the hysteresis to the threshold value
Multiple-phase system treatment	Begins when a dip is detected in any one of the channels among U1 to U3, and ends when no dip is detected in any of the channels.
Saved waveforms	Event waveforms
Trend Data	The data of RMS voltage refreshed each half-cycle and RMS current refreshed each half-cycle obtained in the period between 0.5 sec prior to the EVENT IN and 29.5 sec after the EVENT IN are saved.

10. Interruption measurement specifications Intrpt

Measurement method	Detected when the RMS voltage refreshed each half-cycle falls below the threshold value.
Displayed items	Interruption depth: Worst value for RMS voltage refreshed each half-cycle [V] Interruption duration: Period from the time a U1 to U3 interruption is detected until the reading exceeds the value obtained by adding the hysteresis to the threshold value.
Measurement range	1000.0 V
Measurement accuracy	Same as for RMS voltage refreshed each half-cycle Duration: Within a half-cycle time from the starting time and another half-cycle until the end time
Event threshold	Percentage with respect to declared input voltage
Event IN	Starting time of a half-cycle voltage waveform to which an inrush current belongs on each channel when it exceeds the threshold value
Event OUT	Starting time of a half-cycle voltage waveform to which an inrush current belongs when it falls below the value calculated by subtracting the hysteresis from the threshold value
Multiple-phase system treatment	Begins when an interruption is detected in any one of the channels among U1 to U3, and ends when no interruption is detected in any of the channels.
Saved waveforms	Event waveforms
Trend Data	The data of RMS voltage refreshed each half-cycle and RMS current refreshed each half-cycle obtained in the period between 0.5 sec prior to the EVENT IN and 29.5 sec after the EVENT IN are saved.

11. Inrush current measurement specifications Inrush

Measurement method	Detected by observing the RMS current calculated using data obtained over a 1-cycle time refreshed each half-cycle. (synchronized with voltage of same channel)
Displayed items	Maximum current of the RMS current measured above
Measurement range	Depends on the current sensor in use See “14.8 Range Configuration and Combination Accuracy” (p. 188).
Measurement accuracy	± 0.3% rdg. ± 0.3% f.s. + (current sensor accuracy) (Note: While using 2000 A range of Model CT7742, f.s. tolerance should be 2.5 times the value)
Event threshold	From 0 to the value of the current range
Event IN	Time at the start of the half wave of voltage of each channel for which the inrush current exceeds the threshold value
Event OUT	Start of the voltage half-wave waveform for which the inrush current falls below the value obtained by subtracting the hysteresis from the threshold value in the negative direction.
Multiple-phase system treatment	None
Saved waveforms	Event waveforms
Trend Data	The data of inrush RMS current obtained in the period between 0.5 sec prior to the EVENT IN and 29.5 sec after the EVENT IN is saved.

12. Frequency 10 s measurement specifications Freq10s

Measurement method	Reciprocal method Frequency calculated from the reciprocal of the accumulated time for 10 s on U1 (reference channel)
Displayed items	Frequency
Measurement range	70.000 Hz
Measurement accuracy	±0.010 Hz or less

13. Frequency 200 ms measurement specifications Freq

Measurement method	Reciprocal method Value calculated from the reciprocal of the accumulated time for 20 ms on U1
Displayed items	Frequency
Measurement range	70.000 Hz
Measurement accuracy	±0.020 Hz or less
Event threshold	Specified in deviation, 0.1 Hz to 9.9 Hz, 0.1 Hz increments
Event IN	Starting time of an approximately 200-ms aggregation period to which a value belongs when it exceeds the positive threshold value or falls below the negative threshold value
Event OUT	Starting time of an approximately 200-ms aggregation period to which a frequency value belongs when it falls below the value calculated by subtracting 0.1 Hz from the positive threshold value or exceeds the value calculated by adding 0.1 Hz to the negative threshold value Equivalent to a frequency hysteresis of 0.1 Hz
Multiple-phase system treatment	None
Saved waveforms	Event waveforms

14. Voltage waveform peak measurement specifications Upk

Measurement method	Maximum point and minimum point of the sampled data during the 200-ms aggregation period
Displayed items	Positive waveform peak value Negative waveform peak value
Measurement range	±2200.0 V pk
Measurement accuracy	With a voltage of between 10% to 150% of the declared voltage input: 5% of declared input voltage value With a voltage other than above input: 2% f.s.

15. Current waveform peak measurement specifications Ipk

Measurement method	Maximum point and minimum point of the sampled data during the 200-ms aggregation period
Displayed items	Positive waveform peak value Negative waveform peak value
Measurement range	Ranges added the crest factor to each of the current ranges
Measurement accuracy	With a current of 50% f.s. or more input: 5% rdg. + (current sensor accuracy) With a current of less than 50% f.s. input: 2% f.s.+ (current sensor accuracy)

16. RMS voltage measurement specifications Urms

Measurement method	Measured during the 200-ms aggregation period in accordance with IEC61000-4-30 When set to 3P3W3M or 3P4W (or 3P4W2.5E [available after the firmware update]), the phase voltage and line voltage setting is applied to the RMS voltage, Urms
Displayed items	RMS voltage on each channel AVG (average) RMS voltage on multiple channels (For details, see Calculation Formula.)
Display selection	Phase voltage/line voltage (When 3P3W3M/3P4W/3P4W2.5E [available after the firmware update] are set, both will be stored)
Measurement range	1000.0 V
Measurement accuracy	With a voltage of between 10 V and 660 V input: ± 0.2% of the declared voltage input (at a declared input voltage of 100 V to 440 V but with a voltage of between 10% and 150% of the declared input voltage input) With a voltage other than above input: ±0.1% rdg. ±0.1% f.s.

17. Voltage DC value measurement specifications Udc

Measurement method	Average value of the values obtained during the 200-ms aggregation period
Displayed items	Voltage DC value
Measurement range	1000.0 V
Measurement accuracy	±0.3% rdg.±0.1% f.s.

18. Voltage CF value measurement specifications Ucf

Measurement method	Calculated according to the RMS voltage and the peak value of the voltage waveform
Displayed items	Voltage CF Value
Measurement range	224.00
Measurement accuracy	Accuracy not defined

19. RMS current measurement specifications Irms

Measurement method	True RMS method Measured during the 200-ms aggregation period based on IEC61000-4-30.
Displayed items	RMS current on each channel AVG (average) RMS current on multiple channels (For details, see Calculation Formula.)
Measurement range	Depends on the current sensor in use
Measurement accuracy	±0.1% rdg.±0.1% f.s. + (current sensor accuracy) (Note: While using 2000 A range of Model CT7742, f.s. tolerance should be 2.5 times the value)

20. Current DC value measurement specifications Idc

Measurement method	Average value of the values obtained during the 200-ms aggregation period
Displayed items	Current DC value
Measurement range	Depends on the current sensor in use
Measurement accuracy	±0.5% rdg.±0.5% f.s. + (current sensor accuracy) (Note: While using 2000 A range of Model CT7742, f.s. tolerance should be 2.5 times the value)

21. Current CF value measurement specifications Icf

Measurement method	Calculated from the RMS current and the peak value of the current waveform.
Displayed items	Current CF Value
Measurement range	408.00
Measurement accuracy	Accuracy not defined

22. Active power measurement specifications P

Measurement method	Measured every 200 ms.
Displayed items	Active power on each channel Sum of values on multiple channels (For details, see Calculation Formula.) Inflow (consumption): Unsigned Outflow (regeneration): Negative
Measurement range	Depends on the combination of voltage and current ranges (see Power range configuration table)
Measurement accuracy	DC: ±0.5% rdg.±0.5% f.s. + (current sensor accuracy) AC: ±0.2% rdg.±0.1% f.s. + (current sensor accuracy) (Note: While using 2000 A range of Model CT7742, f.s. tolerance should be 2.5 times the value)
Power Factor Influence	1.0% rdg. or less (40 Hz to 70 Hz at power factor = 0.5) Phase difference between voltage and current of the internal circuit: ± 0.2865°

23. Apparent power measurement specifications S

Measurement method	RMS value calculation: Calculated from RMS voltage value, Urms and RMS current, Irms. Fundamental wave calculation: Calculated from fundamental wave active power and reactive power
Displayed items	Apparent power on each channel Sum of values on multiple channels (For details, see Calculation Formula.)
Display selection	RMS calculation / fundamental wave calculation (Both of them are stored.)
Measurement range	Depends on the voltage × current range combination (see Power range configuration table)
Measurement accuracy	±1 dgt. for calculations derived from the various measured values. (sum is ±3 dgt.)

24. Reactive power measurement specifications Q

Measurement method	RMS value calculation: Calculated from apparent power S and active power P Fundamental wave calculation: Calculated from fundamental wave voltage and current. Lag phase (LAG: current lags the voltage): Unsigned Lead phase (LEAD: current leads the voltage): Negative
Displayed items	Reactive power on each channel Sum of values on multiple channels (For details, see Calculation Formula.)
Display selection	RMS calculation / fundamental wave calculation (Both of them are stored.)
Measurement range	Depends on the voltage × current range combination (see Power range configuration table)
Measurement accuracy	During RMS calculation: ±1 dgt. for calculations derived from the various measured values. (sum is ±3 dgt.) During fundamental wave calculation: ±0.3% rdg.±0.1% f.s. + Current sensor specifications (reactive factor=1) in fundamental wave frequency of 45 Hz to 66 Hz (Note: While using 2000 A range of Model CT7742, f.s. tolerance should be 2.5 times the value)
Influence of Reactive Factors (During fundamental wave calculation)	1.0% rdg. or less (40 Hz to 70 Hz at a reactive factor of 0.5) Phase difference between voltage and current of the internal circuit: ± 0.2865°

25. Active energy, reactive energy, apparent energy measurement specifications WP+, WP−; WQ_LAG, WQ_LEAD; WS

Measurement method	Integrated from active power separately by consumption and regeneration Integrated from reactive power separately by lag and lead Integration from apparent power Electric energy is measured from the start of recording Data update: Every 1 s Integration starts at the same time as the recording, and ends with the last TREND update
Displayed items	• Active energy WP+ (consumption), WP- (regeneration) Sum of values on multiple channels (For details, see Calculation Formula.) • Reactive energy WQ_LAG (lag), WQ_LEAD (lead) Sum of values on multiple channels (For details, see Calculation Formula.) • Apparent energy: WS Sum of values on multiple channels (For details, see Calculation Formula.) • Elapsed time
Measurement range	Depends on the combination of voltage range, current range, and elapsed time. (See Power range configuration table.)
Measurement accuracy	Active energy: Active power measurement accuracy ±10 dgt. Reactive energy: Reactive power measurement accuracy ±10 dgt. Apparent energy: Apparent power measurement accuracy ±10 dgt. Cumulative time accuracy: ±10 ppm±1 s (23°C [73°F])

26. Energy cost measurement specifications Ecost

Measurement method	Calculated by multiplying active energy (consumption) WP+ by the unit energy cost (per kilowatt-hour). Data update: Every 1 s
Displayed items	Energy cost
Measurement accuracy	±1 dgt. relative to calculations from measured values

27. Power factor and displacement power factor measurement specifications PF, DPF

Measurement method	Power Factor: Calculated from apparent power S and active power P Displacement Power Factor: Calculated according to fundamental wave active power and reactive power (Data update: Every 1 s) Lag phase (LAG: current lags more than the voltage): Positive Lead phase (LEAD: current leads more than the voltage): Negative
Displayed items	Power factor/Displacement power factor on each channel Sum of values on multiple channels (For details, see Calculation Formula.)
Display selection	RMS calculation / fundamental wave calculation (Both of them are stored.)

28. Harmonic voltage and harmonic current measurement specifications Uharm, Iharm

Measurement method	Uses IEC61000-4-7 Ed2.1: 2009 Following the harmonic analysis, indicated added the harmonics components that are adjacent to the integer order interharmonic components. (For details, see Calculation Formula.)
Analysis window width	10 cycles/12 cycles
Window point count	Rectangular 2048 points
Displayed items	From 0th to 50th order Options for RMS and content percentage For content percentage, when the RMS is 0, all orders should be set to 0%.
Measurement range	• Harmonic voltage RMS value: 1000.0 V Content percentage: 100% • Harmonic current RMS value: Depends on the current sensor in use Content percentage: 500%
Measurement accuracy	• Voltage Defined by the declared input voltage of 100 V to 440V 0th order: Same as Voltage DC value 1st order: Same as RMS voltage 2nd order or higher: ±10.0% rdg. when the value is more than 1% of the declared input voltage, and the value should be ±0.05% of the declared input voltage when the value is less than 1% of the declared input voltage. • Current 0th order: same as Current DC value 1st to 20th order: ±0.5% rdg.±0.2% f.s. + (current sensor accuracy) 21st to 30th order: ±1.0% rdg.±0.3% f.s. + (current sensor accuracy) 31st to 40th order: ±2.0% rdg.±0.3% f.s. + (current sensor accuracy) 41st to 50th order: ±3.0% rdg.±0.3% f.s. + (current sensor accuracy) (Note: While using 2000 A range of Model CT7742, f.s. tolerance should be 2.5 times the value)

29. Harmonic power measurement specifications Pharm

Measurement method	Indicates harmonic power for each channel and the sum for multiple channels (For details, see Calculation Formula.)
Analysis window width	10 cycles/12 cycles
Window point count	Rectangular 2,048 points
Displayed items	From 0th to 50th order Options for RMS and content percentage For content percentage, when the RMS is 0, all orders should be set to 0%.
Measurement range	Depends on the voltage × current range combination (see Power range configuration table)
Measurement accuracy	0th order : ±0.5% rdg. ±0.5% f.s. + (current sensor accuracy) 1st to 20th order: ±0.5% rdg.±0.2% f.s. + (current sensor accuracy) 21st to 30th order: ±1.0% rdg.±0.3% f.s. + (current sensor accuracy) 31st to 40th order: ±2.0% rdg.±0.3% f.s. + (current sensor accuracy) 41st to 50th order: ±3.0% rdg.±0.3% f.s. + (current sensor accuracy) (Note: While using 2000 A range of Model CT7742, f.s. tolerance should be 2.5 times the value)

30. Interharmonic voltage and interharmonic current measurement specifications Uiharm, Iiharm

Measurement method	Following the harmonic analysis, indicated added the harmonics components between the integer orders harmonics components.
Analysis window width	10 cycles/12 cycles
Window point count	Rectangular 2,048 points
Displayed items	From order 0.5 to 49.5 Options for RMS and content percentage For content percentage, when the RMS is 0, all orders should be set to 0%.
Measurement range	Interharmonic voltage: 1000.0 V Interharmonic current: Depends on the current sensor in use
Measurement accuracy	Interharmonic voltage: Harmonic input has been specified with the declared input voltage, 100 V to 440 V, input. With a harmonic input of 1% or more of the declared input voltage input: ±10.0% rdg. With a harmonic input of less than 1% of the declared input voltage: ±0.05% of the declared input voltage Interharmonic current: Accuracy not defined

31. Harmonic voltage phase angle and harmonic current phase angle measurement specifications Uphase, Iphase

Measurement method	Applies IEC61000-4-7 Ed2.1: 2009.
Analysis window width	10 cycles/12 cycles
Window point count	Rectangular 2,048 points
Displayed items	Indicates the harmonic phase angle component of the integer-numbered order (including the fundamental wave component) (Where the wave phase angle is 0°.)
Measurement range	0.00° to ±180.00°
Measurement accuracy	Accuracy not defined

32. Harmonic voltage and current phase difference measurement specifications Pphase

Measurement method	Uses IEC61000-4-7 Ed2.1: 2009
Analysis window width	10 cycles/12 cycles
Window point count	Rectangular 2,048 points
Displayed items	Indicates the difference between the harmonic voltage phase angle and the harmonic current phase angle (including fundamental wave component). Phase difference between the harmonic voltage and the harmonic current on each channel Sum of values on multiple channels (For details, see Calculation Formula.)
Measurement range	0.00° to ±180.00°
Measurement accuracy	1st order to 3rd order: ± 2° 4th order to 50th order: ± (0.05° × k + 2°) (k: Harmonic Orders) However, current sensor accuracy is added. Harmonic Voltage of every order is specified as 1% of the declared voltage, and current level is specified as 1% f.s. or more.

33. Voltage THD and current THD measurement specifications Uthd, Ithd

Measurement method	Uses IEC61000-4-7 Ed2.1: 2009
Analysis window width	10 cycles/12 cycles
Window point count	Rectangular 2,048 points
Displayed items	THD-F (total harmonic distortion factor for the fundamental wave) THD-R (total harmonic distortion factor for the total harmonics including the fundamental wave)
Display selection	THD-F/THD-R (storage is implemented for both)
Measurement range	Voltage: 0.00% to 100.00% Current: 0.00% to 500.00%
Event threshold	Voltage: 0.0% to 100.0% Current: 0.0% to 500.0%
Event IN	Starting time of an approximately 200-ms aggregation period to which a value belongs when it exceeds the threshold value
Event OUT	Starting time of an approximately 200-ms aggregation period to which a value belongs when it falls below the value calculated by subtracting the hysteresis from the threshold value during the Event In state
Multiple-phase system treatment	Separate by channel
Saved waveforms	Event waveforms

34. Voltage unbalance factor (negative-phase unbalance factor, zero-phase unbalance factor) measurement specifications Uunb, Uunb0

Measurement method	Calculated using the fundamental voltage component of each 3-phase in the 3-phase 3-wire (3P3W2M, 3P3W3M) and 3-phase 4-wire wiring (For details, see Calculation Formula.).
Displayed items	Negative-phase unbalance factor (Uunb) Zero-phase unbalance factor (Uunb0)
Measurement range	Component: V Unbalance factor: 0.00% to 100.00%

35. Current unbalance factor (negative-phase unbalance factor, zero-phase unbalance factor) measurement specifications Iunb, Iunb0

Measurement method	Calculated using the fundamental current component of each 3-phase in the 3-phase 3-wire (3P3W2M, 3P3W3M) and 3-phase 4-wire wiring (For details, see Calculation Formula.).
Displayed items	Negative-phase unbalance factor (Iunb) Zero-phase unbalance factor (Iunb0)
Measurement range	Component: A Unbalance factor: 0.00% to 100.00%.

36. K Factor (multiplication factor) measurement specifications KF

Measurement method	Calculated using the harmonic RMS current value of 2nd order to 50th order. (For details, see Calculation Formula.)
Analysis window width	10 cycles/12 cycles
Window point count	Rectangular 2,048 points
Displayed items	K factor KF
Measurement range	0.00 to 500.00

37. RMS frequency characteristics

Frequency	Voltage	Current	Power
40 Hz to 70 Hz	Specified as RMS value	Specified as RMS value	Specified as RMS value
70 Hz to 1 kHz	±3% rdg.±0.2% f.s.	±3% rdg.±0.2% f.s.	±3% rdg.±0.2% f.s.
1 kHz to 10 kHz	±10% rdg.±0.2% f.s.	±10% rdg.±0.2% f.s.	±10% rdg.±0.2% f.s.
40 kHz	−3 dB	−3 dB	-

(Note: While using 2000 A range of Model CT7742, f.s. tolerance of the current and power should be 2.5 times the value)

14.3 Flagging Concept

IEC61000-4-30 Flagging concept

If an unreliable values are produce during a dip, swell, or interruption, the 200-ms aggregation will be “flagged.” An interval data including the flagged 200-ms aggregation will also be flagged.
Flagged data are referenced to decide the frequency for an interruption, and are recorded in status information of the TREND data. If events of a dip, swell, or interruption are set to off, the values are also flagged.

14.4 QUICK SET Specifications

QUICK SET screen

Start confirmation	Confirmation of whether to launch the settings after initialization of the concerned measurement settings and recording settings
Basic settings	CH123: 1P2W/1P3W/1P3W1U/3P3W2M/3P3W3M/3P4W 3P4W2.5E (available after the firmware update) CH4: OFF/ON
Connected devices	Diagrams for connecting voltage codes and current sensors as well as inserting SD memory card Automatic sensor recognition (Manual setting when a legacy model sensor is connected) Implementation of zero adjustment
Voltage wiring	Make voltage wiring Sets the declared input voltage and confirm the level, phase and frequency.
Current wiring	Make current wiring Sets the range.
Wiring check	Check the wiring
Event settings	Select “Easy Settings Course”
Recording settings	Recording interval: 1/2/5/10/15/30 s, 1/2/5/10/15/30 min, 1/2 h, 150 cycles (only at 50 Hz) / 180 cycles (only at 60 Hz) Display the available save time Recording start: Interval time (*) / manual / specified time / repeat (Recording period is 00:00 to 24:00) Recording stop: Manual (*)/specified time/timer Folder/file name: Auto (*)/variable
Settings confirmation **Recording start**	After confirming the settings, start the measurement (otherwise, complete the settings without starting)

*: Default Settings

Easy settings course

Setting items \ Course		Voltage events	Inrush current	Trend record only	EN50160
Wiring		Set in advance			
Current sensor		Set in advance			
Current range		Set in advance	Switches to an upper range when the reference value is 1/5th or more of the rated range	Set in advance	
Measurement frequency		Set in advance			
Declared input voltage		Set in advance			
Selection of calculation method	Urms type	Default			
	THD type	THD_F			
	PF/Q/S calculation selection	RMS value calculation			
Recorded item settings		Yes harmonic			
Recording interval		1 min		10 min	
Event hysteresis		1%			2%
Transient overvoltage		70% of the declared input voltage	Off		100% of the declared input voltage
Voltage Swell		110% of the declared input voltage	Off		110% of the declared input voltage
Voltage Dip		90% of the declared input voltage	Off		90% of the declared input voltage
Interruption		10% of the declared input voltage	Off		5% of the declared input voltage
Frequency (200 ms)		Nominal input frequency ±5 Hz	Off		Nominal input frequency ±0.5 Hz
Frequency (1 wave)		Off	Off		
Inrush current		Off	200% of the reference value	Off	
Voltage total harmonic distortion		5%	Off		8%
Current total harmonic distortion		Off	Off		

- Range settings for inrush current should not be changed without considering the reference value when the prior set range is at its maximum. A value of 10% of the range is used as threshold value when the reference value (measured value at the effective time of the easy setting) is 10% or less of the range.
  If the reference value of 200% exceeds the rated range, the rated range value is set as the threshold value.
- Voltage THD is set as off if the RMS voltage value is 3% f.s. or less of the range.
- After easy setting, (not only for easy setting) if the VT, CT are changed after setting the threshold value, the threshold value does not change. (Event threshold value is set again after setting the VT, CT)
- Fundamentally, the settings that are not included in the table are taken as default values.

14.5 Event Specifications

Event detection method	It can be detected in the recording interval of 1 s or more. The detection method relative to measured values for each event target is listed in the measurement specifications. External events: Event is detected by detecting the signal towards the EVENT IN terminal. Manual events: Events are detected by pressing the **[MANUAL EVENT]** key. Enabled measurement item events are detected using OR logic. Events cannot be detected using maximum (MAX), minimum (MIN), and average (AVG) values.
Event-synchronized save functionality	Event waveform: Approx. 200-ms aggregation (12.5 kS/s) Event Trend Data: Trend data of the RMS value at each corresponding half wave, 0.5 s before and 29.5 s after the occurrence of an event.

Event contents

✓: Yes, —: No

Event parameter	Event list notation	IN/OUT support	Measurement Items	Event waveforms	Event trend data
Transient overvoltage	**Tran**	IN/OUT	All instantaneous values	✓	—
Swell	**Swell**	IN/OUT	Frequency, voltage, current, electric power, power factor, unbalance factor, harmonic voltage, harmonic current, harmonic power, voltage THD, current THD (event category)	✓	✓
Dip	**Dip**	IN/OUT		✓	✓
Interruption	**Intrpt**	IN/OUT		✓	✓
Frequency (200 ms)	**Freq**	IN/OUT		✓	—
Frequency (1 wave)	**Freq_wav**	IN/OUT		✓	—
Voltage total harmonic distortion	**Uthd**	IN/OUT		✓	—
Inrush current	**Inrush**	IN/OUT		✓	✓
Current total harmonic distortion	**Ithd**	IN/OUT		✓	—
Timer event	**Timer**	—		✓	—
External event	**Ext**	—		✓	—
Manual event	**Manu**	—		✓	—
Pre-event recording	**Before**	—		✓	—
Post-event recording	**After**	—		✓	—
Recording start	**Start**	—		✓	—
Recording stop	**Stop**	—		✓	—

14.6 Interface Specifications

1. SD memory card

Slot	SD standard compliant × 1
Compatible card	SD memory card/ SDHC memory card (Use only Hioki-approved card)
Format	SD memory card format
Supported memory capacity	SD memory card: up to 2 GB SDHC memory card: up to 32 GB
Functions	Save and read the following content: • Binary data (measurement data) • Settings file • Screen copy (save only) Deleting of files Format

2. LAN interface

Connector	RJ-45 × 1
Electrical specifications	IEEE802.3 compliant
Transmission method	100BASE-TX
Protocol	TCP/IP
Functions	HTTP server function (Compatible software: Internet Explorer Ver. 9 or later) Remote control application function Recording Start and End control function Configuration Function Event list function (capable of displaying event waveforms, event vectors, and event harmonic bar graphs) Settings according to the communication commands, acquisition of measurement data, and data download

3. USB interface

Connector	Series B receptacle × 1
Method	USB 2.0 (full-speed, high-speed), mass storage, class
Connection destination	Computer: Windows 7 (32-bit/64-bit) or Windows 10 (32-bit/64-bit)
Functions	When connected to the computer, the computer recognizes the SD memory card to be a removable disk, and downloads the data from the SD memory card. Note: The instrument cannot be connected while recording (including standby).

4. RS-232C interface

Connector	D-sub 9-pin × 1
Method	Compliance with RS-232C “EIA RS-232D,” “CCITT V.24,” and “JIS X 5101.”
Transmission mode	Full-duplex, start-stop synchronization method
Communication speed	19 200 bps / 38 400 bps
Data length	8 bits
Parity check	None
Stop bit	1
Connection destination	Computer: Windows 7 (32-bit/64-bit) or Windows 10 (32-bit/64-bit)
Functions	Measurement and acquisition of measurement data by sending communication commands

5. External control interface

Connector	4-pin screwless terminal block ×1
Details	External event input: input terminal [IN] ×1, ground terminal [GND1] ×1 External event output: output terminal [OUT] ×1, ground terminal [GND2] ×1
Event Input	Recognizes as an event input by the fall in the pulse signal or the short-circuiting (active LOW) of the GND1 terminal and the IN terminal each other. Non-insulated (GND1 is common with this instrument ground) Maximum rated power between terminals: 45 V DC Voltage input (High: 2 V to 45 V, Low: 0 V to 0.5 V) High duration: 100 ms or more, Low duration: 100 ms or more
Event output	Open Collector 30 V, max 5 mA (isolation using photo-couplers) TTL low output at event generation between GND2 terminal and OUT terminal
Low-level output pulse width	Short pulse: approx. 10 ms Long pulse: approx. 2.5 ms

14.7 Calculation Formula

The 3P4W2.5E wiring will be available after the firmware update.

1. RMS voltage refreshed each half-cycle (Urms1/2), Dip, Swell, Interruption (Intrpt), RMS current refreshed each half-cycle (Irms1/2), Inrush current (Inrush)

<table>
<tr><th>Wiring
Item</th><th>Single phase 2-wire
1P2W</th><th>Single phase 3-wire
1P3W</th><th>3-phase 3-wire
3P3W2M</th><th>3-phase 3-wire
3P3W3M</th><th>3-phase 4-wire
3P4W</th></tr>
<tr><td rowspan="3">Urms1/2
Dip
Swell
Intrpt
[Vrms]=U_c</td><td rowspan="2">U_1
U_4
$U_c=\sqrt{\frac{1}{M}\sum_{s=0}^{M-1}(U_{cs})^2}$</td><td>$U_1$
U_2
U_4</td><td rowspan="2">U_1
U_2
U_3 ($U_{3S}=U_{2S}-U_{1S}$)
U_4</td><td rowspan="2">Line voltage
$U_{12}=\frac{1}{M}\sum_{s=0}^{M-1}(U_{1s}-U_{2s})^2$
$U_{23}=\frac{1}{M}\sum_{s=0}^{M-1}(U_{2s}-U_{3s})^2$
$U_{31}=\frac{1}{M}\sum_{s=0}^{M-1}(U_{3s}-U_{1s})^2$</td><td>$U_1$
U_2
U_3
U_4</td></tr>
<tr><td>During 1P3W1U
Without U_2</td><td>During 3P4W2.5E
U_3 ($U_{3S}=U_{1S}-U_{2S}$)
($U_{1S}+U_{2S}+U_{3S}=0$ is the assumption)</td></tr>
<tr><td colspan="5">• For 3P3W2M wiring, it is assumed that $U_{1S}-U_{2S}+U_{3S}=0$
• For 3P3W3M wiring, phase voltage U is measured from the virtual neutral point, and line voltage is determined by calculation.
• Dip, Swell and Intrpt excludes U_4 and U_3 of 3P3W2M</td></tr>
<tr><td rowspan="2">Irms1/2
Inrush
[Arms]=I_c</td><td>I_1
I_4
$I_c=\sqrt{\frac{1}{M}\sum_{s=0}^{M-1}(I_{cs})^2}$</td><td>$I_1$
I_2
I_4</td><td>I_1
I_2
I_3 ($I_{3S}=I_{1S}-I_{2S}$)
I_4</td><td colspan="2">I_1
I_2
I_3
I_4</td></tr>
<tr><td colspan="5">• For 3P3W2M wiring, it is assumed that $I_{1S}+I_{2S}+I_{3S}=0$.</td></tr>
</table>

c: Measurement channel, M: Number of samples per period, s: Number of sample points

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Specifications

2. Voltage waveform peak (Upk), Voltage crest factor (Ucf), Current waveform peak (Ipk), Current crest factor (Icf)

<table>
<tr><th>Wiring / Item</th><th>Single phase 2-wire 1P2W</th><th>Single phase 3-wire 1P3W</th><th>3-phase 3-wire 3P3W2M</th><th>3-phase 3-wire 3P3W3M</th><th>3-phase 4-wire 3P4W</th></tr>
<tr><td rowspan="2">Upk+
Upk−
[V]=Up_c</td><td>Up_1
Up_4</td><td>Up_1
Up_2
Up_4
During 1P3W1U Without Up_2</td><td>Up_1
Up_2
Up_3
Up_4</td><td>Up_{12}
Up_{23}
Up_{31}</td><td>Up_1
Up_2
Up_3
Up_4</td></tr>
<tr><td colspan="5">• For 3P3W2M wiring, it is assumed that $U_{1S}-U_{2S}+U_{3S}=0$
• For 3P3W3M wiring, phase voltage U is measured from the virtual neutral point, and line voltage is determined by calculation.</td></tr>
<tr><td rowspan="2">Ucf[ ]</td><td>Ucf_1
Ucf_4
$Ucf_c=\left|\frac{Up_c}{U_c}\right|$</td><td>$Ucf_1$
Ucf_2
Ucf_4
During 1P3W1U Without Ucf_2</td><td>Ucf_1
Ucf_2
Ucf_3
Ucf_4</td><td>Ucf_{12}
Ucf_{23}
Ucf_{31}</td><td>Ucf_1
Ucf_2
Ucf_3
Ucf_4</td></tr>
<tr><td colspan="5">• The larger absolute value among +, − is used for Up_C.</td></tr>
<tr><td rowspan="2">Ipk+
Ipk−
[A]=Ip_c</td><td>Ip_1
Ip_4</td><td>Ip_1
Ip_2
Ip_4</td><td colspan="3">Ip_1
Ip_2
Ip_3
Ip_4</td></tr>
<tr><td colspan="5">• With 3P3W2M wiring, it is assumed that $I_{1S}+I_{2S}+I_{3S}=0$.</td></tr>
<tr><td rowspan="2">Icf[ ]</td><td>Icf_1
Icf_4
$Icf_c=\left|\frac{Ip_c}{I_c}\right|$</td><td>$Icf_1$
Icf_2
Icf_4</td><td colspan="3">Icf_1
Icf_2
Icf_3
Icf_4</td></tr>
<tr><td colspan="5">• The larger absolute value among +, − is used for Ip_C.</td></tr>
</table>

c: Measurement channel

3. RMS voltage (Urms), RMS current (Irms)

<table>
<tr><th>Wiring / Item</th><th>Single phase 2-wire 1P2W</th><th>Single phase 3-wire 1P3W</th><th>3-phase 3-wire 3P3W2M</th><th>3-phase 3-wire 3P3W3M</th><th>3-phase 4-wire 3P4W</th></tr>
<tr><td rowspan="6">Urms [Vrms]=U_c</td><td rowspan="3">U_1

U_4
U_c=
$\sqrt{\frac{1}{M}\sum_{s=0}^{M-1}(U_{cs})^2}$</td><td>$U_1$
U_2

U_4</td><td rowspan="3">U_1
U_2
U_3 (U_{3S}=U_{2S}−U_{1S})
U_4</td><td rowspan="2">Line voltage
U_{12}= $\frac{1}{M}\sum_{s=0}^{M-1}(U_{1s}-U_{2s})^2$
U_{23}= $\frac{1}{M}\sum_{s=0}^{M-1}(U_{2s}-U_{3s})^2$
U_{31}= $\frac{1}{M}\sum_{s=0}^{M-1}(U_{3s}-U_{1s})^2$</td><td>Phase voltage
U_1
U_2
U_3
U_4</td></tr>
<tr><td rowspan="2">During 1P3W1U
Without U_2</td><td>During 3P4W2.5E
U_3 (U_{3S}=−U_{1S}−U_{2S})
(U_{1S}+U_{2S}+U_{3S}= 0 is the assumption)</td></tr>
<tr><td>Phase voltage
U_1
U_2
U_3</td><td>Line voltage
U_{12}= $\frac{1}{M}\sum_{s=0}^{M-1}(U_{1s}-U_{2s})^2$
U_{23}= $\frac{1}{M}\sum_{s=0}^{M-1}(U_{2s}-U_{3s})^2$
U_{31}= $\frac{1}{M}\sum_{s=0}^{M-1}(U_{3s}-U_{1s})^2$
U_4</td></tr>
<tr><td rowspan="2"></td><td>U_{avg}=
$\frac{1}{2}(U_1+U_2)$</td><td rowspan="2">U_{avg}=
$\frac{1}{3}(U_1+U_2+U_3)$</td><td>Line voltage
U_{avg}= $\frac{1}{3}(U_{12}+U_{23}+U_{31})$</td><td>Phase voltage
U_{avg}= $\frac{1}{3}(U_1+U_2+U_3)$</td></tr>
<tr><td>During 1P3W1U
Without U_{avg}</td><td>Phase voltage
U_{avg}= $\frac{1}{3}(U_1+U_2+U_3)$</td><td>Line voltage
U_{avg}= $\frac{1}{3}(U_{12}+U_{23}+U_{31})$</td></tr>
<tr><td colspan="5">• For 3P3W2M wiring, it is assumed that $U_{1S}-U_{2S}+U_{3S}=0$
• For 3P3W3M wiring, phase voltage U is measured from the virtual neutral point, and line voltage is determined by calculation.</td></tr>
<tr><td rowspan="3">Irms [Arms]=I_c</td><td>I_1
I_4
I_c=
$\sqrt{\frac{1}{M}\sum_{s=0}^{M-1}(I_{cs})^2}$</td><td>$I_1$
I_2

I_4</td><td>I_1
I_2
I_3 (I_{3S}=−I_{1S}−I_{2S})
I_4</td><td colspan="2">I_1
I_2
I_3
I_4</td></tr>
<tr><td></td><td>I_{avg}=
$\frac{1}{2}(I_1+I_2)$</td><td colspan="3">I_{avg}= $\frac{1}{3}(I_1+I_2+I_3)$</td></tr>
<tr><td colspan="5">• For 3P3W2M wiring, it is assumed that $I_{1S}+I_{2S}+I_{3S}=0$.</td></tr>
</table>

c: Measurement channel, M: Number of samples per period, s: Number of sample points

4. Active power (P)

Wiring / Item	Single phase 2-wire 1P2W	Single phase 3-wire 1P3W	3-phase 3-wire 3P3W2M	3-phase 3-wire 3P3W3M	3-phase 4-wire 3P4W
P [W]	P_1 $P_c=$ $\frac{1}{M}\sum_{s=0}^{M-1}(U_{cs}\times I_{cs})$	P_1 P_2	P_1 P_2	P_1 P_2 P_3	
		During 1P3W1U $U_2=-U_1$			
		$P_{sum}=P_1+P_2$	$P_{sum}=P_1+P_2+P_3$		
	• The polarity symbols of active power P, indicate the current flow direction of the power during consumption (+P), and during regeneration (−P).				

c: measurement channel, M: number of samples per period, s: number of sample points

5. Voltage DC value (Udc), Current DC value (Idc)

Wiring / Item	Single phase 2-wire 1P2W	Single phase 3-wire 1P3W	3-phase 3-wire 3P3W2M	3-phase 3-wire 3P3W3M	3-phase 4-wire 3P4W
Udc [V]	Udc_1 Udc_4 $Udc_c=$ $\frac{1}{M}\sum_{s=0}^{M-1}U_{cs}$	Udc_1 Udc_2 Udc_4	Udc_1 Udc_2 Udc_3 ($U_{3S}=U_{2S}-U_{1S}$) Udc_4	$Udc_{12}=\frac{1}{M}\sum_{s=0}^{M-1}(U_{1s}-U_{2s})^2$ $Udc_{23}=\frac{1}{M}\sum_{s=0}^{M-1}(U_{2s}-U_{3s})^2$ $Udc_{31}=\frac{1}{M}\sum_{s=0}^{M-1}(U_{3s}-U_{1s})^2$	Udc_1 Udc_2 Udc_3 Udc_4
		During 1P3W1U Without Udc_2			During 3P4W2.5E U_3 ($U_{3S}=U_{1S}-U_{2S}$) ($U_{1S}+U_{2S}+U_{3S}=0$ is the assumption)
Idc [A]	Idc_1 Idc_4 $Idc_c=$ $\frac{1}{M}\sum_{s=0}^{M-1}I_{cs}$	Idc_1 Idc_2 Idc_4	Idc_1 Idc_2 Idc_3 ($I_{3S}=-I_{1S}-I_{2S}$) Idc_4	Idc_1 Idc_2 Idc_3 Idc_4	

c: Measurement channel, M: Number of samples per period, s: Number of sample points

6. Apparent power (S)

<table>
<tr><th>Wiring
Item</th><th>Single phase 2-wire
1P2W</th><th>Single phase 3-wire
1P3W</th><th>3-phase 3-wire
3P3W2M</th><th>3-phase 3-wire
3P3W3M</th><th>3-phase 4-wire
3P4W</th></tr>
<tr><td rowspan="7">S [VA]</td><td colspan="5">PF/Q/S calculation selection: RMS value calculation
• S_1, S_2 and S_3 of 3P3W3M uses phase voltage, while S_{sum} uses line voltage.</td></tr>
<tr><td rowspan="3">S_1
$S_c = U_c \times I_c$</td><td>S_1
S_2</td><td colspan="3" rowspan="2">S_1
S_2
S_3</td></tr>
<tr><td>During 1P3W1U
$U_2 = U_1$</td></tr>
<tr><td>$S_{sum} = S_1 + S_2$</td><td>$S_{sum} = \frac{\sqrt{3}}{3}(S_1 + S_2 + S_3)$</td><td>$S_{sum} = \frac{\sqrt{3}}{3}(U_{12} \times I_1 + U_{23} \times I_2 + U_{31} \times I_3)$</td><td>$S_{sum} = S_1 + S_2 + S_3$</td></tr>
<tr><td colspan="5">PF/Q/S calculation selection: fundamental wave calculation
• This apparent power S is defined as the fundamental wave apparent power.
• (1): Harmonic calculation fundamental wave (1st order)</td></tr>
<tr><td rowspan="2">S_1
$S_c = \sqrt{P_{c(1)}^2 + Q_{c(1)}^2}$</td><td colspan="2">$S_1$
S_2</td><td colspan="2">S_1
S_2
S_3</td></tr>
<tr><td colspan="4">$S_{sum} = \sqrt{P_{sum(1)}^2 + Q_{sum(1)}^2}$</td></tr>
</table>

c: Measurement channel

7. Reactive power (Q)

<table>
<tr><th>Wiring
Item</th><th>Single phase 2-wire
1P2W</th><th>Single phase 3-wire
1P3W</th><th>3-phase 3-wire
3P3W2M</th><th>3-phase 3-wire
3P3W3M</th><th>3-phase 4-wire
3P4W</th></tr>
<tr><td rowspan="8">Q [var]</td><td colspan="5">PF/Q/S calculation selection: RMS value calculation
• When $S < |P|$ due to the effects of measurement errors or unbalance, $S = |P|$ and $Q = 0$.
• Si: indicates lag and lead. The sign of reactive power Q (fundamental wave reactive power) is used.
Sign +: lag
Sign −: lead</td></tr>
<tr><td rowspan="2">Q_1
$Q_c = Si\sqrt{S_c^2 - P_c^2}$</td><td colspan="2">$Q_1$
Q_2</td><td colspan="2">Q_1
Q_2
Q_3</td></tr>
<tr><td colspan="4">$Q_{sum} = Si\sqrt{S_{sum}^2 - P_{sum}^2}$</td></tr>
<tr><td colspan="5">PF/Q/S calculation selection: Fundamental wave calculation
• This reactive power Q is defined as the fundamental wave reactive power.
• (1): Harmonic calculation fundamental wave (1st order)
• r: resistance after FFT, i: reactance after FFT
• Sign +: lag
Sign −: lead</td></tr>
<tr><td rowspan="3">Q_1
$Q_c = -U_{c(1)r} \times I_{c(1)i} + U_{c(1)i} \times I_{c(1)r}$</td><td>$Q_1$
Q_2</td><td rowspan="2">Q_1
Q_2</td><td colspan="2" rowspan="2">Q_1
Q_2
Q_3</td></tr>
<tr><td>During 1P3W1U
$U_2 = -U_1$</td></tr>
<tr><td colspan="2">$Q_{sum} = Q_1 + Q_2$</td><td colspan="2">$Q_{sum} = Q_1 + Q_2 + Q_3$</td></tr>
</table>

c: Measurement channel

8. Power factor (PF), Displacement power factor (DPF)

Item \ Wiring	Single phase 2-wire 1P2W	Single phase 3-wire 1P3W	3-phase 3-wire 3P3W2M	3-phase 3-wire 3P3W3M	3-phase 4-wire 3P4W
PF [ ] PF/Q/S Calculation Selection: RMS value calculation	PF_1 $PF_c = si\left\lvert\frac{P_c}{S_c}\right\rvert$	PF_1 PF_2		PF_1 PF_2 PF_3	
		$PF_{sum} = si\left\lvert\frac{P_{sum}}{S_{sum}}\right\rvert$			
	• Si: indicates lag and lead. The sign of reactive power Q (fundamental wave reactive power) is used. Sign +: lag Sign −: lead • When $S < \lvert P\rvert$ due to the effects of measurement errors or unbalance, $S = \lvert P\rvert$ and $PF = 1$. • When $S = 0$, PF is taken as invalid data.				
DPF [ ] PF/Q/S Calculation Selection: Fundamental wave calculation	DPF_1 $DPF_c = si\left\lvert\frac{P_{c(1)}}{S_{c(1)}}\right\rvert$	DPF_1 DPF_2		DPF_1 DPF_2 DPF_3	
		$DPF_{sum} = si\left\lvert\frac{P_{sum(1)}}{S_{sum(1)}}\right\rvert$			
	• Si: indicates lag and lead. The sign of reactive power Q (fundamental wave reactive power) is used. Sign +: lag Sign −: lead • (1): indicates the harmonic calculation fundamental wave (1st order) • When $S_{c(1)} = 0$, DPF is taken as invalid data.				

c: Measurement channel

9. Active energy (WP+/WP−), Reactive energy (WQ_LAG/WQ_LEAD), Apparent energy (WS), Energy cost (Ecost)

Item \ Wiring	Single phase 2-wire 1P2W	Single phase 3-wire 1P3W	3-phase 3-wire 3P3W2M	3-phase 3-wire 3P3W3M	3-phase 4-wire 3P4W
WP+ [Wh] (consumption)	$WP+= k\sum_{1}^{h} P_{sum}(+)$				
	• $P(+)$: Only the consumption component of active power (positive component) is used.				
WP− [Wh] (Regeneration)	$WP-= k\sum_{1}^{h} P_{sum}(-)$				
	• $P(-)$: Only the regeneration component of active power (negative component) is used.				
WQ_LAG [varh] (Lag)	$WQ\_LAG= k\sum_{1}^{h} Q_{sum}(LAG)$				
	• $Q(LAG)$: Only the lag component of reactive power is used.				
WQ_LEAD [varh] (Lead)	$WQ\_LEAD= k\sum_{1}^{h} Q_{sum}(LEAD)$				
	• $Q(LEAD)$: Only the lead component of reactive power is used.				
WS [VAh]	$WS= k\sum_{1}^{h} S_{sum}$				
Ecost [Variable]	$Ecost= WP+\times rate$				
	• $rate$: Electrical unit cost (variable setting from 0.00000 to 99999.9/kWh)				

k: Calculation unit time [h], h: Measurement duration

10. Voltage negative-phase unbalance factor (Uunb), Voltage zero-phase unbalance factor (Uunb0), Current negative-phase unbalance factor (Iunb), Current zero-phase unbalance factor (Iunb0)

Item \ Wiring	Single phase 2-wire 1P2W	Single phase 3-wire 1P3W	3-phase 3-wire 3P3W2M	3-phase 3-wire 3P3W3M	3-phase 4-wire 3P4W
Uunb[%]			$U_{unb}=\frac{U_{neg}}{U_{pos}}\times 100$		
Uunb0[%]					$U_{unb0}=\frac{U_{zero}}{U_{pos}}\times 100$
Iunb[%]			$I_{unb}=\frac{I_{neg}}{I_{pos}}\times 100$		
Iunb0[%]					$I_{unb0}=\frac{I_{zero}}{I_{pos}}\times 100$

	3-phase 3-wire 3P3W2M	3-phase 3-wire 3P3W3M	3-phase 4-wire 3P4W
Uzero *Upos* *Uneg*	$\frac{1}{3}\sqrt{(U_1 \bullet \cos(\alpha)+U_2 \bullet \cos(\beta+seq2)+U_3 \bullet \cos(\gamma+seq3))^2+(U_1 \bullet \sin(\alpha)+U_2 \bullet \sin(\beta+seq2)+U_3 \bullet \sin(\gamma+seq3))^2}$		
	• The fundamental RMS voltage (phase voltage) from the results of harmonic calculations is used. • α: Phase angle of U_1, β: Phase angle of U_2, γ: Phase angle of U_3 • Use 3P3W2M after vector calculations in phase voltage as it is detected by line voltage.		
Izero *Ipos* *Ineg*	$\frac{1}{3}\sqrt{(I_1 \bullet \cos(\alpha)+I_2 \bullet \cos(\beta+seq2)+I_3 \bullet \cos(\gamma+seq3))^2+(I_1 \bullet \sin(\alpha)+I_2 \bullet \sin(\beta+seq2)+I_3 \bullet \sin(\gamma+seq3))^2}$		
	• The fundamental RMS current (phase voltage) from the results of harmonic calculations is used. • α: Phase angle of I_1, β: Phase angle of I_2, γ: Phase angle of I_3 • For 3P3W2M, the calculations are performed with I_2 and I_3 replaced with each other.		

	Seq2	*Seq3*
Uzero, *Izero*	0°	0°
Upos, *Ipos*	120°	240°
Uneg, *Ineg*	240°	120°

11. Harmonic voltage (Uharm), Harmonic current (Iharm), Interharmonic voltage (Uiharm), Interharmonic current (Iiharm)

<table>
<tr><th>Wiring
Item</th><th>Single phase 2-wire
1P2W</th><th>Single phase 3-wire
1P3W</th><th>3-phase 3-wire
3P3W2M</th><th>3-phase 3-wire
3P3W3M</th><th>3-phase 4-wire
3P4W</th></tr>
<tr><td rowspan="3">Uharm [Vrms]=U_{ck}
(including adjacent interharmonic components)</td><td rowspan="2">U_{1k}
U_{4k}
$U'_{ck}=\sqrt{(U_{ckr})^2+(U_{cki})^2}$
$U_{ck}=\sqrt{\sum_{n=-1}^{1}\left(U'_{c\left(\frac{10k+n}{10}\right)}\right)^2}$</td><td>$U_{1k}$
U_{2k}
U_{4k}</td><td rowspan="2">U_{1k}
U_{2k}
U_{3k}
U_{4k}</td><td rowspan="2">U_{12k}
U_{23k}
U_{31k}</td><td rowspan="2">U_{1k}
U_{2k}
U_{3k}
U_{4k}</td></tr>
<tr><td>During 1P3W1U
Without U_{2k}</td></tr>
<tr><td colspan="5">• For 60 Hz measurement, the value 10 in the formula is replaced with 12.
• Harmonic voltage content percentage (%): $U_{ck}/U_{c1} \times 100$ (%)
• For 3P3W2M wiring, it is assumed that $U_{1s}-U_{2s}+U_{3s}=0$
• U_{c0} component is treated as DC for 0th order when $k=0$.</td></tr>
<tr><td rowspan="2">Iharm [Arms]=I_{ck}
(including adjacent interharmonic components)</td><td>I_{1k}
I_{4k}
$I'_{ck}=\sqrt{(I_{ckr})^2+(I_{cki})^2}$
$I_{ck}=\sqrt{\sum_{n=-1}^{1}\left(I'_{c\left(\frac{10k+n}{10}\right)}\right)^2}$</td><td>$I_{1k}$
I_{2k}
I_{4k}</td><td>I_{1k}
I_{2k}
I_{3k}
I_{4k}</td><td colspan="2">I_{1k}
I_{2k}
I_{3k}
I_{4k}</td></tr>
<tr><td colspan="5">• For 60 Hz measurement, the value 10 in the formula is replaced with 12.
• Harmonic voltage and current content percentage (%): $I_{Ck}/I_{C1} \times 100$ (%)
• For 3P3W2M wiring, it is assumed that $I_{1s}+I_{2s}+I_{3s}=0$.
• I_{c0} component is treated as DC for 0th order when $k=0$.</td></tr>
<tr><td rowspan="3">Uiharm [Vrms]=U_{ck}</td><td rowspan="2">U_{1k}
U_{4k}
$U'_{ck}=\sqrt{(U_{ckr})^2+(U_{cki})^2}$
$U_{ck}=\sqrt{\sum_{n=-3}^{3}\left(U'_{c\left(\frac{10k+n}{10}\right)}\right)^2}$</td><td>$U_{1k}$
U_{2k}
U_{4k}</td><td rowspan="2">U_{1k}
U_{2k}
U_{3k}
U_{4k}</td><td rowspan="2">U_{12k}
U_{23k}
U_{31k}</td><td rowspan="2">U_{1k}
U_{2k}
U_{3k}
U_{4k}</td></tr>
<tr><td>During 1P3W1U
Without U_{2k}</td></tr>
<tr><td colspan="5">• For 60 Hz measurement, the value 10 in the formula is replaced with 12; 3, with -3; and 4, with −4.
• Intermediate harmonic voltage content percentage (%): $U_{Ck}/U_{C1} \times 100$ (%)
• For 3P3W2M wiring, it is assumed that $U_{1s}-U_{2s}+U_{3s}=0$</td></tr>
<tr><td rowspan="2">Iiharm [Arms]=I_{ck}</td><td>I_{1k}
I_{4k}
$I'_{ck}=\sqrt{(I_{ckr})^2+(I_{cki})^2}$
$I_{ck}=\sqrt{\sum_{n=-3}^{3}\left(I'_{c\left(\frac{10k+n}{10}\right)}\right)^2}$</td><td>$I_{1k}$
I_{2k}
I_{4k}</td><td>I_{1k}
I_{2k}
I_{3k}
I_{4k}</td><td colspan="2">I_{1k}
I_{2k}
I_{3k}
I_{4k}</td></tr>
<tr><td colspan="5">• For 60 Hz measurement, the value 10 in the formula is replaced with 12; 3, with −3; and 4, with −4.
• Intermediate harmonic current content percentage (%): $I_{Ck}/I_{C1} \times 100$ (%)
• For 3P3W2M wiring, it is assumed that $I_{1s}+I_{2s}+I_{3s}=0$.</td></tr>
</table>

c: Measurement channel

12. Harmonic power (Pharm), Harmonic reactive power (Qharm), K factor (KF)

Item \ Wiring	Single phase 2-wire 1P2W	Single phase 3-wire 1P3W	3-phase 3-wire 3P3W2M	3-phase 3-wire 3P3W3M	3-phase 4-wire 3P4W
Pharm [W]=P_{ck}	P_{1k} $P_k = U_{ckr} \times I_{ckr} + U_{cki} \times I_{cki}$	P_{1k} P_{2k} During 1P3W1U $U_2 = -U_1$	(P_{1k}) (P_{2k})	P_{1k} P_{2k} P_{3k}	
		$P_{sumk} = P_{1k} + P_{2k}$		$P_{sumk} = P_{1k} + P_{2k} + P_{3k}$	
	• Harmonic voltage content percentage (%): $P_{Ck}/\|P_{C1}\| \times 100$ (%) • The P_{1k}, P_{2k} values of the 3P3W2M wiring are used in internal calculations, but are not displayed.				
Qharm [W]=Q_{ck}	(Q_{1k}) $Q_k = U_{ckr} \times I_{cki} - U_{cki} \times I_{ckr}$	(Q_{1k}) (Q_{2k}) During 1P3W1U $U_2 = -U_1$	(Q_{1k}) (Q_{2k})	(Q_{1k}) (Q_{2k}) (Q_{3k})	
		$(Qsumk) = Q_{1k} + Q_{2k}$		$(Qsumk) = Q_{1k} + Q_{2k} + Q_{3k}$	
	• Harmonic reactive power Q_{ck} is used in internal calculations, but is not displayed.				
KF [ ]	KF_1 KF_4 $KF_c = \dfrac{\sum_{k=1}^{50}\left(k^2 \times I_{ck}^2\right)}{\sum_{k=1}^{50} I_{ck}^2}$	KF_1 KF_2 KF_4	KF_1 KF_2 KF_3 KF_4		
	• K factor, also referred to as multiplication factor, indicates the power loss caused due to the harmonic current RMS value in the transformer.				

c: Measurement channel, k: Order of analysis, r: Resistance after FFT, i: Reactance after FFT

13. Harmonic voltage phase angle (Uphase), Harmonic current phase angle (Iphase), Harmonic power phase angle (Pphase)

<table>
<tr><th>Wiring
Item</th><th>Single phase 2-wire
1P2W</th><th>Single phase 3-wire
1P3W</th><th>3-phase 3-wire
3P3W2M</th><th>3-phase 3-wire
3P3W3M</th><th>3-phase 4-wire
3P4W</th></tr>
<tr><td rowspan="3">Uphase [deg]=ϕU_k</td><td rowspan="2">ϕU_{1k}
ϕU_{4k}
$\phi U_{ck} = \tan^{-1}\left(\frac{U_{ckr}}{-U_{cki}}\right)$</td><td>$\phi U_{1k}$
ϕU_{2k}
ϕU_{4k}</td><td rowspan="2">ϕU_{1k}
ϕU_{2k}
ϕU_{3k}
ϕU_{4k}</td><td rowspan="2">ϕU_{12k}
ϕU_{23k}
ϕU_{31k}</td><td rowspan="2">ϕU_{1k}
ϕU_{2k}
ϕU_{3k}
ϕU_{4k}</td></tr>
<tr><td>During 1PU3W1U Without ϕU_{2k}</td></tr>
<tr><td colspan="5">• For 3P3W2M wiring, it is assumed that $U_1 - U_2 + U_3 = 0$
• When $U_{ckr} = U_{cki} = 0$, $\phi U_{ck} = 0°$</td></tr>
<tr><td rowspan="2">Iphase [deg]=ϕI_k</td><td>ϕI_{1k}
ϕI_{4k}
$\phi I_{ck} = \tan^{-1}\left(\frac{I_{ckr}}{-I_{cki}}\right)$</td><td>$\phi I_{1k}$
ϕI_{2k}
ϕI_{4k}</td><td colspan="3">ϕI_{1k}
ϕI_{2k}
ϕI_{3k}
ϕI_{4k}</td></tr>
<tr><td colspan="5">• For 3P3W2M wiring, it is assumed that $I_1 + I_2 + I_3 = 0$.
• When $I_{ckr} = I_{cki} = 0$, $\phi I_{ck} = 0°$</td></tr>
<tr><td rowspan="3">Pphase[deg]=ϕP_k</td><td>ϕP_{1k}
$\phi P_{ck} = \tan^{-1}\left(\frac{Q_{ck}}{P_{ck}}\right)$</td><td colspan="2">$\phi P_{1k}$
ϕP_{2k}</td><td colspan="2">ϕP_{1k}
ϕP_{2k}
ϕP_{3k}</td></tr>
<tr><td></td><td colspan="4">ϕP_{sumk}</td></tr>
<tr><td colspan="5">• When $P_{ck} = Q_{ck} = 0$, $\phi P_{ck} = 0°$.</td></tr>
</table>

c: Measurement channel, k: Order of analysis, r: Resistance after FFT, i: Reactance after FFT

14. Voltage THD (Uthd-F/Uthd-R), Current THD (Ithd-F/Ithd-R)

Item \ Wiring	Single phase 2-wire 1P2W	Single phase 3-wire 1P3W	3-phase 3-wire 3P3W2M	3-phase 3-wire 3P3W3M	3-phase 4-wire 3P4W
Uthd-F [%]=$THD\text{-}F\_U_c$	$THD\text{-}F\_U_1$ $THD\text{-}F\_U_4$ $THD\text{-}F\_U_c=\dfrac{\sqrt{\sum_{k=2}^{K}U_{ck}^2}}{U_{c(1)}}\times 100$	$THD\text{-}F\_U_1$ $THD\text{-}F\_U_2$ $THD\text{-}F\_U_4$ During 1P3W1U Without $THD\text{-}F\_U_2$	$THD\text{-}F\_U_1$ $THD\text{-}F\_U_2$ $THD\text{-}F\_U_3$ $THD\text{-}F\_U_4$	$THD\text{-}F\_U_{12}$ $THD\text{-}F\_U_{23}$ $THD\text{-}F\_U_{31}$	$THD\text{-}F\_U_1$ $THD\text{-}F\_U_2$ $THD\text{-}F\_U_3$ $THD\text{-}F\_U_4$
	• For 3P3W2M wiring, it is assumed that $U_1-U_2+U_3=0$				
Ithd-F [%]=$THD\text{-}F\_I_c$	$THD\text{-}F\_I_1$ $THD\text{-}F\_I_4$ $THD\text{-}F\_I_c=\dfrac{\sqrt{\sum_{k=2}^{K}I_{ck}^2}}{I_{c(1)}}\times 100$	$THD\text{-}F\_I_1$ $THD\text{-}F\_I_2$ $THD\text{-}F\_I_4$ During 1P3W1U Without $THD\text{-}F\_I_2$	$THD\text{-}F\_I_1$ $THD\text{-}F\_I_2$ $THD\text{-}F\_I_3$ $THD\text{-}F\_I_4$		
	• For 3P3W2M wiring, it is assumed that $I_1+I_2+I_3=0$. • The numerator of the mathematical formula is recorded but is not displayed (MAX, MIN, AVG)				
Uthd-R [%]=$THD\text{-}R\_U_c$	$THD\text{-}R\_U_1$ $THD\text{-}R\_U_4$ $THD\text{-}R\_U_c=\dfrac{\sqrt{\sum_{k=2}^{K}U_{ck}^2}}{\sqrt{\sum_{k=1}^{K}U_{ck}^2}}\times 100$	$THD\text{-}R\_U_1$ $THD\text{-}R\_U_2$ $THD\text{-}R\_U_4$ During 1P3W1U Without $THD\text{-}R\_U_2$	$THD\text{-}R\_U_1$ $THD\text{-}R\_U_2$ $THD\text{-}R\_U_3$ $THD\text{-}R\_U_4$	$THD\text{-}R\_U_{12}$ $THD\text{-}R\_U_{23}$ $THD\text{-}R\_U_{31}$	$THD\text{-}R\_U_1$ $THD\text{-}R\_U_2$ $THD\text{-}R\_U_3$ $THD\text{-}R\_U_4$
	• For 3P3W2M wiring, it is assumed that $U_1-U_2+U_3=0$				
Ithd-R [%]=$THD\text{-}R\_I_c$	$THD\text{-}R\_I_1$ $THD\text{-}R\_I_4$ $THD\text{-}R\_I_c=\dfrac{\sqrt{\sum_{k=2}^{K}I_{ck}^2}}{\sqrt{\sum_{k=1}^{K}I_{ck}^2}}\times 100$	$THD\text{-}R\_I_1$ $THD\text{-}R\_I_2$ $THD\text{-}R\_I_4$	$THD\text{-}R\_I_1$ $THD\text{-}R\_I_2$ $THD\text{-}R\_I_3$ $THD\text{-}R\_I_4$		
	• For 3P3W2M wiring, it is assumed that $I_1+I_2+I_3=0$. • The numerator of the mathematical formula is recorded but is not displayed (MAX, MIN, AVG)				

c: Measurement channel, K: Total number of analyzed orders, k: Analysis order, (1): Harmonic calculation fundamental wave (1st order)

15. Averaging method

	CH 1 to 4	sum/AVG	Comment
Freq	Signed average		Freq10s is similar as well
Upk (+/−)	Signed average		
Ipk (+/−)	Signed average		
Ucf	Calculated from the average of Upk (absolute values of the positive one or the negative one, whichever is larger) and the average of Urms.		
Icf	Calculated from the average of Ipk (absolute values of the positive one or the negative one, whichever is larger) and the average of Irms.		
Urms	Root mean square (RMS)	Average results for all channels are averaged.	
Irms	Root mean square (RMS)	Average results for all channels are averaged.	
Udc	Signed average		
Idc	Signed average		
P	Signed average	Average results for all channels are added.	
S	Signed average	Average results for all channels are added.	
Q	Signed average	Average results for all channels are added.	
PF	Calculated from Pavg and Savg.		
DPF	Calculated from $P_{(1)}$avg and $S_{(1)}$avg.		
Uunb	Calculated from mean square of U_{neg} and U_{pos}		
Uunb0	Calculated from mean square of U_{zero} and U_{pos}		
Iunb	Calculated from mean square of I_{neg} and I_{pos}		
Iunb0	Calculated from mean square of I_{zero} and I_{pos}		
Uharm (Level)/ Uiharm (Level)	Root mean square (RMS)		0th order is signed average.
Iharm (Level)/ Iiharm (Level)	Root mean square (RMS)		0th order is signed average.
Pharm (Level)	Signed average	Average results for all channels are added.	
Uharm (Content percentage)/ Uiharm (Content percentage)	{(N-th order harmonic average value) / (Fundamental average value)} × 100%		
Iharm (Content percentage)/ Iiharm (Content percentage)	{(N-th order harmonic average value) / (Fundamental average value)} × 100%		

	CH 1 to 4	sum/AVG	Comment
Pharm (Content percentage)	{(N-th order harmonic average value) / (Fundamental average value)} × 100%		
Uphase	Vector average		
Iphase	Vector average		
Pphase	Vector average		
Uthd-F/Uthd-R	Calculated from mean squared RMS values		
Ithd-F/Ithd-R	Calculated from mean squared RMS values		
KF	Calculated from mean squared RMS values		

Signed averaging: Signs of values are included in average calculation.

AVG calculation of Uphase

$$\tan^{-1}\left(\frac{U_{ckr}}{-U_{cki}}\right)$$

Here, U_{ckr} and U_{cki} use the signed average values for each channel.

AVG calculation of Iphase

$$\tan^{-1}\left(\frac{I_{ckr}}{-I_{cki}}\right)$$

Here, I_{ckr} and I_{cki} use the signed average values for each channel.

AVG calculation of Pphase

(Averaging process for each channel) $\tan^{-1}\left\{\frac{Qharm_k}{Pharm_k}\right\}$

Here, $Qharm_{\mathrm{k}}$ and $Pharm_{\mathrm{k}}$ use the signed average values for each channel.

(Averaging process of the sum) $\tan^{-1}\left\{\frac{Q_{sumk}}{P_{sumk}}\right\}$

Here, Q_{sumk} and P_{sumk} use the sum calculation of the signed average results for each channel.

14.8 Range Configuration and Combination Accuracy

The 3P4W2.5E wiring is available after the firmware update.

1. While using the Model CT7131 AC Current Sensor

Power range configuration

Wiring	Current range		
	5.0000 A	50.000 A	100.00 A
1P2W	5.0000 kW	50.000 kW	100.00 kW
1P3W 1P3W1U 3P3W2M 3P3W3M	10.000 kW	100.00 kW	200.00 kW
3P4W 3P4W2.5E	15.000 kW	150.00 kW	300.00 kW

Display format varies according to the declared voltage settings.

Combination Accuracy

Current range	45 ≤ f ≤ 66 (Hz)
100.00 A	0.4% rdg+0.12% f.s.
50.00 A	0.4% rdg+0.14% f.s.
5.000 A	0.4% rdg+0.50% f.s.

2. While using the Model CT7136 AC Current Sensor

Power range configuration

Wiring	Current range		
	5.0000 A	50.000 A	500.00 A
1P2W	5.0000 kW	50.000 kW	500.00 kW
1P3W 1P3W1U 3P3W2M 3P3W3M	10.000 kW	100.00 kW	1.0000 MW
3P4W 3P4W2.5E	15.000 kW	150.00 kW	1.5000 MW

Display format varies according to the declared voltage settings.

Combination Accuracy

Current range	45 ≤ f ≤ 66 (Hz)
500.00 A	0.4% rdg+0.112% f.s.
50.00 A	0.4% rdg+0.22% f.s.
5.000 A	0.4% rdg+1.3% f.s.

3. While using the Model CT7126 AC Current Sensor

Power range configuration

Wiring	Current range		
	500.00 mA	5.0000 A	50.000 A
1P2W	500.00 W	5.0000 kW	50.000 kW
1P3W 1P3W1U 3P3W2M 3P3W3M	1.0000 kW	10.000 kW	100.00 kW
3P4W 3P4W2.5E	1.5000 kW	15.000 kW	150.00 kW

Display format varies according to the declared voltage settings.

Combination Accuracy

Current range	$45 \leq f \leq 66$ (Hz)
50.000 A	0.4% rdg.+0.112% f.s.
5.0000 A	0.4% rdg.+0.22% f.s.
500.0 mA	0.4% rdg.+1.3% f.s.

4. While using Model CT7731 AC/DC Auto-Zero Current Sensor

Power range configuration

Wiring	Current range	
	10.000 A	100.00 A
1P2W	10.000 kW	100.00 kW
1P3W 1P3W1U 3P3W2M 3P3W3M	20.000 kW	200.00 kW
3P4W 3P4W2.5E	30.000 kW	300.00 kW

Display format varies according to the declared voltage settings.

Combination Accuracy

Current range	DC	$45 \leq f \leq 66$ (Hz)
100.00 A	1.5% rdg.+1.0% f.s.	1.1% rdg.+0.6% f.s.
10.000 A	1.5% rdg.+5.5% f.s.	1.1% rdg.+5.1% f.s.

5. While using Model CT7736 AC/DC Auto-Zero Current Sensor

Power range configuration

Wiring	Current range	
	50.000 A	500.00 A
1P2W	50.000 kW	500.00 kW
1P3W 1P3W1U 3P3W2M 3P3W3M	100.00 kW	1.0000 MW
3P4W 3P4W2.5E	150.00 kW	1.5000 MW

Display format varies according to the declared voltage settings.

Combination Accuracy

Current range	DC	45 ≤ f ≤ 66 (Hz)
500.00 A	2.5% rdg.+1.1% f.s.	2.1% rdg.+0.70% f.s.
50.000 A	2.5% rdg.+6.5% f.s.	2.1% rdg.+6.10% f.s.

6. While using Model CT7742 AC/DC Auto-Zero Current Sensor

Power range configuration

Wiring	Current range		
	500.00 A	1000.0 A	2000.0 A
1P2W	500.00 kW	1.0000 MW	2.0000 MW
1P3W 1P3W1U 3P3W2M 3P3W3M	1.0000 MW	2.0000 MW	4.0000 MW
3P4W 3P4W2.5E	1.5000 MW	3.0000 MW	6.0000 MW

Display format varies according to the declared voltage settings.

Combination Accuracy

Current range	Input	DC	45 ≤ f ≤ 66 (Hz)
2000.0 A	I > 1800 A	2.0% rdg.+1.75% f.s.	2.1% rdg.+0.75% f.s.
	I ≤ 1800 A		1.6% rdg.+0.75% f.s.
1000.0 A	-	2.0% rdg.+1.5% f.s.	1.6% rdg.+1.1% f.s.
500.00 A	-	2.0% rdg.+2.5% f.s.	1.6% rdg.+2.1% f.s.

7. While using the Model CT7044, CT7045, CT7046 AC Flexible Current Sensor

Power range configuration

Wiring	Current range	Sensor range within ( )	
	50.000 A (600A)	500.00 A (600A)	5000.0 A (6000A)
1P2W	50.000 kW	500.00 kW	5.0000 MW
1P3W 1P3W1U 3P3W2M 3P3W3M	100.00 kW	1.0000 MW	10.000 MW
3P4W 3P4W2.5E	150.00 kW	1.5000 MW	15.000 MW

Display format varies according to the declared voltage settings.

Combination Accuracy

Current range	45 ≤ f ≤ 66 (Hz)
5000.0 A	1.6% rdg.+0.4% f.s.
500.00 A	
50.000 A	1.6% rdg.+3.1% f.s.

8. While using the Model CT7116 AC Leakage Current Sensor

Power range configuration

Wiring	Current range		
	50.000 mA	500.00 mA	5.0000 A
1P2W	50.000 W	500.00 W	5.0000 kW
1P3W 1P3W1U 3P3W2M 3P3W3M	100.00 W	1.0000 kW	10.000 kW
3P4W 3P4W2.5E	150.00 W	1.5000 kW	15.000 kW

Display format varies according to the declared voltage settings.

Combination Accuracy

Current range	45 ≤ f ≤ 66 (Hz)
5.0000 A	1.1% rdg.+0.16% f.s.
500.00 mA	1.1% rdg.+0.7% f.s.
50.000 mA	1.1% rdg.+6.1% f.s.

15 Maintenance and Service

⚠WARNING

Customers are not allowed to modify, disassemble, or repair the instrument. Doing so may cause fire, electric shock, or injury.

Calibrations

The calibration frequency varies depending on the status of the instrument or installation environment. We recommend that the calibration period be determined in accordance with the status of the instrument or installation environment. Please contact your Hioki distributor to have your instrument periodically calibrated.

15.1 Troubleshooting

If damage is suspected, check the “Troubleshooting” section before contacting your authorized Hioki distributor or reseller.

Before having the instrument repaired

Symptom	Check Item, or Cause	Remedy and Reference
Unable to write data to the SD memory card. Unable to manipulate folders and files, or format the card.	The write-protected lock of the SD memory card is in an intermediate position.	Check the position of the write-protect lock and disengage it. The connector of the SD memory card is used to judge whether the card is write-protected. If the write-protected lock is in an intermediate position, the determination of whether the card is write-protected will depend on the connector. For example, even if the instrument determines that the card is not write-protected and allows data to be written to it, a computer may determine that it is write-protected, preventing data from being written to it. “2.4 Inserting the SD Memory Card” (p. 42)
The display does not appear when you turn the power on.	If powering the instrument with the AC adapter • Are the power cord and AC adapter connected properly?	Verify that the power cord and AC adapter are connected properly. “2.5 Power Supply” (p. 43)
	If powering the instrument with the battery • Has the Z1003 Battery Pack been properly installed? • Has the Battery Pack been charged properly?	Verify that the battery pack has been charged and installed. “Installing the battery pack” (p. 38)
Keys do not work.	• Has the key lock been activated? LOCK	Press and hold the **ESC** key for at least 3 s to cancel the key lock.

Symptom	Check Item, or Cause	Remedy and Reference
Voltage or current measured values are not displayed.	• Are the voltage cord and current sensors connected properly? • Are the input channels and displayed channels correct? • Has an appropriate current range been selected?	Verify the connections and wiring. See “4.3 Connecting Voltage Cords to Instrument” (p. 51) through “4.9 Checking Wiring” (p. 59).
Measured values do not stabilize.	• Is the frequency of the measuring line 50 Hz/60 Hz? The instrument is not supporting 400 Hz frequency lines.	The instrument can only be used with 50/60 Hz lines. 400 Hz frequency cannot be measured.
	• Is there any voltage input applied?	The instrument may not be able to perform stable measurement without voltage input to U1 (Sync source).
Unable to charge the Z1003 Battery Pack (the Charge LED does not light up).	• Verify that the ambient temperature is within the range of 10°C to 35°C.	The instrument’s battery can be charged within the ambient temperature range of 10°C to 35°C.
	• Has the instrument been stored for an extended period of time with the battery pack installed?	The battery pack may be degraded. Please purchase a new battery pack. Contact your authorized Hioki distributor or reseller. If you do not want to use the instrument for one month or longer, remove the battery pack and store at −20°C to 30°C.

If the cause of the issue remains unclear, execute a system or factory reset. Doing so will initialize settings to their factory defaults.
See “System reset (Default)” (p. 76) and “Factory reset (Default)” (p. 77).

Replaceable parts and operating lifetimes

The characteristics of some of the parts used in the product may deteriorate with extended use. To ensure the product can be used over the long term, it is recommended to replace these parts on a periodic basis.
When replacing parts, please contact your authorized Hioki distributor or reseller.
The service life of parts varies with the operating environment and frequency of use. Parts are not guaranteed to operate throughout the recommended replacement cycle.

Part	Life	Notes
Lithium battery	Approx. 10 years	The instrument contains a built-in backup lithium battery. The backup battery offers a service life of about 10 years. If the date and time deviate substantially when the instrument is switched on, it is the time to replace that battery. Contact your authorized Hioki distributor or reseller.
Electrolytic Capacitors	Approx. 10 years	The service life of electrolytic capacitors varies with the operating environment. Requires periodic replacement.
LCD backlight (with 50% brightness)	Approx. 50,000 hr	Requires periodic replacement.

Part	Life	Notes
Model Z1003 Battery Pack	Approx. 1 year or approx. 500 recharge/discharge cycles whichever comes first	Requires periodic replacement.

15.2 Cleaning

- To clean the instrument, wipe it gently with a soft cloth moistened with water or mild detergent.
- Wipe the LCD gently with a soft, dry cloth.

15.3 Error Indication

<System Error>

Code	Error indication	Cause	Corrective action/more information
SY01	**The internal programming of the PQ3100 is corrupted and the instrument must be repaired.**	The internal programming of the instrument is corrupt.	The instrument must be repaired. Contact your authorized Hioki distributor or reseller.
SY02	**The SDRAM of the PQ3100 is corrupted and the instrument must be repaired.**	The memory of the instrument is corrupt.	
SY03	**The adjustment values of the PQ3100 are corrupted and the instrument must be repaired.**	The adjustment values of the instrument are corrupt.	
SY04	**The display memory of the PQ3100 is corrupted and the instrument must be repaired.**	The display memory of the instrument is corrupt.	
SY05	**BACKUP ERROR. The PQ3100 must be returned to default factory condition. Initialize? YES: ENTER key**	Backed-up system variables are incorrect or contradictory.	Initialize and reconfigure the settings. If you experience backup errors frequently, the backup battery may have deteriorated. The instrument needs to be repaired. Contact your authorized Hioki distributor or reseller.

15

Maintenance and Service

<File Error>			
Code	**Error indication**	**Cause**	**Corrective action/more information**
FL01	**Save failed.**	The instrument was unable to save the file due to a problem with the SD memory card.	Format the SD memory card (p. 126).
		The instrument was unable to save the file due to a problem with its internal memory.	Format the internal memory (p. 126).
FL02	**Load failed.**	The instrument was unable to load settings data due to a problem with the settings file.	Save the settings file once again (p. 122) and load it (p. 123).
FL03	**File or folder could not be deleted.**	The SD memory card is in the locked (write-protected) state, or the file or folder attribute is set to “read-only.”	If the SD memory card is locked, unlock it (p. 42). If the file or folder attribute is set to “read-only,” change the attribute using a computer.
FL04	**A file of the same name exists.**	The instrument was unable to copy data from its internal memory to the SD memory card because data with the same filename already existed on the SD memory card.	Delete the data with the same filename from the SD memory card (p. 125) or change the filename using a computer.
FL05	**Formatting failed.**	An SD memory card error occurred, or the card was ejected, during formatting it.	Reinsert the SD memory card and format it again (p. 126). If the card cannot be formatted, the card may be damaged and should be replaced with a new one.
		An internal memory error occurred.	The instrument must be repaired. Contact your authorized Hioki distributor or reseller.
FL06	**Maximum files reached. Additional files cannot be created.**	The maximum number of files or folders that can be created was exceeded.	Execute any of the following. • Replace the SD memory card with a new one. • Copy the data on the SD memory card to a computer (p. 129), delete unnecessary data on the card with the instrument (p. 125), or format the card (p. 126).

<SD Card Error>			
Code	**Error indication**	**Cause**	**Corrective action/more information**
SD01	**SD card not found. Insert an SD card.**	Data cannot be saved to the SD memory card because no SD memory card has been inserted into the instrument. Otherwise, data cannot be loaded from the SD memory card.	Insert an SD memory card (p. 42).
SD02	**Error while attempting to access the SD card.**	You attempted to access a corrupt file or a corrupt SD memory card. Or, the SD memory card was removed while it was being accessed.	Copy the data on the SD memory card to a computer (p. 129) and format the SD memory card with the instrument (p. 126).
SD03	**Unlock the SD card.**	The SD memory card is in the locked (write-protected) state.	Unlock the SD memory card (p. 42).
SD04	**SD card is full. Delete files or reformat.**	Data cannot be saved to the SD memory card because the card is full.	Execute any of the following. • Replace the SD memory card with a new one. • Copy the data on the SD memory card to a computer (p. 129), delete unnecessary data on the card with the instrument (p. 125), or format the card (p. 126).
SD05	**SD card is not formatted properly. Format card? YES: ENTER key No: ESC key**	SD memory card is not formatted properly.	Format the SD memory card (p. 126).
SD06	**SD card not compatible.**	An unsupported card such as an SDXC memory card has been inserted into the instrument.	Use the instrument's optional SD memory card (p. 3).
SD07	**This is a read-only file.**	The SD memory card is in the locked (write-protected) state, or the file or folder attribute is set to "read-only."	If the SD memory card is locked, unlock it (p. 42). If the file or folder attribute is set to "read-only," change the attribute using a computer.

<Internal Memory Error>			
Code	**Error indication**	**Cause**	**Corrective action/more information**
ME01	**Internal memory is full. Delete files or reformat.**	The instrument’s internal memory is full.	Perform this procedure. 1. If recording is in progress, stop recording. 2. Copy the data on the internal memory to the SD memory card (p. 125). 3. Delete all the files on the internal memory (p. 125) or format the internal memory (p. 126).
ME02	**Cannot be used because internal memory is damaged. Proceed with reformatting? YES: ENTER key No: ESC key**	The instrument’s internal memory is corrupt.	Format the internal memory (p. 126).

<Operation Error>			
Code	**Error indication**	**Cause**	**Corrective action/more information**
OP01	**This folder cannot be deleted.**	You attempted to delete the [PQ3100] base folder.	The [PQ3100] base folder cannot be deleted. If you wish to delete it, you must do so on a computer.

<Error>			
Code	**Error indication**	**Cause**	**Corrective action/more information**
ER01	**Invalid setting value.**	You attempted to configure the setting with a value that is outside the valid setting range.	Configure the setting with a value that falls within the valid setting range. See “5 Setting Change (SET UP Screen)” (p. 63)
ER02	**Maximum number of recordable events exceeded.**	The number of events exceeds the upper limit, 9999. No further events can be recorded.	Stop the recording and change the event threshold value in order that 10000 events do not occur. See “5 Event Settings” (p. 72)

15.4 Disposing the Instrument

When disposing of this instrument, remove the lithium battery and dispose of battery and instrument in accordance with local regulations.

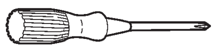
⚠WARNING

To avoid electric shock, turn off the power switch, disconnect all the cords and cables from the device to be measured, and remove the lithium battery.

CALIFORNIA, USA ONLY
Perchlorate Material - special handling may apply.
See www.dtsc.ca.gov/hazardouswaste/perchlorate

Required items

☐ Phillips screwdriver (No. 2)

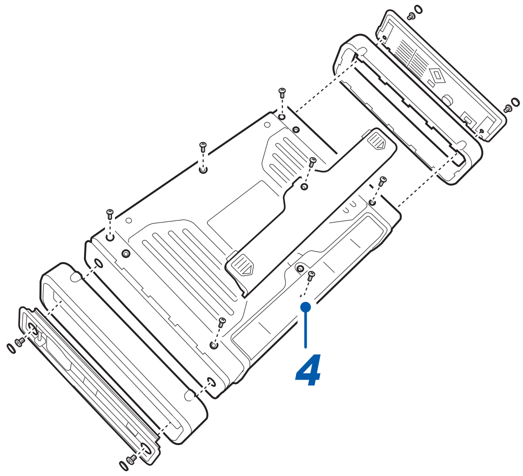


1 **Turn off the instrument. (p. 44)**

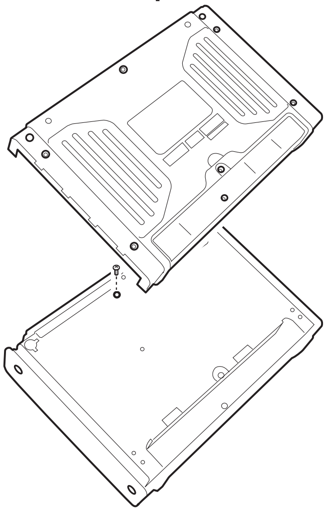
2 **Remove all the cords connected to the instrument.**

3 **Remove the 10 screws shown in the following diagram with the Phillips head screwdriver and remove the battery pack cover and side covers.**

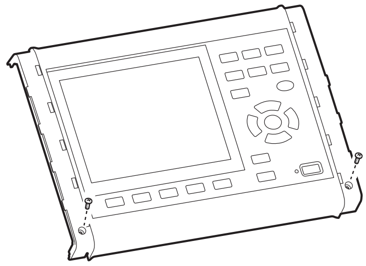
4 **If the Z1003 Battery Pack has been installed, remove the battery and the screw at the battery pack holder.**



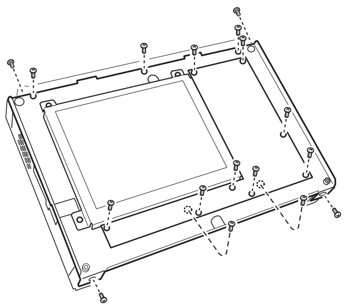
5 **Remove the rear cover and remove one screw of the metal plate.**



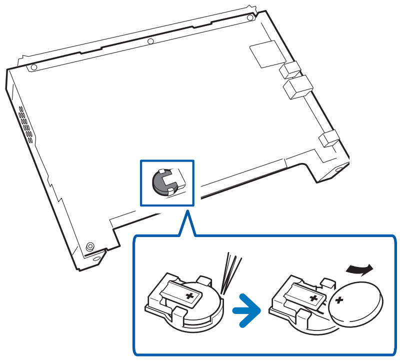
6 **Remove the 2 screws on the front cover and then remove the front cover and rubber key.**



7 **Remove the 17 screws shown in the following diagram and then remove the key printed circuit board and upper chassis.**



8 **Insert the tweezers between the battery holder and the battery and lift the battery up to remove it.**



Appendix

Appx. 1 Fundamental Measurement Items

Item	Display	Item	Display
Transient overvoltage	Tran	Power factor	PF
Frequency (1 wave)	Freq_wav	Displacement power factor	DPF
RMS voltage refreshed each half-cycle	Urms1/2	Active power demand quantity (Consumption)*	Dem_WP+
RMS current refreshed each half-cycle	Irms1/2	Active power demand quantity (Regeneration)*	Dem_WP-
Swell	Swell	Active power demand value (Consumption)*	Dem_P+
Dip	Dip	Active power demand value (Regeneration)*	Dem_P-
Interruption	Intrpt	Reactive power demand quantity (Lag)*	Dem_WQ_LAG
Inrush current	Inrush	Reactive power demand quantity (Lead)*	Dem_WQ_LEAD
Frequency (10 s)	Freq10s, F10s	Reactive power demand value (Lag)*	Dem_Q_LAG
Interharmonic voltage	Uiharm	Reactive power demand value (Lead)*	Dem_Q_LEAD
Interharmonic current	Iiharm	Apparent power demand quantity*	Dem_WS
Frequency (200 ms)	Freq	Apparent power demand value*	Dem_S
Voltage waveform peak+	Upk+	Power factor demand value*	Dem_PF
Voltage waveform peak-	Upk-	Harmonic voltage (0th to 50th order harmonics)	Uharm
Current waveform peak+	Ipk+	Harmonic current (0th to 50th order harmonics)	Iharm
Current waveform peak-	Ipk-	Harmonic power (0th to 50th order harmonics)	Pharm
RMS voltage (phase/line)	Urms	Harmonic voltage phase angle (1st to 50th order harmonics)	Uphase
Voltage DC	Udc	Harmonic current phase angle (1st to 50th order harmonics)	Iphase
Voltage CF	Ucf	Harmonic voltage-current phase difference (1st to 50th order harmonics)	Pphase
RMS current	Irms	Total harmonic distortion (THD-F/THD-R) (voltage)	Uthd (Uthd-F or Uthd-R)
Current DC	Idc	Total current harmonic distortion (current) (THD-F/THD-R)	Ithd (Ithd-F or Ithd-R)
Current CF	Icf	Voltage negative-phase unbalance factor	Uunb

*: Available after the firmware update

Item	Display	Item	Display
Active power	P	Voltage zero-phase unbalance factor	Uunb0
Apparent power	S	Current negative-phase unbalance factor	Iunb
Reactive power	Q	Current zero-phase unbalance factor	Iunb0
Active energy (Consumption)	WP+	K factor	KF
Active energy (Regeneration)	WP-		
Reactive energy (Lag)	WQ_LAG		
Reactive energy (Lead)	WQ_LEAD		
Apparent energy	WS		
Energy cost	Ecost		

Appx. 2 Event Item

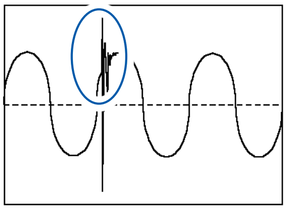
Category	Sub-category	Display
Transient overvoltage	-	**Tran**
Swell	-	**Swell**
Dip	-	**Dip**
Interruption	-	**Intrpt**
RVC (IN) **(Available after the firmware update)**	-	**-**
RVC (Fixed) **(Available after the firmware update)**	-	**RVC**
Inrush current	-	**Inrush**
Frequency (200 ms)	Upper frequency limit exceeded	**Freq Up**
	Lower frequency limit exceeded	**Freq Low**
Frequency (1 wave)	Upper frequency limit exceeded, lower frequency limit exceeded	**Freq_wav**
Voltage total harmonic distortion	-	**Uthd**
Current total harmonic distortion	-	**Ithd**
External event	External input event	**Ext**
	Manual key event	**Manu**
	Starting recording event	**Start**
	Stopping recording event	**Stop**
	Timer event	**Timer**
Recording before/after event	Recording before the event	**Before**
	Recording after the event	**After**

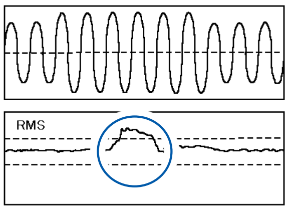
Appx.

Appx. 3 Explanation of Power Quality Parameters and Events

Power quality parameters are necessary to investigate and analyze power supply issues*[1].
By measuring these parameters, it is possible to assess power quality.
To allow instrument to detect abnormal values and abnormal waveforms, you set the threshold values. When these threshold values are exceeded, events are generated.

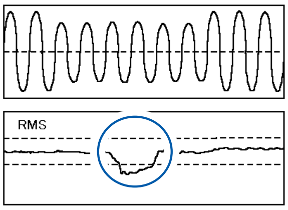
(Threshold values are set based on an estimation of abnormal values, so events do not necessarily indicate an error.)

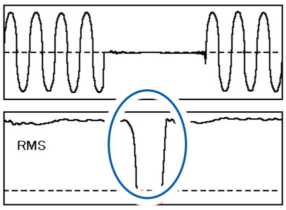
Transient overvoltage (Impulse)		
Waveform and event		An event caused by lightning strikes, circuit-breaker and relay contact obstruction and tripping, etc. Often occurs when there is a steep change in voltage or when the peak voltage is high.
Primary fault	Close to the source of the break, the power supply of the device is damaged because of the exceptionally high voltage and this may cause the device to reset.	
Event to be detected	Transient (A transient of 5 kHz or higher occurred*[2])	

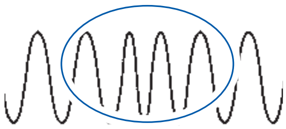
Voltage swell (Surge)		
Waveform and event		Mainly occurs under following circumstances and the voltage rises momentarily. • Lightning • Open/close of power line with heavy load • When switching capacitor bank with large capacity • One-line ground fault • Disconnection from high capacity load • Voltage surges due to grid-tied dispersed power supplies (solar power, etc.) during reverse power supply
Primary fault	A surge in voltage may cause the power supply of the device to be damaged or the device to reset.	
Event to be detected	Swell	

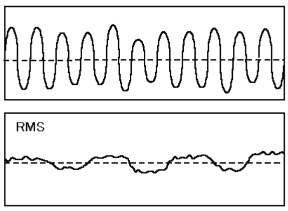
*1: Issues caused by a reduction in the power quality. These issues cause failures of substation equipment and electronically controlled devices. (Lighting flicker, frequent burning out of incandescent light bulbs, malfunctioning office equipment, occasional malfunctioning of machine operations, overheating of reactor-equipped capacitor equipment, and occasional malfunctioning of overload, negative-phase, and open-phase relays.)

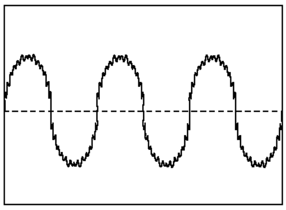
*2: Measurement band for the transient overvoltage of the instrument is 40 kHz (200 kHz sampling). Use Model PW3198 Power Quality Analyzer to capture higher-speed transient overvoltage. Measurement band of Model PW3198 is 700 kHz (sampling: 2 MHz).

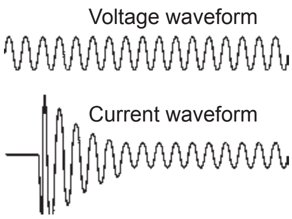
Voltage dip (Sag)		
Waveform and event		Most dips are caused by natural phenomena such as lighting. Short-term voltage drops occur under the following conditions: • An equipment fault is detected and the power supply is switched off, due to the occurrence of a power system ground fault or short-circuit • When there is a inrush current with a large load, such as when a motor starts.
Primary fault	Power supply voltage dips may cause the following events: • Equipment stops operating or is reset • Lamps turn off • Speed fluctuation or stopping of motors • Synchronized motors and generators lose synchronization	
Event to be detected	Dip	

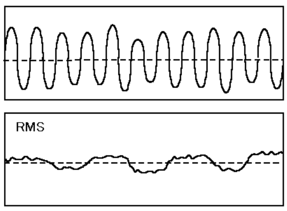
Interruption		
Waveform and event		Interruptions are caused by momentary, short/long-term power supply outages, mainly under the following circumstances: • Fault at the power company (interruption of power due to lightning strikes, etc.) • Circuit breaker tripping due to power supply short-circuits
Primary fault	Interruptions may cause the device to stop operating or to reset.	
Event to be detected	Interruption	

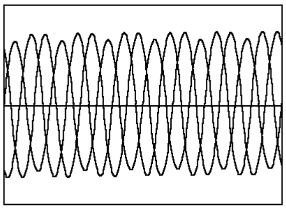
Frequency fluctuations		
Waveform and event		Occurs due to line separation caused by changes in the supply/demand balance of active power, the shutdown of a high-capacity generator, or circuit issues.
Primary fault	Changes in the speed of synchronized motors may cause product defects.	
Event to be detected	Frequency: 200 ms (Freq), frequency 1 wave (Freq_wav)	
Measurement Items	IEC61000-4-30 Average frequency of frequencies obtained for 10-s periods (Freq10s)	

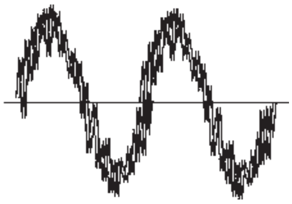
Harmonics		
Waveform and event		Harmonics are caused by distortions of the voltage and current waveforms when a device's power supply uses semiconductor control devices.
Primary fault	Larger harmonic components may cause any of the following major failures: • Abnormal heat or increased noise of motors and transformers • Fire of reactor connected to phase advance capacitor	
Event that may be detected	Total harmonic distortion (THD) (voltage)	
Measurement Items	Harmonic voltage, harmonic current, harmonic power	

Interharmonics		
Waveform and event		Frequency components that are not a whole multiple of the fundamental wave caused by distortions of the voltage and current waveforms due to any of the following: • Static frequency conversion equipment • Cycloconverters • Scherbius machines • Induction motors • Welder machines • Arc furnaces
Primary fault	Displacement of the voltage waveform zero-cross may damage equipment, cause it to malfunction, or degrade its performance.	
Event that may be detected	Total harmonic distortion (THD) (voltage)	
Measurement Items	Interharmonic voltage, interharmonic current	

Inrush current		
Waveform and event		Inrush current is a large current that flows momentarily, for example, when the electric equipment is turned on.
Primary fault	Inrush current may cause the following events: • Fusing of power switch contact or relay • Fuse blowouts • Circuit breaker disconnections • Failure of rectifying circuits • Supply voltage instability • Equipment sharing the same power supply stops operating or resets due to supply voltage instability	
Event to be detected	Inrush current	

Flicker (Available after the firmware update)		
Waveform and event		Voltage fluctuation caused by blast furnace, arc welding, and thyristor control loads. This causes flicker in light bulbs etc.
Primary fault	Because this phenomenon reoccurs regularly, it may cause the light to flicker or the device to malfunction. Large flicker values indicate that most people would find the flickering of lighting unpleasant.	
Measurement Items	ΔV10 flicker, IEC flicker Pst, Plt	

<table>
<tr><th colspan="3">Unbalance</th></tr>
<tr><td>Waveform and event</td><td></td><td>Unbalance is caused by increase or decrease in the load connected to each phase of a power line, or by distortions in voltage and current waveforms, voltage drops, or negative-phase voltage caused by the operation of unbalanced equipment or devices.</td></tr>
<tr><td>Primary fault</td><td colspan="2">Voltage unbalance, negative-phase voltage, and harmonics generation may cause the following events:
• Variations in motor rotation and noise
• Reduced torque
• Tripping of 3E breakers
• Overloading and heating of transformers
• Increased loss in rectifiers with smoothing capacitor</td></tr>
<tr><td>Measurement Items</td><td colspan="2">Voltage unbalance factor, current unbalance factor</td></tr>
</table>

<table>
<tr><th colspan="3">High-order harmonic component</th></tr>
<tr><td>Notes</td><td colspan="2">This cannot be measured with the instrument. Use Model PW3198 Power Quality Analyzer for such measurements.</td></tr>
<tr><td>Waveform and event</td><td></td><td>The high-order harmonic component consists of noise components of several kHz or more caused by voltage and current waveform distortions when equipment power supply uses semiconductor devices. It includes various frequency components.</td></tr>
<tr><td>Primary fault</td><td colspan="2">The high-order harmonic component can damage the equipment power supply, cause the equipment operation to be reset, or result in abnormal sound from TV and radio.</td></tr>
<tr><td>Event that is detected by the instrument</td><td colspan="2">High-order harmonic voltage component RMS values, high-order harmonic current component RMS values</td></tr>
</table>

Appx. 4 Event Detection Methods

Transient overvoltage

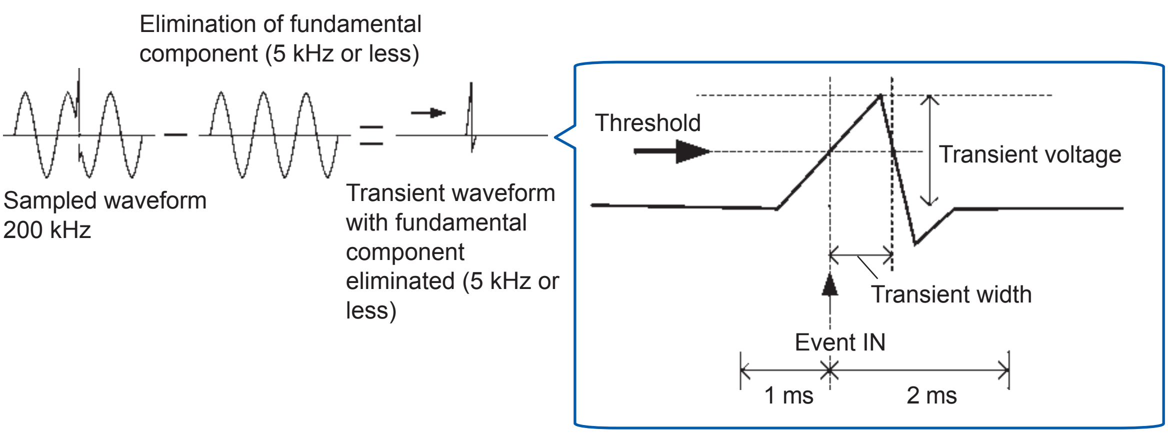
Measurement method

Transient overvoltage event is detected when the waveform obtained by eliminating the fundamental component (50 Hz/60 Hz) from a waveform sampled at 200 kHz exceeds a threshold value specified as an absolute value.
Detection occurs once for each the fundamental voltage waveform, and voltages of up to ±2,200 V can be measured.

Recorded data

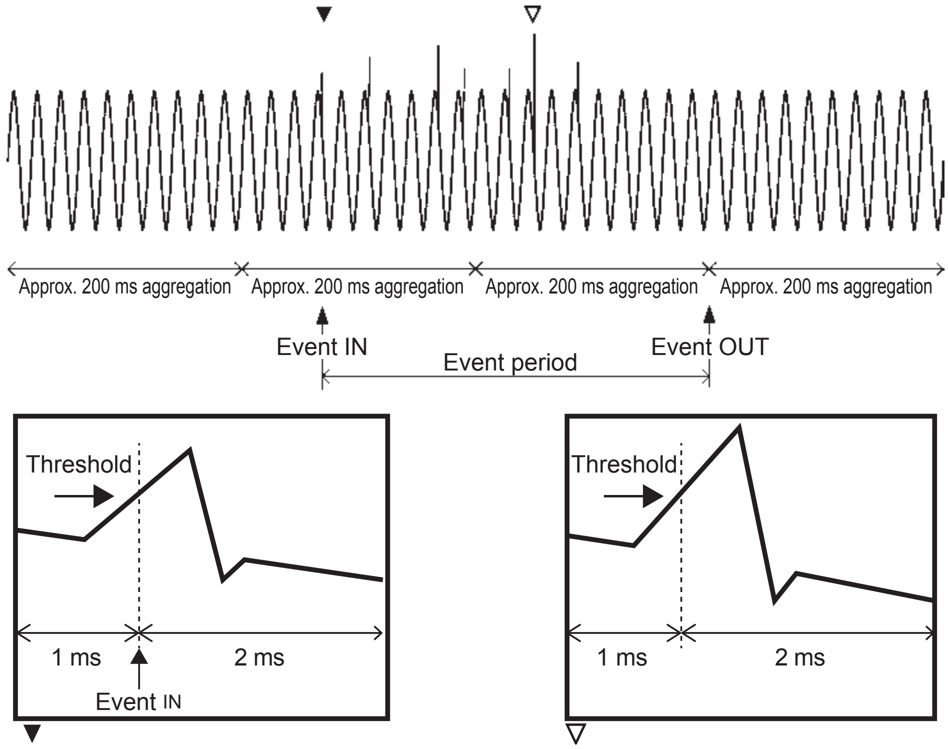
Transient voltage value	Waveform peak value during 3 ms period after elimination of fundamental component
Transient width	Period during which threshold value is exceeded (2 ms max.)
Max. transient voltage value	Max. peak value of waveform obtained by eliminating the fundamental component during the period from transient IN to transient OUT (leaving channel information)
Transient period	Period from transient IN to transient OUT
Transient count during period	Number of transients occurring during period from transient IN to transient OUT (Transients occurring across all channels or simultaneously on multiple channels are counted as 1)
Transient waveform (Available after the firmware update)	

Transient waveform



Event IN and OUT

Event IN	Time when the first transient overvoltage is detected (the waveform exceeded the threshold value) in an approx. 200 ms aggregation interval.
Event OUT	Start time of approx. 200 ms aggregation in which no transient overvoltage was detected for any channel within the first approx. 200 ms aggregation period following the transient event IN state.



Transient waveform
(including fundamental component)
The first detected transient waveform after event IN is saved.

Transient waveform
(including fundamental component)
The waveform with the largest transient voltage value from the IN to the OUT point is saved at event OUT.

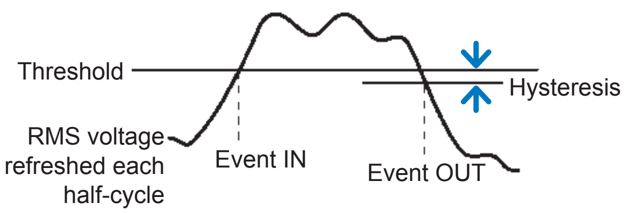
Voltage swells, Voltage dips, Interruptions

Measurement method

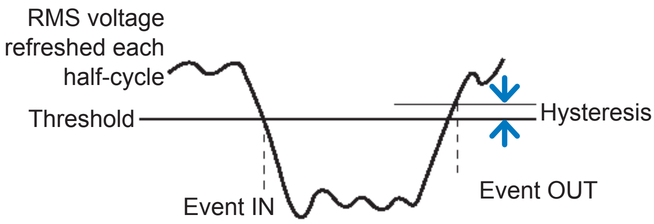
- Voltage swell, voltage dip, and interruption events are detected using the RMS voltage refreshed each half-cycle that is calculated from the voltage waveform obtained over a 1-cycle time, refreshed each half-cycle.
- Events are detected using line voltage for 3-phase 3-wire wiring and phase voltage for 3-phase 4-wire wiring.
- Voltage swells are detected when RMS voltage refreshed each half-cycle exceeds the threshold value.
- Voltage dips and interruptions are detected when RMS voltage refreshed each half-cycle falls below the threshold value.

Event IN and OUT

Event IN	Voltage swells: Time when RMS voltage refreshed each half-cycle exceeds the threshold value. Voltage dip/Interruption: Time when RMS voltage refreshed each half-cycle falls below than the threshold value.
Event OUT	Voltage swells: The time when an RMS voltage refreshed each half-cycle falls below the value calculated by subtracting the hysteresis from the threshold value after once the RMS voltage refreshed each half-cycle exceeds the threshold value Voltage dip/Interruption: The time when an RMS voltage refreshed each half-cycle exceeds the value calculated by adding the hysteresis to the threshold value after once the RMS voltage refreshed each half-cycle falls below the threshold value

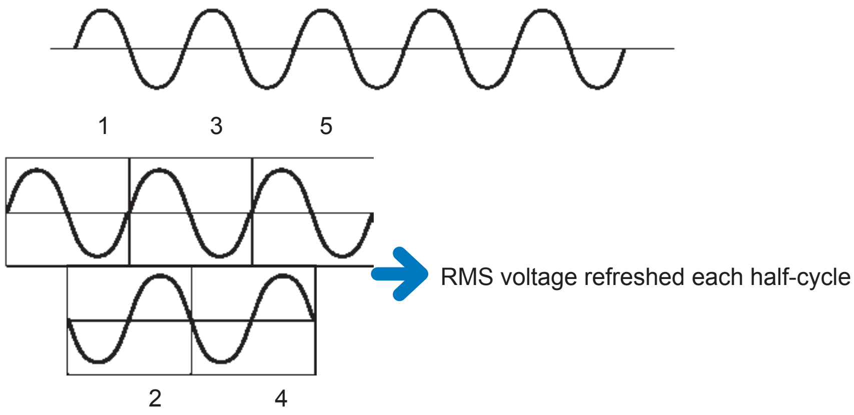


Voltage swell



Voltage dip, interruption

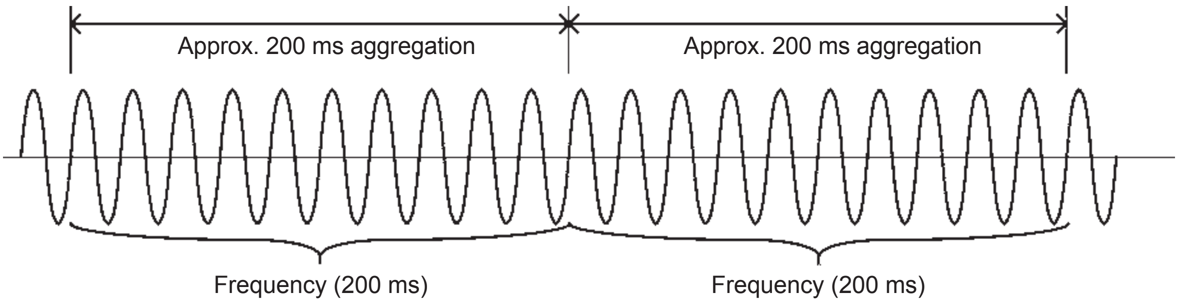
RMS voltage refreshed each half-cycle



Frequency (200 ms)

Measurement method (Reciprocal method)

Values of Frequency (200 ms) are calculated from the reciprocal of the accumulated time over the approximately 200-ms (10/12-cycle for 50 Hz / 60 Hz, respectively) aggregation period on U1 (reference channel). This value is detected when this value exceeds the positive threshold value or falls below the negative threshold value.



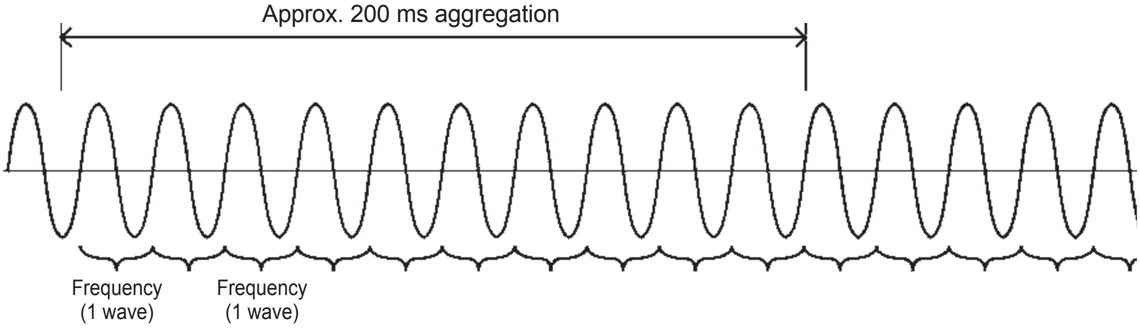
Event IN and OUT

Event IN	Starting time of an approximately 200-ms aggregation period to which the frequency value belongs when it exceeds the positive threshold value or falls below the negative threshold value
Event OUT	Starting time of the approximately 200-ms aggregation period to which a frequency value belongs when it falls below the value calculated by subtracting 0.1 Hz from the positive threshold value or exceeds the value calculated by adding 0.1 Hz to the negative threshold value (Equivalent to a frequency hysteresis of 0.1 Hz)

Frequency (1 wave)

Measurement method (Reciprocal method)

Frequency for every U1 (reference channel) waveform.



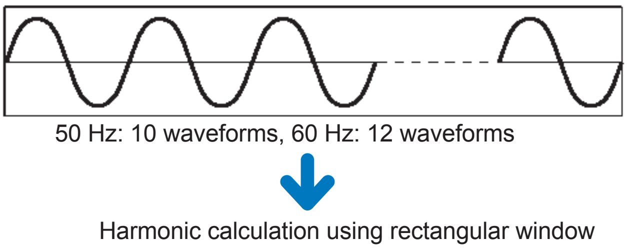
Event IN and OUT

Event IN	Time when a frequency exceeds the positive threshold value or falls below the negative threshold value
Event OUT	Time when a frequency falls below the value calculated by subtracting 0.1 Hz from the positive threshold value or exceeds the value calculated by adding 0.1 Hz to the negative threshold value (Equivalent to a frequency hysteresis of 0.1 Hz)

Voltage total harmonic distortion, Current total harmonic distortion

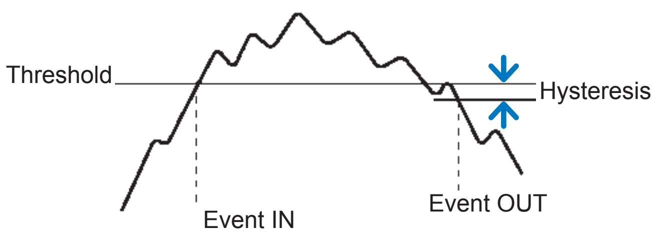
Measurement method

Measured values are calculated for a rectangular window of 2 048 points over the approximately 200-ms (10/12-cycle for 50 Hz / 60 Hz, respectively) aggregation. Events are detected when the calculated values are greater than or less than the corresponding threshold value.



Event IN and OUT

Event IN	Starting time of an approximately 200-ms aggregation period to whicha value belongs when it exceeds the threshold value
Event OUT	Starting time of an approximately 200-ms aggregation period to which a value belongs when it falls below the value calculated by subtracting the hysteresis from the threshold value

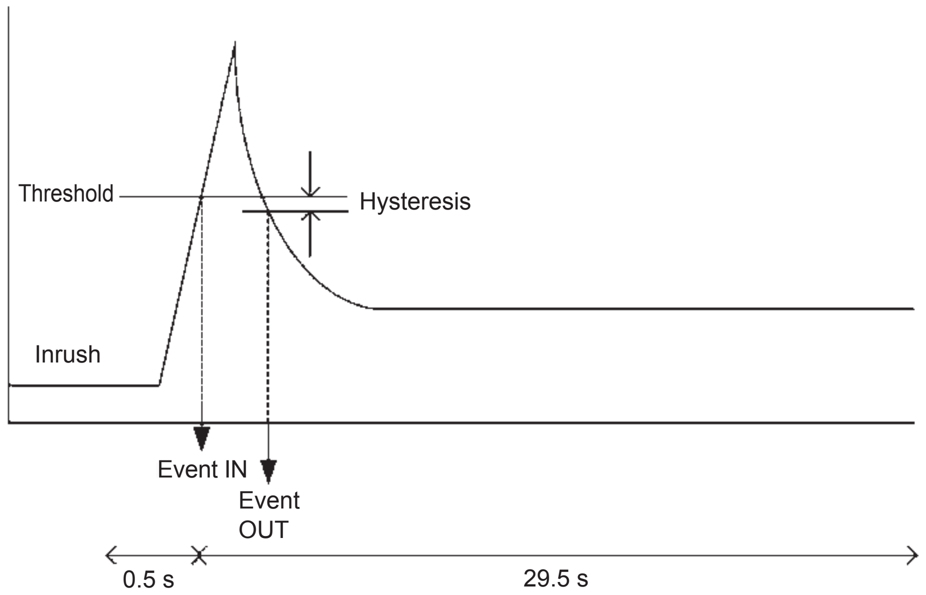


Harmonic distortion

Inrush current

Measurement method

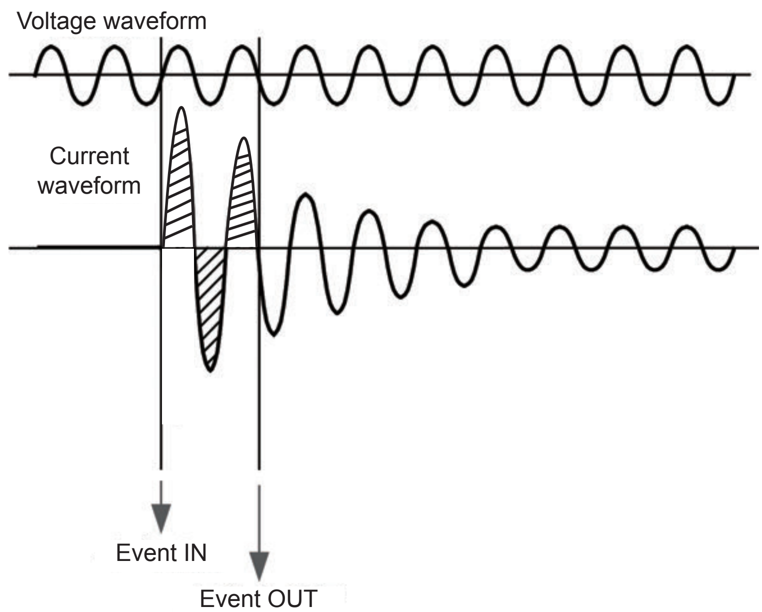
Inrush current events are detected when the RMS current (inrush current) calculated for every half cycle exceeds the threshold value.



Inrush current, Inrush is saved from 0.5 s before the event to 29.5 s after the event as event trend data.

Event IN and OUT

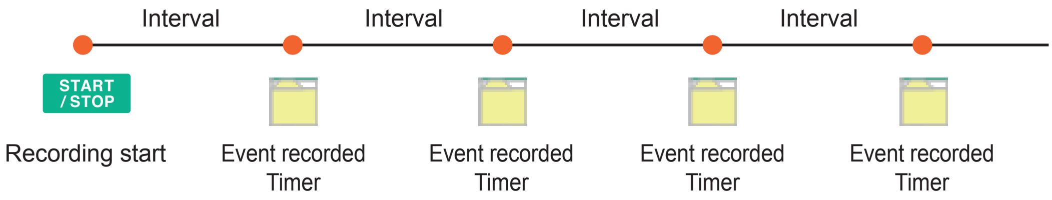
Event IN	Starting time of a half-cycle voltage waveform to which an inrush current (Inrush) belongs on each channel when it exceeds the threshold value
Event OUT	Starting time of a half-cycle voltage waveform to which an inrush current (Inrush) belongs when it falls below the value calculated by subtracting the hysteresis from the threshold value



Appx.

Timer event

- Events are generated at the set interval.
- Once recording is started, timer events will be recorded at a fixed interval (the set time) from the start time.



External event

External events are detected when any of the following occurs due to the input signal for the EXT I/O terminals.

- When a falling of the pulse signal input to Pin 1 (EVENT IN) is detected
- When Pin 1 (EVENT IN) and Pin 3 (GND1) are short-circuited each other

The voltage and current waveforms and measured values are recorded, when the external event occurs.
See “13 External I/O” (p. 147).

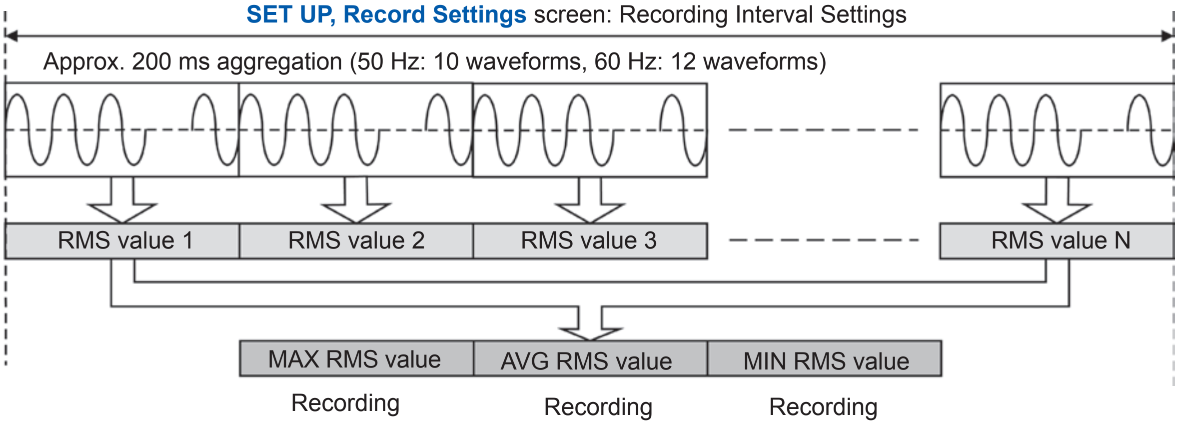
Manual event

Pressing the **[MANUAL EVENT]** key generates an event.
The voltage and current waveforms as well as measured values are recorded, when the manual event occurs.

Appx. 5 Recording Trends and Event Waveforms

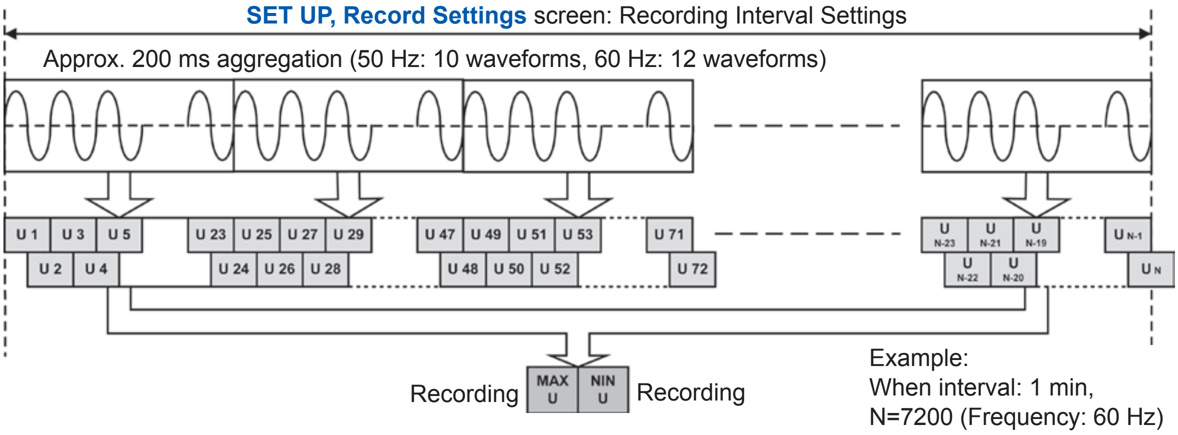
Trend screen recording method

Basic trend and harmonics trend (available after the firmware update)



Example: When interval: 1 min, N = 300

Detailed trend



RMS voltage refreshed each half-cycle (Urms1/2) is calculated for one waveform shifted over half a wave.
Example: There are 24 RMS voltage refreshed each half-cycle in approx. 200 ms aggregation at 60 Hz (12 cycles).

Appx.

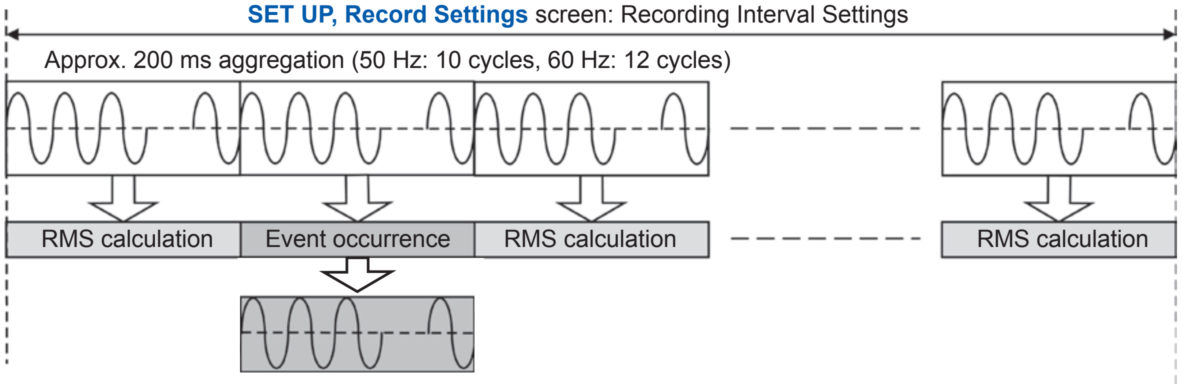
Recording event waveforms

Waveforms observed in the approximately 200-ms aggregation period are recorded as event waveforms.

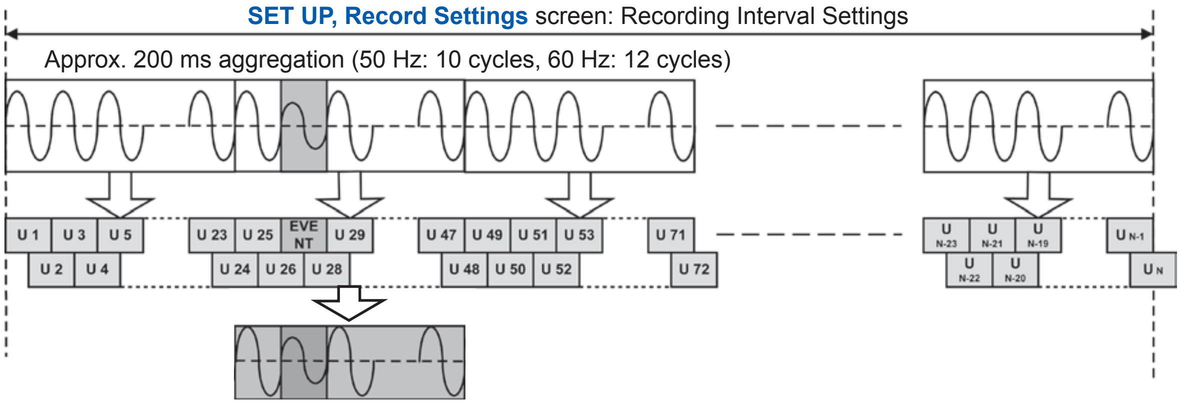
Event waveform recording period

50 Hz: Waveform observed for a 10-cycle period
60 Hz: Waveform observed for a 12-cycle period

When an event occurs on a measured value obtained over an approximately 200-ms aggregation period



When an event is occurred on a measured value obtained a 1-cycle or half-cycle



- On the **SET UP, Event settings 2** screen**, Event waveform recording time: "Before event occurs"** setting allows an immediately previous waveform with a length of a set time to be stored in addition to an event waveform with a length of a 200-ms aggregation period observed at an event (p. 74).
  Event waveform recording time: "Before event occurs": **OFF**, **200 ms**, **1 s**
- On the **SET UP, Event settings 2** screen**, Event waveform recording time: "After event occurs"** setting allows an immediately previous waveform with a length of a set time to be stored in addition to an event waveform with a length of a 200-ms aggregation period observed at an event. (p. 74).
  Event waveform recording time: "After event occurs": **OFF**, **200 ms**, **400 ms**, **1 s**, **5 s**, **10 s**

Method for verifying aggregation values required by IEC61000-4-30

	3-s aggregated values (= 150/180-cycle data)	10-min aggregated values	2-h aggregated values
Magnitude of the supply voltage	Applies to the average value of Urms values obtained on each channel over the recording interval.		
Voltage harmonics	Measurement condition: **Recording items***1 is set to **Yes harmonic**. Applies to the average value of the values obtained over the recording interval.		
Voltage interharmonics			
Supply voltage unbalance	Applies to the average value of unb values and unb0 values of Uunb obtained over the recording interval.		
Measurement conditions	• **Recording interval***1 is set to **150/180 cycle**.	• **Recording interval***1 is set to **10 min**.	• **Recording interval***1 is set to **2 hour**.
	• **TREND** screen check requires that **Tdiv** (horizontal axis) be set to the minimum value to make cursor measurements.*2		

*1: See “5.2 Recording Settings” (p. 69).
*2: See “8.1 Verifying the Basic Trend” (p. 98).

IEC flicker (available after the firmware update)

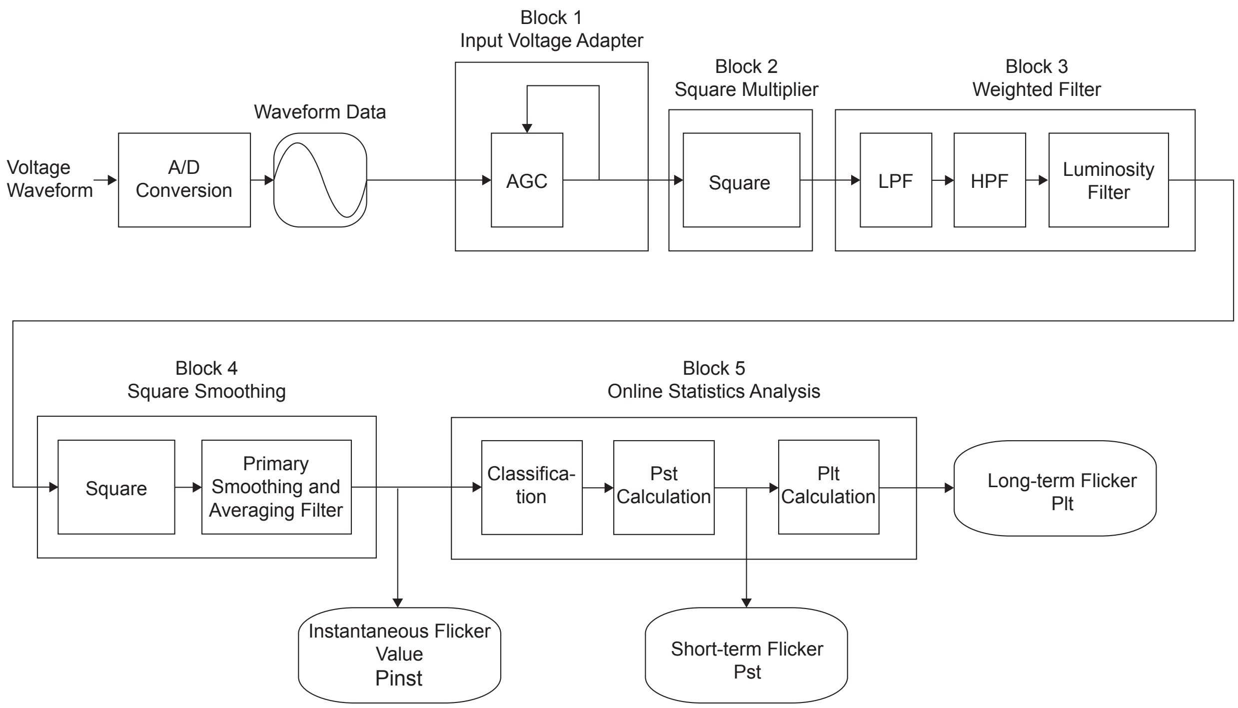
When measuring IEC flicker based on the standard, set the **Recording interval** to **2 hour** and use only a Plt value with even-numbered but 2 hours after the recording starts (e.g., 2 hours, 4 hours and more).

Appx. 6 Detailed Explanation of IEC Flicker and ΔV10 Flicker (available after the firmware update)

IEC flicker meter

The IEC flicker function is based on the international standard IEC61000-4-15, “Flickermeter - Functional and design specifications.”

IEC flicker meter function diagram



Weighting filter

You can select a weighted filter for either a 230 V lamp system or a 120 V lamp system.

Statistical processing

Statistics on flicker are compiled by applying the cumulative probability function (CPF) to 1,024 divisions of instantaneous flicker values Pinst in the range from 0.0001 P.U.* to 10000 P.U. on the logarithmic axis to obtain cumulative probabilities P0.1, P1s, P3s, P10s, and P50s.

*: The unit [P.U.] stands for perceptibility unit. Various filters are designed in order that the maximum value of Pinst corresponds to 1 [P.U.] when a voltage fluctuation that human beings recognize as a flicker is input to them.

Short interval flicker (*Pst*)

This indicates degree of perceptibility (severity) of flicker measured over a 10-min period.

Short interval flicker value is defined with the following expression.

$$Pst = \sqrt{0.0314P0.1+0.0525P1s+0.0657P3s+0.28P10s+0.08P50s}$$

P50s = (P30+P50+P80)/3
P10s = (P6+P8+P10+P13+P17)/5
P3s = (P2.2+P3+P4)/3
P1s = (P0.7+P1+P1.5)/3
P0.1 is not smoothed

Long interval flicker (*Plt*)

Indicates the degree of perceptibility (severity) of flicker determined from successive *Pst* measurements over a 2-hour period.
The displayed value is updated every 10 min because *Pst* is calculated with the moving average.

Long interval flicker value is defined with the following expression.

$$Plt = \sqrt[3]{\frac{\sum (Psti)^3}{N}}$$

ΔV10 flicker meter

ΔV10 flicker

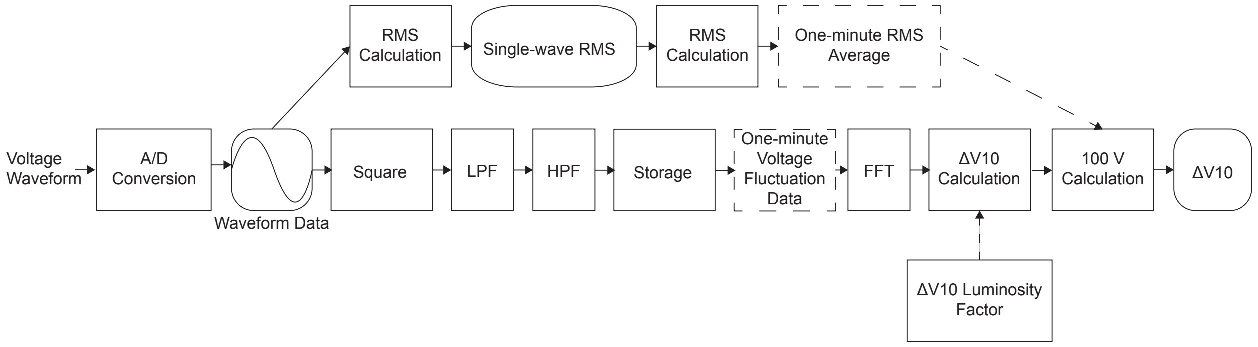
The ΔV10 flicker function is calculated using the "perceived flicker curve" calculation method, which is based on the digital Fourier transformation.

The ΔV10 flicker is defined with the following expression.

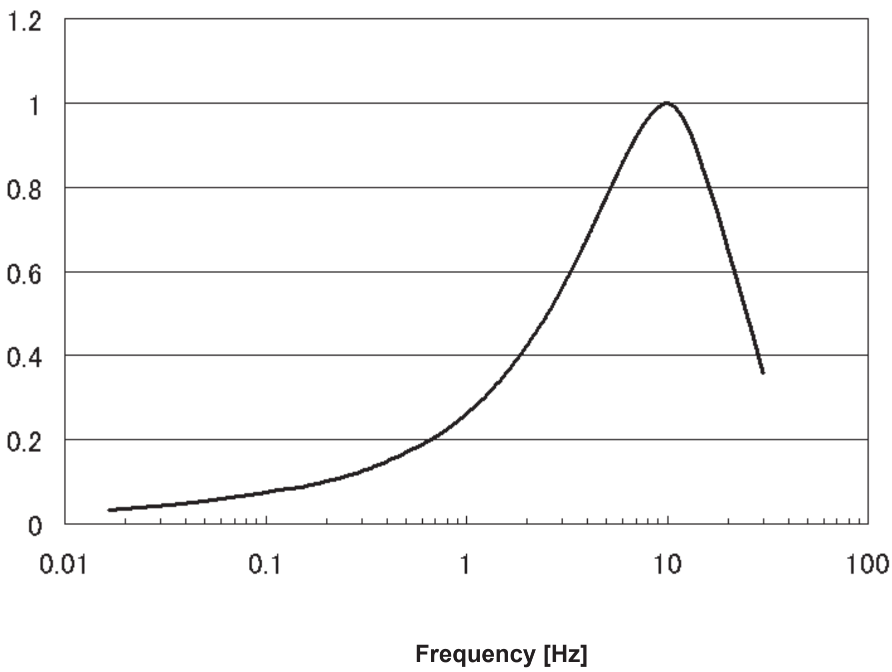
$$\Delta V_{10} = \sqrt{\sum_{n=1}^{\infty} (a_n \cdot \Delta V_n)^2}$$

ΔVn: RMS value [V] for voltage fluctuations in frequency fn.
a_n: Luminosity coefficient for fn where 10 Hz is 1.0. (0.05 Hz to 30 Hz)
Evaluation period: for 1 min

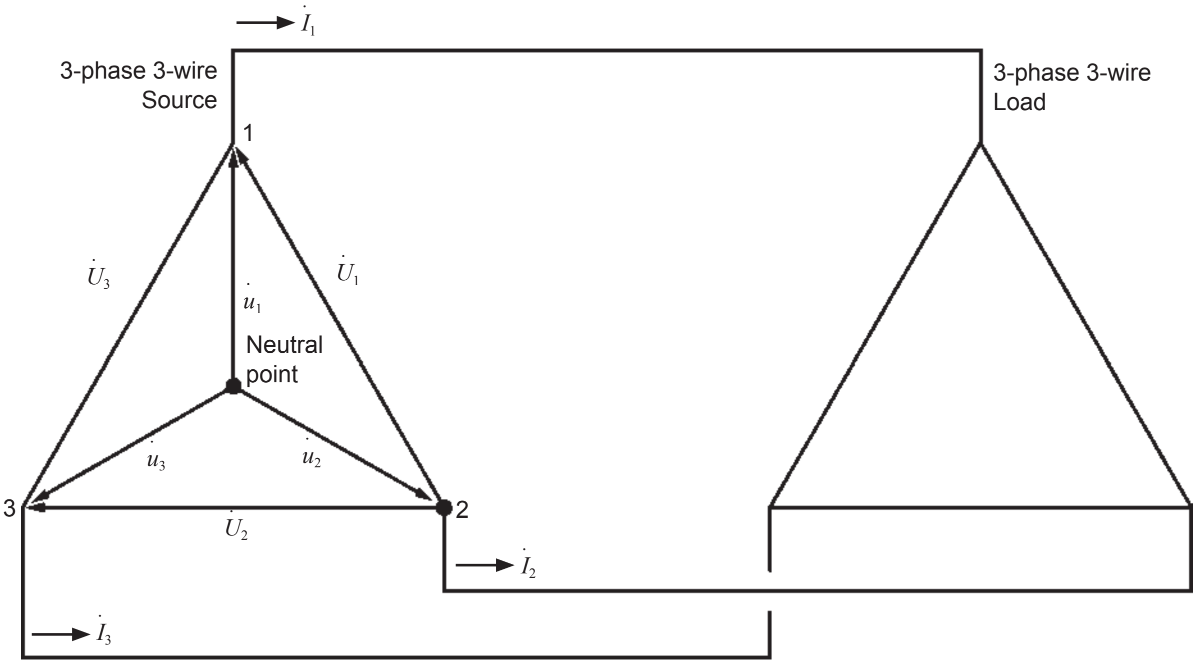
ΔV10 flicker function diagram



ΔV10 Perceived flicker coefficient



Appx. 7 3-phase 3-wire Measurement



Similar circuit of 3-phase 3-wire line

$\dot{U}_1$, $\dot{U}_2$, $\dot{U}_3$: The vectors of line-to-line voltage
$\dot{u}_1$, $\dot{u}_2$, $\dot{u}_3$: The vectors of phase to neutral voltage
$\dot{I}_1$, $\dot{I}_2$, $\dot{I}_3$: The vectors of line (phase) current

3-phase/3-wire/3-wattmeter measurement (3P3W3M)

In 3-wattmeter measurement, 3 phase voltages $\dot{u}_1$, $\dot{u}_2$, $\dot{u}_3$ and three line (phase) currents $\dot{I}_1$, $\dot{I}_2$, $\dot{I}_3$ are measured.
Measuring actual phase voltages are not possible because of the lack of a neutral point in the 3-phase, 3-wire line, therefore, phase voltages are measured from a virtual neutral point.
The 3-phase active power P is calculated as the sum of all the phase active power values.

$\mathrm{P} = \dot{u}_1\dot{I}_1 + \dot{u}_2\dot{I}_2 + \dot{u}_3\dot{I}_3$ (1)

3-phase/3-wire/2-wattmeter measurement (3P3W2M)

In 2-wattmeter measurement, two line-to-line voltages $\dot{U}_1$, $\dot{U}_2$ and two line (phase) currents $\dot{I}_1$, $\dot{I}_3$ are measured.
The 3-phase active power P can be derived from two voltage and current values, as shown below:

$\mathrm{P} = \dot{U}_1\dot{I}_1 + \dot{U}_2\dot{I}_3$ (from $\dot{U}_1 = \dot{u}_1 - \dot{u}_2$, $\dot{U}_2 = \dot{u}_3 - \dot{u}_2$)
$= (\dot{u}_1 - \dot{u}_2)\dot{I}_1 + (\dot{u}_3 - \dot{u}_2)\dot{I}_3$
$= \dot{u}_1\dot{I}_1 + \dot{u}_2(-\dot{I}_1 - \dot{I}_3) + \dot{u}_3\dot{I}_3$ (from $\dot{I}_1 + \dot{I}_2 + \dot{I}_3 = 0$ as the precondition of a closed circuit)
$= \dot{u}_1\dot{I}_1 + \dot{u}_2\dot{I}_2 + \dot{u}_3\dot{I}_3$ (2)

Since equations (1) and (2) agree, it is possible to prove that 2-wattmeter measurement can be used to measure the power of a 3-phase, 3-wire line. The circuit allowing 3-phase power measurements with this method is a only closed circuit without leakage current. Since there are no special conditions other than the above, it is possible to calculate 3-phase power regardless of the balanced or unbalanced state of the electric circuit.
Additionally, since the sum of the voltage and current vectors always equals 0 under these conditions, the instrument internally calculates the third voltage $\dot{U}_3$ and current $\dot{I}_2$ values as follows:
$\dot{U}_3 = \dot{U}_1 - \dot{U}_2$
$\dot{I}_2 = -\dot{I}_1 - \dot{I}_3$

Appx.

Since the values calculated internally $\dot{U}_3$ and $\dot{I}_2$ are also applied to the 3-phase total reactive power Q, apparent power S, and power factor PF values, these values can also be calculated accurately in the event of an unbalanced state. [When **PF/Q/S** setting (p. 66) is **RMS**]

However, because the three phases are calculated from two power values in 2-wattmeter measurement, it is not possible to check the power balance between respective phases. If you wish to check the power balance for individual phases, use 3-wattmeter (3P3W3M) measurement.

Item		3P3W2M		Relative merits	3P3W3M	
Voltage	U1	$\dot{U}_1$		=	$\dot{U}_1 = \dot{u}_1 - \dot{u}_2$	
	U2	$\dot{U}_2$			$\dot{U}_2 = \dot{u}_2 - \dot{u}_3$	
	U3	$\dot{U}_3 = \dot{U}_2 - \dot{U}_1$			$\dot{U}_3 = \dot{u}_3 - \dot{u}_1$	
Current	I1	$\dot{I}_1$		=	$\dot{I}_1$	
	I2	$\dot{I}_3$			$\dot{I}_2$	
	I3	$\dot{I}_2 = \dot{I}_1 - \dot{I}_3$			$\dot{I}_3$	
Active power	P1	$\dot{U}_1\dot{I}_1$	Since the three phases are calculated from 2-wattmeter, it is not possible to check the active power balance for individual phases.	<	$\dot{u}_1\dot{I}_1$	It is possible to check the active power balance for individual phases.
	P2	$\dot{U}_2\dot{I}_3$			$\dot{u}_2\dot{I}_2$	
	P3	-			$\dot{u}_3\dot{I}_3$	
	P	$\dot{U}_1\dot{I}_1 + \dot{U}_2\dot{I}_3 = \dot{u}_1\dot{I}_1 + \dot{u}_2\dot{I}_2 + \dot{u}_3\dot{I}_3$ See equation (2).		=	$\dot{u}_1\dot{I}_1 + \dot{u}_2\dot{I}_2 + \dot{u}_3\dot{I}_3$	
Apparent power (When PF/Q/S setting is RMS)	S1	U_1I_1	Since calculations are based on the line-to-line voltage and phase (line) current, apparent power values are not generated for individual phases.	<	u_1I_1	Since calculations are based on the phase voltage and phase (line) current, it is possible to check the apparent power for individual phases.
	S2	U_2I_3			u_2I_2	
	S3	U_3I_2			u_3I_3	
	S	$\frac{\sqrt{3}}{3}(U_1I_1+U_2I_3+U_3I_2)$		=	$\frac{\sqrt{3}}{3}(U_1I_1+U_2I_2+U_3I_3)$	

In 3P3W2M measurement, the instrument inputs the 3-phase line's T-phase current as each current's I2 parameter. For display purposes, a current value of Phase T in the 3-phase line is displayed as the current I2; and a calculated value of Phase S in the 3-phase line, as the current I3.

Appx. 8 Method for Calculating Active Power Accuracy

The accuracy of active power calculations can be calculated as follows, taking into account the phase accuracy:

Example measurement conditions

Wiring: 3-phase/4-wire (3P4W)
Current sensor: Model CT7136
Current range: 50 A (power range: 150 kW)
"14.8 Range Configuration and Combination Accuracy" (p. 188)
Measured values: Active power of 30 kW, power factor lag 0.8

Accuracy

Current sensor combined accuracy (Model CT7136 sensor, 50 A range): **±0.5% rdg.±0.22% f.s.**
Internal circuit voltage of the instrument - current phase difference: ±0.2865° (Effect of power factor: 1.0% rdg. or less)
Phase accuracy of the CT7136: ±0.5°
"14.2 Input Specifications/Output Specifications/Measurement Specifications" (p. 155)
"14.8 Range Configuration and Combination Accuracy" (p. 188)
Phase accuracy shown in "Specifications" of the CT7136 Instruction Manual

Power factor accuracy based on phase accuracy

Phase accuracy (in combination with current sensor) = Instrument internal circuit phase accuracy $(\pm 0.2865°)$ + CT7136 phase accuracy $(\pm 0.5°) = \pm 0.7865°$

Phase difference $\theta = \cos^{-1}$ (power factor)$= \cos^{-1} 0.8 = 36.87°$

Power factor error range based on phase accuracy $= \cos(36.87° \pm 0.7865°) = 0.7916$ to 0.8082

Power factor accuracy based on phase accuracy (minimum) = $\dfrac{0.7915 - 0.8}{0.8} \times 100\% = \boxed{-1.05\%}$

use the worst value as the power factor accuracy.

Power factor accuracy based on phase accuracy (maximum) = $\dfrac{0.8083 - 0.8}{0.8} \times 100\% = \boxed{+1.025\%}$

The value, whichever is worse, is specified to be the phase accuracy.

Power factor accuracy based on phase accuracy: **±1.05% rdg.**

Active power accuracy

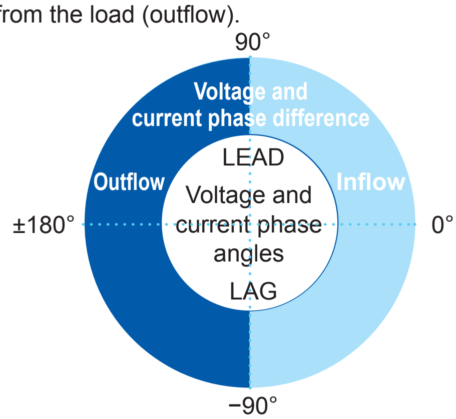
Active power accuracy = current sensor combined accuracy + power factor accuracy based on phase accuracy

$= \pm 0.5\%$ rdg. $\pm 0.22\%$ f.s. $\pm 1.05\%$ rdg.
$= \pm 1.55\%$ rdg.$\pm 0.22\%$ f.s.

Accuracy relative to measured values = active power 30 kW $\times \pm 1.55\%$ rdg. $+ 150$ kW range $\times 0.22\%$ f.s.
$= \pm 0.795$ kW
$= \pm 0.795$ kW/30 kW $= \pm 2.65\%$ rdg.

Appx. 9 Terminology

Active power	Power that is consumed doing work.
Active power demand	The average active power used during a set period of time (usually 30 min).
Apparent power	The (vector) power obtained by combining active power and reactive power. As its name suggests, apparent power expresses the “visible” power and comprises the product of the RMS voltage and RMS current.
Binary data	All data other than text (character) data. Since the measured data of the instrument is written in binary format, the data cannot be directly opened in commercially available spreadsheet software. Use the supplied software to load the data from the instrument to your computer for analysis.
Declared input voltage (Udin)	The value calculated from the nominal supply voltage using the transformer ratio. The declared input voltage is defined by IEC61000-4-30.
Declared voltage (Uref)	The same voltage as the nominal supply voltage (Uc) or the rated voltage (Un) defined by IEC61000-4-30 . Declared voltage (Uref) = declared input voltage (Udin) × VT ratio
Dip	A short-lived voltage drop caused by the occurrence of a inrush current with a large load, such as when a motor starts. When recording voltage and current trends at the power service inlet, you can determine whether you should look for the cause of the dip inside or outside the building. If the voltage drops while the building’s current consumption rises, the likely cause lies inside the building. If the voltage and current are both low, the cause is likely to lie outside the building.
EN50160	A European power quality standard that defines limit values for supply voltage and other characteristics. Obtaining statistics from the instrument data with the supplied application software PQ One allows standard-compliant evaluation and analysis (version upgrade supported).
Event	Power quality parameters are necessary in order to investigate and analyze power supply issues. These parameters include disturbances such as transients, dips, swells, interruptions, and frequency fluctuations. As a rule, the term “event” refers to the state detected based on threshold values for which abnormal values and abnormal waveforms for these parameters have been set. Events also include the timer and manual event settings that are unrelated to power quality parameters.
External event function	Functionality for generating events by detecting a signal input to the instrument’s external event input terminal and recording measured values and event waveforms at the time of detection. In this way, events are generated based on an alarm signal from a device other than the instrument. By inputting an operating signal from an external device, an operation start or stop trigger can be applied in order to record waveforms with the instrument.
Flag	A marker used to distinguish unreliable measured values occurring due to disturbances such as swells, dips, and interruptions. Flags are recorded as part of the trend record data status information. The concept is defined by the IEC61000-4-30 standard.
Flicker	A disturbance caused by a voltage drop resulting when equipment with a large load starts up or when a large current flows under a temporary high-load state. For lighting loads, flicker primarily manifests itself as blinking. Electric-discharge lamps such as fluorescent and mercury-vapor lights are particularly prone to the effects of flicker. When temporary dimming of lights due to voltage drop occurs frequently, a flickering effect that causing an extremely unpleasant visual sensation is produced. Measurement methods can be broadly divided into IEC flicker and ΔV10 flicker. In Japan, the ΔV10 method is most frequently used.
Frequency (1 wave) (Freq wav)	The frequency of a single waveform. By measuring the frequency (1 wave), it is possible to monitor frequency fluctuations on an interconnected system at a high degree of detail.

Frequency 10 s (Freq10s)	The frequency measured value as calculated according to IEC61000-4-30. This value is an average of the frequencies measured for 10 s. It is recommended to measure this characteristic for at least one week.
Harmonics	A phenomenon caused by distortions in the voltage and current waveforms that affect many devices with power supplies using semiconductor control devices. In the analysis of non-sine waves, the term refers to one RMS value among the components with harmonic frequencies
Harmonic content percentage	The ratio of the K-th order size to the size of the fundamental wave, expressed as a percentage using the following equation: (K-th order wave) / (fundamental wave) × 100 [%] By observing this value, it is possible to ascertain the harmonic component content for individual orders. This metric provides a useful way to track the harmonic content percentage when monitoring a specific order.
Harmonics phase angle and phase difference	The harmonic voltage phase angle and harmonic current phase angle are expressed in terms of the synchronized source's fundamental component phase. The difference between each order's harmonic component phase and the fundamental component phase is expressed as an angle (°), and its sign indicates either a lagging phase (LAG) "−" (negative) or leading phase (LEAD) "+" (positive). Angle signs of the above are the opposite of those for power factor. The harmonic voltage-current phase angle expresses the difference between each order's harmonic voltage component phase angle and harmonic current component phase angle for each channel as an angle (°). When using the sum display, the sum of each order's harmonic power factor (calculated from the sums of harmonic power and harmonic reactive power) is converted to an angle (°). When the harmonic voltage-current phase angle is between −90° and +90°, that order's harmonics are flowing toward the load (influx). When the harmonic voltage-current phase angle is between +90° and +180° or between −90° and −180°, that order's harmonics are flowing from the load (outflow).  Harmonics phase angle
IEC61000-4-7	An international standard governing measurement of harmonic current and harmonic voltage in power supply systems as well as harmonic current emitted by equipment. The standard specifies the performance of a standard instrument.
IEC61000-4-15	A standard that defines testing techniques for voltage fluctuation and flicker measurement as well as associated measuring instrument requirements.

<table>
<tr><td>IEC61000-4-30</td><td>A standard governing testing involving power quality measurement in AC power supply systems and associated measurement technologies. Target parameters are restricted to phenomena that are propagated in power systems. The target parameters consist of frequency, supply voltage amplitude (RMS), flicker, supply voltage dips, swells, (momentary) interruptions, transient overvoltage, supply voltage unbalance, harmonics, interharmonics, supply voltage carrier signals, and high-speed voltage variations.
The standard defines measurement methods for these parameters as well as the necessary instrument performance. It does not define specific threshold values.
Measurement classes:
The standard defines three classes (A, S, and B) for various instrument measuring methods and measurement performance levels:
<table>
<tr><th>Class</th><th>Applications</th></tr>
<tr><td>Class A</td><td>Used in applications where accurate measurement is required, for example verification of standard compliance and dispute settlement. In order to ensure accurate measurement, the standard includes detailed stipulations concerning instrument time clock accuracy, RMS value calculation methods, and trend data grouping.</td></tr>
<tr><td>Class S</td><td>Used in surveys and power quality evaluation.</td></tr>
<tr><td>Class B</td><td>Used in applications where a high level of accuracy is not required, for example troubleshooting.</td></tr>
</table>
</td></tr>
<tr><td>Inrush current</td><td>A large current that flows temporarily, for example when an electric device is turned on.
An inrush current can be equal to or greater than 10 times the current that flows when the device is in the normal operating state.
Inrush current measurement can be a useful diagnostic when setting circuit breaker capacity.
The inrush current measurements by the instrument use the RMS value refreshed each half-cycle.</td></tr>
<tr><td>Interharmonics</td><td>All frequencies that are not a whole-number multiple of the fundamental frequency.
The interharmonics include inter-order harmonics. The term refers to RMS values for the spectral components of electrical signals with frequencies between two contiguous harmonic frequencies.
(Interharmonics of the order 3.5 assume a drive of 90 Hz or similar rather than a frequency synchronized to the fundamental wave of an inverter or other device. However, interharmonics do not generally occur in high-voltage circuits under present-day conditions. Most interharmonics are currently thought to be caused by the circuit load.)</td></tr>
<tr><td>Interruption</td><td>A phenomenon in which the supply of power stops momentarily or for a short or long period of time due to factors such as a circuit breaker tripping as a result of a power company accident or power supply short-circuit.</td></tr>
<tr><td>ITIC curve</td><td>This curve was created by the Information Technology Industry Council.
Voltage disturbance data for detected events is plotted on a graph using the event duration and worst value (as a percentage of the declared input voltage). The graph format makes it easy to clearly identify which event data distribution should be analyzed.
The supplied software PQ One can be used to create ITIC curves using the data of the instrument (available after the firmware update).</td></tr>
</table>

K factor	Shows the power loss caused by the harmonic current in transformers. Also referred to as the “multiplication factor.” **The K factor (KF) is formulated as shown below:** $$KF = \frac{\sum_{k=1}^{50} (k^2 \times I_k^2)}{\sum_{k=1}^{50} I_k^2}$$ where k: Order of harmonics I_k: Harmonic current value [A] Higher-order harmonic currents have a greater influence on the K factor than lower-order harmonic currents. **Purpose of measurement:** To measure the K factor in a transformer when subjected to maximum load. If the measured K factor is larger than the multiplication factor of the transformer used, the transformer must be replaced with one with a larger K factor, or the load on the transformer must be reduced. The replacement transformer should have a K factor one rank higher than the measured K factor for the transformer being replaced.
LAN	LAN is the abbreviation of Local Area Network. The LAN was developed as a network for transferring data through a computer within a local area, such as an office, factory, or school. The instrument is equipped with the LAN adapter Ethernet 100BASE-TX. Use a twisted-pair cable and connect with a star connection to the device generally called the hub (central computer) of your LAN. The maximum length of the cable that can be used for connecting the terminal and the hub is 100 m. Communications using TCP/IP as the Ethernet interface protocol are supported.
Manual event function	Functionality for generating events when the **[MANUAL EVENT]** key is pressed and recording the measured value and event waveform at that time. In this way, events can be generated as a snapshot of the system being measured. Use this functionality when you wish to record a waveform but cannot find an event that defines the desired phenomenon or when you wish to record data manually to avoid the generation of too many events.
Measurement frequency (fnom)	The nominal frequency of the system being measured. Select 50 Hz or 60 Hz.
Multiple-phase system treatment	Method for defining the start and end of events such as dips, swells, and interruptions in multiple-phase systems, for example systems with 3 phases **Swell:** A swell begins when the voltage on at least one channel exceeds the threshold and ends when the voltage readings on all measurement channels falls below the value calculated by subtracting the hysteresis from the threshold value. **Dip:** A dip begins when the voltage on at least one channel falls below the threshold and ends when voltage readings on all measurement channels exceeds the value calculated by adding the hysteresis to the threshold value. **Interruption:** An interruption begins when voltage readings on all channels falls below the threshold and ends when the voltage on a user-specified channel exceeds or is equal to the value calculated by adding the hysteresis to the threshold value.
Nominal supply voltage (Uc)	Typically, the system’s rated voltage Un. When a voltage that differs from the rated voltage is applied to the contact in accordance with an agreement between the electricity provider and the customer, that voltage is used as the nominal supply voltage Uc. The nominal input voltage is defined by IEC61000-4-30.

Power factor demand value	The power factor calculated using the active power demand value (consumption) and the reactive power demand value (lag) for the set interval time (usually 30 min). $PFdem = \frac{Pdem+}{\sqrt{(Pdem+)^2 + (Qdem\_LAG)^2}}$
Power factor (PF/ DPF)	Power factor is the ratio of active power to apparent power. The larger the absolute value of the power factor, the greater the proportion of active power to the apparent power, and greater the efficiency. The maximum absolute value is 1. Conversely, the smaller the absolute value of the power factor, the greater the reactive power with the apparent power, and lower the efficiency. The minimum absolute value is 0. For this device, the sign of the power factor indicates whether the current phase is lagging or leading the voltage. A positive value (no sign) indicates that the current phase is lagging the voltage. Inductive loads (such as motors) are characterized by a lagging phase. A negative value indicates that the current phase is leading the voltage. Capacitive loads (such as capacitors) are characterized by a leading phase. These signs are the opposite of those for the harmonics phase angle and phase difference. The power factor (PF) is calculated using RMS values that include harmonic components. Larger harmonic current components cause the power factor to deteriorate. By contrast, since the displacement power factor (DPF) calculates the ratio of active power to apparent power from the fundamental voltage and fundamental current, no voltage or current harmonic component is included. This is the same measurement method used by reactive power meters installed at commercial-scale utility customers' facilities. Displacement power factor, or DPF, is typically used by the electric power system, although power factor, or PF, is sometimes used to measure equipment in order to evaluate efficiency. When a lagging phase caused by a large inductive load such as a motor results in a low displacement power factor, there are corrective measures that can be taken to improve the power factor, for example by adding a phase advance capacitor to the power system. Displacement power factor (DPF) measurements can be taken under such circumstances to verify the improvement made by the phase advance capacitor.
Reactive power	Power that does not perform actual work, resulting in no power consumption as it travels between the load and the power supply. Reactive power is calculated by multiplying the active power with the sine of the phase difference (sinθ). It arises from inductive loads (deriving from inductance) and capacitive loads (deriving from capacitance), with reactive power derived from inductive loads known as lag reactive power and reactive power derived from capacitive loads known as lead reactive power.
Reactive power demand	The average reactive power used during a set period of time (usually 30 min).
RMS current refreshed each half-cycle (Irms1/2)	The RMS current is calculated using a value measured over a 1-cycle time refreshed each half-cycle. Model PW3198 Power Quality Analyzer uses the RMS for every half-cycle.
RMS value	The root mean square of instantaneous values for a quantity obtained over a particular time interval or bandwidth.
RMS voltage refreshed each half-cycle (Urms1/2)	The RMS voltage is calculated using a value measured over a 1-cycle time refreshed each half-cycle.
RS-232C	The RS-232C is a serial interface established by the EIA (Electronics Industries Association). RS-232C also conforms with the specifications of DTE (data terminal equipment) and DCE (data circuit terminating equipment) interface conditions.
SD memory card	A type of flash memory card.
Swell	A phenomenon in which the voltage rises momentarily due to a lightning strike or the switching of a high-load power line.
Text data	A file containing only data expressed using characters and character codes.

Timer event function	Functionality for generating events at a set time interval and recording the measured value and event waveform at that time. This function allows you to capture instantaneous waveforms and other data regularly, even if no abnormalities have occurred. Use this functionality when you wish to record a waveform at a fixed time interval.
Total harmonic distortion factor	**THD-F:** The ratio of the size of the total harmonic component to the size of the fundamental wave, expressed as a percentage using the following equation: $\dfrac{\sqrt{\sum \text{(2nd order and above)}^2}}{\text{Fundamental wave}} \times 100[\%]$ (for the instrument, calculated to the 50th order) This value can be monitored to assess waveform distortion for each item, providing a yardstick that indicates the extent to which the total harmonic component is distorting the fundamental waveform. As a general rule, the total distortion factor for a high-voltage system should be 5% or less; it may be higher at the terminal point of the system. **THD-R:** The ratio of the size of the total harmonic component to the size of the RMS, expressed as a percentage using the following equation: $\dfrac{\sqrt{\sum \text{(2nd order and above)}^2}}{\text{RMS}} \times 100[\%]$ (for the instrument, calculated to the 50th order) THD-F is typically used.
Transient overvoltage	An event caused by lightning strikes, circuit-breaker and relay contact obstructions and tripping, and other phenomena. Transient overvoltage are often characterized by steep voltage changes and a high peak voltage.
Unbalance factor	**Unbalanced (symmetrical) 3-phase voltage (current):** 3-phase AC voltage (current) with equal voltage and current magnitude for each phase and 120° phase separation. **Unbalanced (asymmetrical) 3-phase voltage (current):** 3-phase AC voltage (current) with unequal voltage magnitude for each phase or without 120° phase separation. **Degree of unbalance in 3-phase alternating voltage** Normally described as the voltage unbalance factor, which is the ratio of negative-phase voltage or zero-phase voltage to positive-phase voltage $\text{Voltage negative-phase unbalance factor} = \dfrac{\text{Negative-phase voltage}}{\text{Positive-phase voltage}} \times 100[\%]$ $\text{Voltage zero-phase unbalance factor} = \dfrac{\text{Zero-phase voltage}}{\text{Positive-phase voltage}} \times 100[\%]$ **Zero-phase/positive-phase/negative-phase voltage:** The concept of a zero-phase-sequence/positive-phase-sequence/negative- phase-sequence component in a three-phase alternating circuit applies the method of symmetrical coordinates (a method in which a circuit is treated so as to be divided into symmetrical components of a zero phase, positive phase, and negative phase).

Zero-phase-sequence component	Voltage that is equal in each phase. Described as $[V_0]$ (Subscript 0: Zero-phase-sequence component).
Positive-phase-sequence component	Symmetrical three-phase voltage in which the value for each phase is equal, and each of the phase is delayed by 120 degrees in the following phase sequence: a, b, and c. Described as $[V_1]$ (Subscript 1: Positive-phase-sequence component).
Negative-phase-sequence component	Symmetrical three-phase voltage in which the value for each phase is equal, and each of the phases is delayed by 120 degrees in the following phase sequence: a, b, and c. Described as $[V_2]$ (Subscript 2: Negative-phase-sequence component).

	If $\dot{V}a$, $\dot{V}b$, and $\dot{V}c$ are applied as the three-phase alternating voltage, the zero-phase voltage, positive-phase voltage, and negative-phase voltage are formulated as shown below. Zero-phase Voltage $\dot{V}_0 = \dfrac{\dot{V}a + \dot{V}b + \dot{V}c}{3}$ Positive-phase Voltage $\dot{V}_1 = \dfrac{\dot{V}a + a\dot{V}b + a^2\dot{V}c}{3}$ Negative-phase Voltage $\dot{V}_2 = \dfrac{\dot{V}a + a^2\dot{V}b + a\dot{V}c}{3}$ a is referred to as the “vector operator.” It is a vector with a magnitude of 1 and a phase angle of 120 degrees. Therefore, the phase angle is advanced by 120 degrees if multiplied by a, and by 240 degrees if multiplied by a^2. If the three-phase alternating voltage is balanced, the zero-phase voltage and negative-phase voltage are 0, and positive phase voltage is equal to the RMS value of the three-phase alternating voltage. **Unbalance factor of three-phase current:** Used in applications such as the verification of power supplied to electrical equipment powered by a 3-phase induction motor. The current unbalance factor is several times larger than the voltage unbalance factor. The less a three-phase induction motor slips, the greater the difference between these two factors. Voltage unbalance causes phenomena such as current unbalance, an increase in temperature, an increase in input, a decline in efficiency, and an increase in vibration and noise. The requirements may require that Uunb does not exceed 2%, and Iunb is 10% or less. In a 3P4W system with an unbalanced load, the Uunb0 and Inub0 components indicate the current that flows to the N (neutral) line.
Zero, positive, and negative phases	The positive phase can be considered normal 3-phase power consumption. The negative phase functions to operate a 3-phase motor backwards. The positive phase causes the motor to operate in the forward direction, while the negative phase acts as a brake. This negative phase causes heat to be generated. This heat has a negative impact on the motor. Like the negative phase, the zero phase is not necessary. With a 3-phase 4-wire wiring, the zero phase causes current to flow and heat to be generated. Normally, an increase in the negative phase causes an increase of the same magnitude in the zero phase.

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Warranty Certificate

HIOKI

Model	Serial No.	Warranty period Three (3) years from date of purchase (___ / ___)

This product passed a rigorous inspection process at Hioki before being shipped.

In the unlikely event that you experience an issue during use, please contact the distributor from which you purchased the product, which will be repaired free of charge subject to the provisions of this Warranty Certificate. This warranty is valid for a period of three (3) years from the date of purchase. If the date of purchase is unknown, the warranty is considered valid for a period of three (3) years from the product's date of manufacture. Please present this Warranty Certificate when contacting the distributor. Accuracy is guaranteed for the duration of the separately indicated guaranteed accuracy period.

1. Malfunctions occurring during the warranty period under conditions of normal use in conformity with the Instruction Manual, product labeling (including stamped markings), and other precautionary information will be repaired free of charge, up to the original purchase price. Hioki reserves the right to decline to offer repair, calibration, and other services for reasons that include, but are not limited to, passage of time since the product's manufacture, discontinuation of production of parts, or unforeseen circumstances.
2. Malfunctions that are determined by Hioki to have occurred under one or more of the following conditions are considered to be outside the scope of warranty coverage, even if the event in question occurs during the warranty period:
   a. Damage to objects under measurement or other secondary or tertiary damage caused by use of the product or its measurement results
   b. Malfunctions caused by improper handling or use of the product in a manner that does not conform with the provisions of the Instruction Manual
   c. Malfunctions or damage caused by repair, adjustment, or modification of the product by a company, organization, or individual not approved by Hioki
   d. Consumption of product parts, including as described in the Instruction Manual
   e. Malfunctions or damage caused by transport, dropping, or other handling of the product after purchase
   f. Changes in the product's appearance (scratches on its enclosure, etc.)
   g. Malfunctions or damage caused by fire, wind or flood damage, earthquakes, lightning, power supply anomalies (including voltage, frequency, etc.), war or civil disturbances, radioactive contamination, or other acts of God
   h. Damage caused by connecting the product to a network
   i. Failure to present this Warranty Certificate
   j. Failure to notify Hioki in advance if used in special embedded applications (space equipment, aviation equipment, nuclear power equipment, life-critical medical equipment or vehicle control equipment, etc.)
   k. Other malfunctions for which Hioki is not deemed to be responsible

*Requests
- Hioki is not able to reissue this Warranty Certificate, so please store it carefully.
- Please fill in the model, serial number, and date of purchase on this form.

16-01 EN

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- Please visit our website at www.hioki.com for the following:
  - ■ Regional contact information
  - ■ The latest revisions of instruction manuals and manuals in other languages.
  - ■ Declarations of Conformity for instruments that comply with CE mark requirements.
- All reasonable care has been taken in the production of this manual, but if you find any points which are unclear or in error, please contact your supplier or the International Sales and Marketing Department at Hioki headquarters.
- In the interests of product development, the contents of this manual are subject to revision without prior notice.
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