

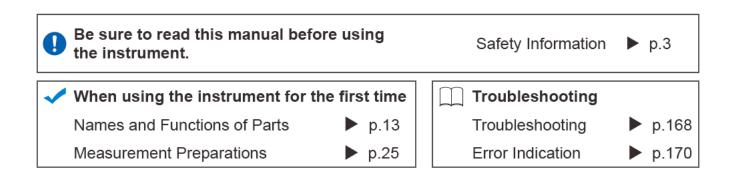


# PW3335-01,PW3335-02 PW3335-03,PW3335-04

Instruction Manual

# **POWER METER**





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# Contents

Introduction	1
Confirming Package Contents	2
Safety Information	3
Operating Precautions	5

# Chapter 1 Overview 11

Product Overview1	1
Features1	11
Names and Functions of Parts1	3
Measurement Workflow2	20
	Features       1         Names and Functions of Parts       1

# Chapter 2 Measurement Preparations 25

2.1	Installation and Connection Procedures
	25
2.2	Connecting the Measurement Lines26
	Connecting the measurement lines27
2.3	Connecting the Power Cord33
2.4	Turning On the Instrument
2.5	Performing Zero-adjustment35
2.6	Activating Power to the Measurement
	Lines
2.7	Turning Off the Instrument

# Chapter 3 Configuration and Measurement 37

3.1	Pre-Measurement Inspection					
3.2	Configuring Settings					
3.2.1	Selecting the Current Input Method	ł				
		38				
3.2.2	Selecting Display Content	40				
	Selecting display parameters	40				
	Selecting the rectifier					
3.2.3	Selecting the Voltage and Current					
	Ranges	43				
	Selecting the desired range	43				

	Automatically setting the range					
	(auto-range operation) 44 Skipping unnecessary ranges					
	(range select function)	46				
3.2.4	Setting the Synchronization Source (SYNC)	48				
3.2.5	Setting the Frequency Measuremen					
	Range(Zero-cross filter)					
	Significance of changing the zero-cross	-0				
	threshold level Setting the zero-cross filter's	52				
	threshold level	53				
3.2.6	Setting the Timeout	54				
3.2.7	-1					
	Average (AVG: Averaging)					
3.2.8	5					
	Setting the VT ratio Setting the CT ratio					
3.3						
	Starting integration					
	Stopping integration	64				
	Starting integration while adding to previous integrated values (additional integration)					
	Canceling integration (resetting integrated	04				
_	values) (DATA RESET)	65				
	Performing integration after setting an integration time (timer integration)	65				
	Enabling auto-range integration					
	Starting and stopping auto-range	~ ~				
-	Integration Integration precautions					
3.3.1						
3.4	Viewing Harmonic Measured Values					
3.4.1	Setting the Synchronization Source					
3.4.2	Method for Displaying Harmonic					
	Measurement Parameters	71				
3.4.3	Setting the Harmonic Analysis Order					
	Upper Limit	76				
3.4.4	About the HRM ERROR lamp	77				
3.5	Performing Synchronized Measuremen	t				
	with Multiple Instruments					
	(Multiple-instrument Synchronized					
_		78				
	Connecting 2 instruments (PW3335) with	70				
	a synchronization cable Configuring synchronized measurement .	79 80				

# Contents

3.6	External Control82
	External control terminal
_	(EXT.CONTROL)
	Connecting wires to the external control terminals
3.7	Using D/A Output85
	Connecting wires to D/A output terminals87
3.7.1	-
0.7.1	Output, and Waveform Output
	Setting the output parameter, rectifier,
	and output method for D/A output channels
_	
	Setting D/A output when enabling auto-range integration
	Example uses
	Output voltage of level output
	Output voltage of waveform output
3.8	Using a Current Sensor100
	Before connecting a current sensor 101
	Connecting a TYPE.1 current sensor 102
	Connecting a TYPE.2 current sensor 102 Setting external current sensor input 104
	Using an external CT 105
3.9	Other Functions
3.9.1	Fixing Display Values
	(Display Hold)106
	Activating display hold 106
	Canceling the display hold state 106
3.9.2	
_	Values (MAX/MIN)107
	Switching the display among the maximum,
	minimum, and instantaneous values107 Clearing maximum and minimum values .108
3.9.3	Disabling Control Keys (Key Lock) .109
	Enabling the key lock state
	Canceling the key lock state 109
3.9.4	Initializing the Instrument
	(System Reset)110
	Factory Settings 111
3.10	When warning lamp, o.r, or the Unit
	Indicator Flashes112
3.10.	1 If the PEAK OVER U or
	PEAK OVER I Lamp Lights Up112
3.10.	2 If the CURRENT • Lamp Flashes .112
3.10.	3 When o.r (over-range) Is Displayed 113
3.10.	4 When the Unit Indicator Flashes114
3.11	Connecting the Instrument to
-	Hioki LR8410 Link compatible Logger . 115
	1

# Chapter 4 Connection to a PC 119

4.1	Configuring and Connecting the
	Instrument 120
4.1.1	Using the LAN Interface 120
	Setting the LAN's IP address 121
	Setting the LAN's subnet mask 122
	Setting the LAN's default gateway 123
	Displaying the LAN's MAC address 124
	Connecting the instrument to a computer
	with a LAN cable
_	Using the RS-232C Interface 127
	Setting the RS-232C communications
_	speed
	Connecting the RS-232C Cable 129
4.1.3	5
	Connecting the GP-IB Cable 132
	Setting the GP-IB address 133
4.2	Operating the Instrument from a PC's
	Browser (LAN only) 134
	Operating the instrument remotely 135
4.3	Canceling the Remote State
	(Activating the Local State) 137
	Canceling the remote state 137

# Chapter 5 Specifications 139

5.1	Environmental and Safety Specifications
5.2	General Specifications
5.3	Measurement specifications
5.4	Functional Specifications 158
5.5	Calculation Formulas Specificfations .163

# Chapter 6 Maintenance and Service 167

6.1 Troubleshooting	6.1	Troubleshooting		168
---------------------	-----	-----------------	--	-----

6.2 Error Indication	170
----------------------	-----

# ii

# Appendix

1	Detailed Specifications of	
	Measurement Items	
	(Display Items)	A1
2	Detailed Specifications of	
	Output	A2
2.1	Detailed Specifications of	
	Level Output	A2
2.2	Detailed Specifications of	
	High-speed Level Output	A3
2.3	Detailed Specifications of	
	Waveform Output	A3
3	Example Accuracy	
	Calculations	A4
4	Rack Mounting	A5
5	Dimensional Diagram	A9
6	Terminology	A10
	2 2.1 2.2 2.3 3 4 5	<ul> <li>Measurement Items (Display Items)</li></ul>

Index

Index1

**A1** 

N = 4 1 = - 4 = 11 = -1

# Introduction

Thank you for purchasing the HIOKI PW3335, PW3335-01, PW3335-02, PW3335-03, PW3335-04 Power Meter. To obtain maximum performance from the instrument software, please read this manual first, and keep it handy for future reference.

DW3335	DW3335-01	DW3335-02	DW3335-03	PW3335-04	Show the model that is equipped with each function
F W0000	F W3333-01	F W3333-02	F W3333-03	F W 3333-04	as the icon.

The models are classified according to the factory-installed options as follows.

					<ul> <li>– : Not installed</li> </ul>
	Standard equipment	Factory-installed options			
Model	LAN	RS-232C	GP-IB	D/A output	External current sensor input
PW3335	•	•	_	-	_
PW3335-01	•	-	•	-	-
PW3335-02	•	•	-	•	-
PW3335-03	•	•	_	_	•
PW3335-04	•	•	•	•	•

You can check the model number on the rear of the instrument.

See: "Rear" (p.18)

Model PW3335-03 and PW3335-04 can measure relatively high current with the use of HIOKI Clamp on Sensors (clamp sensors), which are option, or current sensors. Hereafter, those sensors are collectively referred to as "current sensors". Please read the instruction manuals of each sensor for details before using. The current sensors are classified as either "TYPE.1" or "TYPE.2" according to the output specifications. Using a TYPE.2 current sensor requires Model 9555-10 Sensor Unit, which is option. Please refer to the instruction manual of Model 9555-10 for details.

See: "3.8 Using a Current Sensor" (p.100)

## Trademark

- Microsoft and Internet Explorer are either registered trademarks or trademarks of Microsoft Corporation in the United States and other countries.
- Bluetooth<sup>®</sup> is a registered trademark of Bluetooth SIG, Inc.(USA). The trademark is used by HIOKI E.E. CORPORATION under license.
- Parani<sup>TM</sup> is a trademark of Sena Technologies Inc.

# **Confirming Package Contents**

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

Store the packaging in which the instrument was delivered, as you will need it when transporting the instrument.

## Instrument and accessories

Confirm that these contents are provided.

Example: PW3335



□ PW3335, PW3335-01, PW3335-02, PW3335-03, PW3335-04 Power Meter

□ Power cord

 $\square$  Voltage and current input terminal safety cover ×2

□ Safety cover installation screws (M3×6 mm) ×4

## **Options (sold separately)**

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

#### **Communications and control options**

	•
Model 9637	RS-232C Cable (9pin-9pin/ 1.8 m, crossover cable)
Model 9638	RS-232C Cable (9pin-25pin/ 1.8 m, crossover cable)
Model 9642	LAN Cable(5 m, Supplied with Cross-Over Adapter)
□ Model 9151-02	GP-IB Connector Cable (2 m)
Model 9165	Connection Cord (1.5 m, metal BNC to metal BNC, not CE marked, for the synchronized
	measurements)

#### **Current sensor options**

□ Model 9661 □ Model 9669	Clamp on Sensor (500 A AC) Clamp on Sensor (1000 A AC)
□ Model 9660	Clamp on Sensor (100 A AC)
□ Model CT9667	Flexible Clamp on Sensor (500 A/5000 A AC)
□ Model 9555-10	Sensor Unit
Model L9217	Connection Cord
□ Model 9272-10	Clamp on Sensor (20 A/200 A AC)
Model 9277	Universal Clamp on CT (20 A AC/DC)
Model 9278	Universal Clamp on CT (200 A AC/DC)
Model 9279	Universal Clamp on CT (500 A AC/DC)
Model 9709	AC/DC Current Sensor (500 A AC/DC)
□ Model CT6862	AC/DC Current Sensor (50 A AC/DC)
□ Model CT6863	AC/DC Current Sensor (200 A AC/DC)
□ Model CT6865	AC/DC Current Sensor (1000 A AC/DC)
□ Model CT6841	AC/DC Current Probe (20 A AC/DC)
□ Model CT6843	AC/DC Current Probe (200 A AC/DC)

# **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.



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.



With regard to the electricity supply, there are risks of electric shock, heat generation, fire, and arc discharge due to short circuits. If persons unfamiliar with electricity measuring instruments are to use the instrument, another person familiar with such instruments must supervise operations.

# Notation

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

1 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.
	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.
Â	Indicates a high voltage hazard. If a particular safety check is not performed or the instrument is mishandled, this may give rise to a haz- ardous situation; the operator may receive an electric shock, may get burnt or may even be fatally injured.
$\bigcirc$	Indicates prohibited actions.
	Indicates the action which must be performed.
*	Additional information is presented below.

# Symbols affixed to the instrument

$\triangle$	Indicates cautions and hazards. When the symbol is printed on the instrument, refer to a corresponding topic in the Instruction Manual.
	Indicates the ON side of the power switch.
Ο	Indicates the OFF side of the power switch.
Ŧ	Indicates a grounding terminal.
$\sim$	Indicates AC (Alternating Current).

# Symbols for various standards



Indicates the Waste Electrical and Electronic Equipment Directive (WEEE Directive) in EU member states.

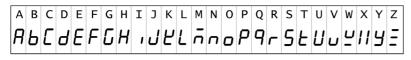
This symbol indicates that the product conforms to regulations set out by the EU Directive.

# **Other Symbols**

(p. )	Indicates the location of reference information.
SET (Boldface)	Bold-faced alphanumeric characters in the text indicate characters shown on the operation keys and display panel.

# Screen display

The screen of this instrument displays characters in the following manner.



1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0

# Accuracy

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

f.s. (range)	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.	

For example accuracy calculations, see "Appendix 3 Example Accuracy Calculations" (p. A4).

# **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.

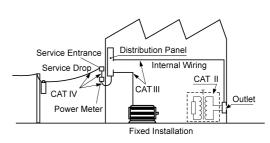


Using a measuring instrument in an environment designated with a higher-numbered category than that for which the instrument is rated could result in a severe accident, and must be carefully avoided.

 Using a measuring instrument without categories in an environment designated with the CAT II to CAT IV category could result in a severe accident, and must be carefully avoided.

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

CAT II	When directly measuring the electrical outlet recepta- cles of the primary electrical circuits in equipment con- nected 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 di- rectly 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 pri- mary overcurrent protection device (distribution panel)



# **Operating Precautions**

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

# **Before Use**



If the connection cable or the instrument is damaged, there is a risk of electric shock. Before using the instrument, perform the following inspection.

- Before using the instrument, check that the coating of the connection cables are neither ripped nor torn and that no metal parts are exposed. Using the instrument under such conditions could result in electrocution or a short-circuit. Replace the connection cables with those specified by our company.
- Before using the instrument for the first time, 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.

#### To measure accurately

- Warm up the instrument for more than 30 minutes before use.
- To maintain sufficient measurement accuracy of the instrument, be sure to help heat radiation.
   Example: Keeping away the instrument from a heat, leaving sufficient clearances around the instrument, installing cooling fans to the rack in which the instrument is mounted, or other measures.

# **Instrument Installation**

For more information about the operating temperature and humidity range and the storage temperature and humidity range, see "Chapter 5 Specifications" (p.139).

Avoid the following locations that could cause an accident or damage to the instrument.
Exposed to direct sunlight or high temperature
Exposed to corrosive or combustible gases
Exposed to water, oil, chemicals, or solvents
Exposed to high humidity or condensation
Exposed to a strong electromagnetic field or electrostatic charge
Exposed to high quantities of dust particles
Near induction heating systems (such as high-frequency induction heating systems and IH cooking equipment)

Susceptible to vibration

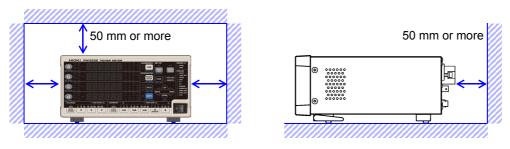
Ventilation holes for heat radiation are provided on the side and rear panels of the instrument. Leave sufficient space around the ventilation holes and install the instrument with the holes unobstructed. Installation of the instrument with the ventilation holes obstructed may cause a malfunction or fire.

Do not place another PW3335 or measuring instrument or other heat-generating device underneath or on top of this instrument. Doing so may damage the instrument or cause burns or fire.

## Installing

To prevent overheating, be sure to leave the specified clearances around the unit.

- The instrument should be operated only with the bottom downwards.
- · Vents must not be obstructed.



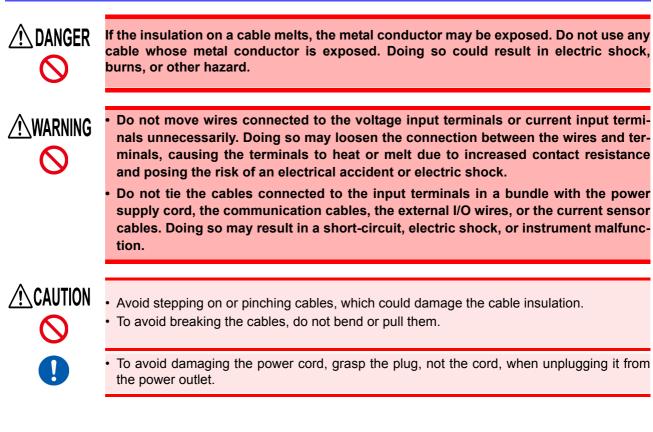
- Correct measurement may be impossible in the presence of strong magnetic fields, such as near transformers and high-current conductors, or in the presence of strong electromagnetic fields such as near radio transmitters.
- Unplugging the power cord kills power to the instrument. Be sure to provide enough unobstructed space to unplug the power cord immediately in an emergency.
- The instrument can be used with the stands flipped out.(p.19)
- To mount the instrument in a rack, refer to "Appendix 4 Rack Mounting" (p. A5)

# Handling the Instrument

▲ DANGER	To avoid electric shock, do not remove the instrument's case. The internal components of the instrument carry high voltages and may become very hot during operation.
∕∑WARNING	Do not allow the instrument to get wet, and do not take measurements with wet hands. This may cause an electric shock.
CAUTION	<ul> <li>To avoid damage to the instrument, protect it from physical shock when transporting and handling. Be especially careful to avoid physical shock from dropping.</li> <li>After use, always turn OFF the power.</li> </ul>

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

# Handling the Cables



# **Connecting, Input and Measurement**

<u>The maximum input voltage is 1000 V DC/AC and the maximum input current to the current input terminals is 30 A DC/AC.</u>

Attempting to measure a voltage or current in excess of each of the maximum inputs could destroy the instrument and result in personal injury or death.

• <u>The maximum rated voltage between input terminals and the ground is as follows:</u> (CAT II) 1000 V DC, 1000 V AC

(CAT III) 600 V DC, 600 V AC

Attempting to measure voltages exceeding this level with respect to ground could damage the instrument and result in personal injury.

- The external current sensor input terminals are not insulated. The terminals are exclusive to the optional current sensors. To prevent instrument damage and bodily injury, do not connect any device other than an optional current sensor.
- To avoid the danger of electric shock, do not input a signal in excess of the ratings to the external I/O terminals.
- <u>This instrument should only be connected to the secondary side of a breaker</u>, so the breaker can prevent an accident if a short circuit occurs. Connections should never be made to the primary side of a breaker, because unrestricted current flow could cause a serious accident if a short circuit occurs.
- To avoid electrical accidents, confirm that <u>all terminals are secure</u>. The increased resistance of loose connections can lead to overheating and fire. (Tightening torque of the input terminals: 3 Nm)

Safety covers

- The safety covers play a protective role by preventing contact with the terminals. Always attach the safety covers before using the instrument.
- Turn off the supply of power to measurement lines before attaching or removing the safety covers.

# A WARNING

#### When connecting

Observe the following to avoid electric shock and short circuits.

- Turn off the power to lines to be measured before making connections to input terminals and turning on the instrument.
- When making connections, do not mix up the voltage input terminals (U) and the current input terminals (I). In particular, do not input a voltage across the current input terminals (between I and ±). Using the instrument with a faulty wiring will damage the instrument or cause injury.

• Be careful to avoid shorting between the voltage input terminals with the wires.

# When abnormalities such as smoke, unusual noise, or unusual odor are observed

Stop the measurement immediately, and observe the following procedure. Using the instrument in such a abnormal condition could cause death or injury.

- 1. Turn off the power to the instrument.
- 2. Disconnect the power cord from the outlet.
- 3. Turn off the power to the line to be measured.
  - Remove the measurement cables.
- 4. Contact your authorized Hioki distributor or reseller.

When connecting cables to the input terminals, the communication connectors, or the external I/O terminals, observe the following to avoid electric shock and short circuits.

- Always turn off the power to the instrument and any device to be connected before making connections.
- Be careful to avoid exceeding the ratings of the input terminals or external control terminals.
- During operation, a wire becoming dislocated and contacting another conductive object can be serious hazard. Use the screws to secure the communication connectors.



For safety reasons, disconnect the power cord when the instrument is not used and before connecting it to a device to be tested.

- To avoid damage to the instrument, do not input the voltage to the output terminals. Also do
  not short between any terminals.
- When the instrument is turned off, do not apply voltage or current to the instrument. Doing so may cause the instrument to become hot, resulting in burns or damage to the instrument. (p.36)
- Do not connect or disconnect the current sensor or disconnect or connect the connection cord from the 9555-10 Sensor Unit while power is being supplied to the instrument or 9555-10. Doing so may damage the instrument, current sensor, or 9555-10.
- Do not input current to the current sensor when it is not connected to the instrument or when the instrument and 9555-10 Sensor Unit are turned off. Doing so may damage the current sensor, instrument, or 9555-10 Sensor Unit.

The instrument and input terminals may become hot when a large voltage or current is input.

# **Before Turning Power On**



 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.

 To avoid electrical accidents and to maintain the safety specifications of this instrument, connect the power cord provided only to a 3-contact (two-conductor + ground) outlet.

See: Connection Methods: "2.3 Connecting the Power Cord" (p.33) See:



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.

# **Overview**

# **Chapter 1**

# 1.1 Product Overview

The PW3335 is a power meter that can be used to perform power measurements for single-phase devices such as battery-driven devices and household electronics.

Thanks to its broad selection of current ranges from 1 mA to 20 A (with an effective measurement range of 10  $\mu$ A to 30 A), it comprises a single-device solution for measuring parameters ranging from standby power consumption to power consumption during normal operation of devices such as household electronics.

# 1.2 Features

# Guaranteed accuracy up to 30 A with direct input

- · Accuracy is guaranteed for currents of up to 30 A with direct input.
- (The maximum input current is 30 A, ±100 A peak.)
- An optional current sensor can be used to measure currents in excess of 30 A. (p.100)

# High-accuracy, wide-band performance

- The instrument delivers a high fundamental accuracy of ±0.15% rdg. (at less than 50% of range, ±0.1% rdg. ±0.05% f.s.).
- Over a wide band from DC and 0.1 Hz to 100 kHz, the instrument covers not only the fundamental frequency band for inverter-driven equipment, but also the carrier frequency band.
- Power factor effects are low at ±0.1%f.s. or less (with a internal circuit voltage/current phase difference of ±0.0573°), allowing high-accuracy measurement of active power during low power-factor operation, for example during no-load testing of transformers and motors.

# Standard harmonic measurement function compliant with IEC 61000-4-7:2002 (p.71)

- The instrument can perform harmonic measurement compliant with the IEC 61000-4-7:2002 international standard on harmonic measurement methods.
- You can set an upper limit for the analyzed order from the 2nd to 50th order according to the harmonic measurement standard in use.

# Extensive measurement functionality, standard

Since processing for functions such as AC+DC (RMS), AC+DC Umn (voltage average value rectified RMS equivalent), DC (DC component), AC (AC component), FND (fundamental wave component), and harmonic measurement as well as integration measurement can be performed internally and in parallel, it is possible to obtain simultaneous measured values simply by switching the display.

# High-speed D/A output to capture harsh load variations (p.85) PW3335-02 PW3335-04

- The PW3335 can generate level (analog) output for each cycle of an input voltage or input current. Additionally, The active power level can be output for each cycle for the voltage or current assigned to the synchronization source.
- Variations over extended periods of time can be recorded by using the instrument in conjunction with equipment such as a recorder or data logger using level output (updated every 200 ms) to measure parameters such as voltage, current, and active power.
- Safe, insulated waveforms can be observed using waveform output (equivalent to a sampling rate of approximately 700 kHz) instantaneous voltage, instantaneous current, and instantaneous power.

# Building a system with 3 interfaces (p.119)

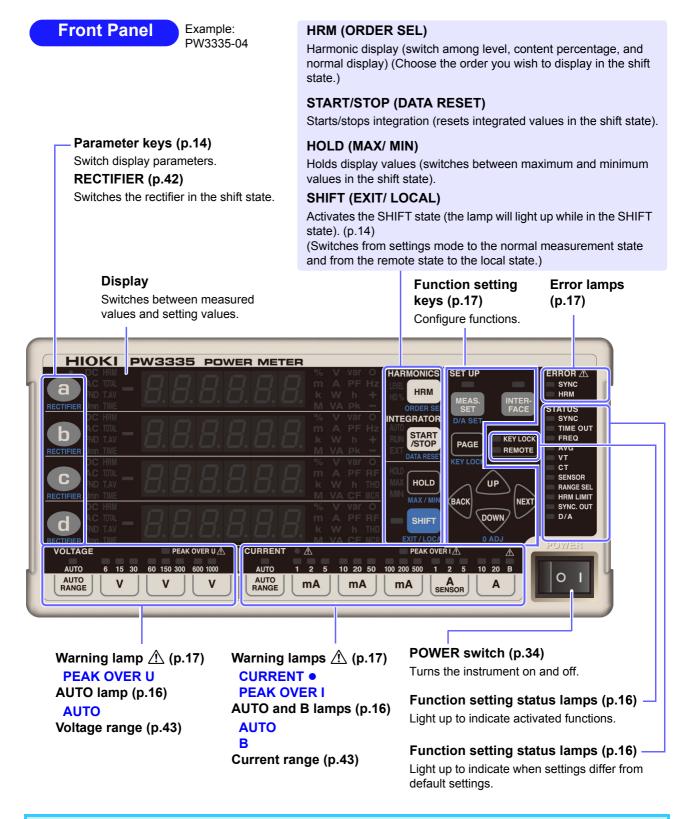
- You can control the instrument or capture data from it using a computer by using the LAN interface (standard) or RS-232C interface (excluding PW3335-01). (You can also communicate with a computer over USB by using a commercially available USB serial [RS232-C] conversion cable.)
- The instrument is also available with a GP-IB interface, which is essential for system development.

( PW3335-01 PW3335-04 )

# Synchronized control function with support for measurement of multiple circuits (p.78)

- Simultaneous measurement can be performed by connecting two instruments with an optional BNC cable.
- Calculations, display updates, data updates, integration control, display hold timing, zero-adjustment, and key lock operation of the instrument set as the slave (IN setting) are matched to the master instrument (OUT setting).
- Up to eight instruments can perform simultaneous measurement, including the PW3336 and the PW3337 series of power meters.

# 1.3 Names and Functions of Parts



- The shift state is automatically canceled after Approx. 10 seconds. When the RECTIFIER key is pressed, the shift state is canceled after Approx. 2 seconds.
- If key operation causes a message or indication that is not described in this manual to be displayed, immediately cycle the instrument's power.

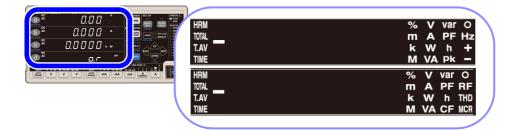
1.3 Names and Functions of Parts

# Activates the SHIFT state



Press SHIFT to light up the blue lamp before setting functions shown in blue underneath theys.

# **Display parameters**



Pressing (a) on the first row, (b) on the second row, (c) on the third row, or (d) on the fourth row of the measured value display switches the display parameter, causing the selected display parameter to light up.

V	Voltage (U)	CF V	Voltage crest factor (Ucf)
Α	Current (I)	CF A	Current crest factor (Icf)
W	Active power (P)	MCR	Maximum current ratio
VA	Apparent power (S)	T.AV A	Time average current (T.AV I)
var	Reactive power (Q)	T.AV W	Time average active power (T.AV P)
PF	Power factor (λ)	RF V %	Voltage ripple rate (Urf)
0	Phase angle (φ)	RF A %	Current ripple rate (Irf)
V Hz	Voltage frequency (f)	THD V %	Total harmonic voltage distortion (Uthd)
A Hz	Current frequency (f)	THD A %	Total harmonic current distortion (Ithd)
Ah +	Positive current integration	HRM V LEVEL	Harmonic voltage RMS value (Uk)
Ah -	Negative current integration	HRM A LEVEL	Harmonic current RMS value (Ik)
Ah	Current integration sum	HRM W LEVEL	Harmonic active power (Pk)
Wh +	Positive active power integration	HRM V % HD%	Harmonic voltage content percentage (UHDk)
Wh -	Negative active power integration		
Wh	Active power integration sum	HRM A % HD%	Harmonic current content percentage (IHDk)
TIME	Integration time		Harmonic active power content per-
V pk	Voltage waveform peak value (Upk)	HRM W % HD%	centage (PHDk)
A pk	Current waveform peak value (lpk)		

# **Rectifier indicator lamps (p.42)**



DC AC	When using the AC+DC rectifier, both the DC and AC lamps light up.
DC AC Umn	When using the AC+DC Umn rectifier, the DC, AC, and Umn lamps light up.
DC	Lights up when using the DC rectifier.
AC	Lights up when using the AC rectifier.
FND	Lights up when using the FND rectifier.

# Harmonic measurement (HARMONICS) lamps (p.71)

	LEVEL	Lights up when the instrument is displaying a harmonic compo- nent level (harmonic voltage RMS value, harmonic current RMS value, or harmonic active power).
HARMONICS LEVEL HD % ORDER SEL	HD%	Lights up when the instrument is displaying a harmonic content percentage (harmonic voltage content percentage, harmonic current content percentage, or harmonic active power content percentage).

# Integration (INTEGRATOR) status indicator lamps (p.61)

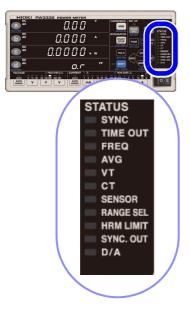
	Αυτο	Indicates the integration operating mode. AUTO lamp on: Auto-range integration mode AUTO lamp off: Fixed-range integration mode
INTEGRATOR AUTO RUN START EXT DATA RESET	RUN	Indicates the status of integration based on START/STOP key operation or communications. <b>RUN</b> lamp on: Integration active <b>RUN</b> lamp flashing: Integration stopped <b>RUN</b> lamp off: Integration reset
	RUN EXT	Indicates the status of integration based on external control. <b>RUN</b> lamp on, <b>EXT</b> lamp on: Integration active <b>RUN</b> lamp flashing, <b>EXT</b> lamp on: Integration stopped <b>RUN</b> lamp off, <b>EXT</b> lamp off: Integration reset

# Hold (HOLD) status indicator lamp (p.106)

HOL MA MI	

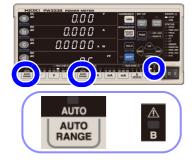
HOLD	When the HOLD, MAX, and MIN lamps are all off, pressing the SHIFT key and then HOLD causes the instrument to enter the display hold state and the HOLD lamp to light up. To cancel display hold: Pressing HOLD once more causes the display hold state to be canceled and the HOLD lamp to be turned off.
МАХ	When the HOLD, MAX, and MIN lamps are all off, pressing SHIFT and then HOLD causes the maximum value to be held and the MAX lamp to light up.
MIN	Pressing HOLD while the MAX lamp is lit up (indicating that the maximum value is being held) causes the minimum value to be held and the MIN lamp to light up. Pressing HOLD while the MIN lamp is lit up (indicating that the minimum value is being held) causes the minimum value hold to be canceled, returning to the normal measured value display.

# Function setting status lamps



	(the default setting is voltage. 0). (p.+0)	
TIME OUT	Lights up when the synchronization detection timeout is set to 1 sec. or 10 sec. (the default setting is 0.1 sec.). (p.54)	
FREQ	Lights up when the zero-cross and frequency measure- ment filter setting is set to 100 Hz, 5 kHz, or 100 kHz (the default setting is 500 Hz). (p.50)	
AVG	Lights up when the number of averaging iterations is set to a value other than the default value of 1. (p.56)	
VT	Lights up when the VT ratio setting is set to a value other than the default setting of 1. (p.58)	
СТ	Lights up when the CT ratio setting is set to a value other than the default setting of 1. (p.58)	
SENSOR	Lights up when the current input method setting is set to TYPE.1 or TYPE.2 (current sensor input) (the default set ting is OFF [current value direct input]). (p.38)	
RANGE SEL	Lights up when either the voltage measurement range or current measurement range is set to OFF. (the default set- ting is range select: ON). (p.46) Lights up when any of the zero-cross threshold levels is set to a value other than the default setting of 1%. (p.52)	
HRM LIMIT	<b>RM LIMIT</b> Lights up when the harmonic analysis order upper limit is set to a value other than the default value of 50. (p.76)	
SYNC. OUT Lights up when the synchronized measurement I/O sett is set to OUT (Master). Flashes with external synchroniz signal input when set to IN (Slave). Turns off when set OFF. (p.78)		
D/A	PW3335-02 PW3335-04 Lights up when the 7 channels of D/A output are set to val ues other than their default values. (p.88)	

Function lamps light up when set to a value other than the default setting.



WARNING

They light up when the corresponding function is ON.		
<b>KEY LOCK</b> Lights up when key operation is disabled. (p.109)		
<b>REMOTE</b> Lights up when the instrument is in remote operation mod (p.137)		
AUTO Lights up when the voltage or current measurement range is set to auto range (the default setting is auto range OFF (p.43)		
B Indicates the B 20 A range used in auto-range integra mode. Lights up when a range is selected while integr is stopped. (p.61)		

When the VT and CT lamps are lit up (particularly when the VT ratio and CT ratio are set to values less than 1), a voltage or current greater than the displayed measured value may have been input to the instrument. To prevent an electrical accident or short-circuit, do not unnecessarily touch the instrument's input terminal or the measurement lines.

These lamps indicate the instrument's overall setting status.

SYNCLights up when the synchronization source is set to I or DC<br/>(the default setting is voltage: U). (p.48)

These lamps indicate the setting status.

# Warning <a>M</a> indicator lamps

PEAK OVER U 🖄	CURRENT
PEAK OVER I 🗥	

The following warning lamps are lit up when there is a hazard or the instrument is unable to perform measurement accurately:

PEAK OVER U	Lights up when an overvoltage input warning occurs, indicating that the input voltage peak value has exceeded $\pm 1,500$ V or $\pm 600\%$ of the voltage measurement range.
PEAK OVER I	Lights up when an overcurrent input warning occurs, indicating that the input current peak value has exceeded $\pm 100 \text{ A}$ or $\pm 600\%$ of the current measurement range.
CURRENT ●	Instrument protection mode. Flash when if current of greater than or equal to $\pm$ 612 mA peak is inputted continuously for 10 or more seconds when using a range from 1 mA to 100 mA with fixed range. If you attempt to switch from one of the 200 mA to 20 A rang- es to one of the 1 mA to 100 mA ranges while a current of $\pm$ 612 mA peak or greater is being input, you will not be able to switch ranges, and the indicator will flash.

# **Error indicator lamps**

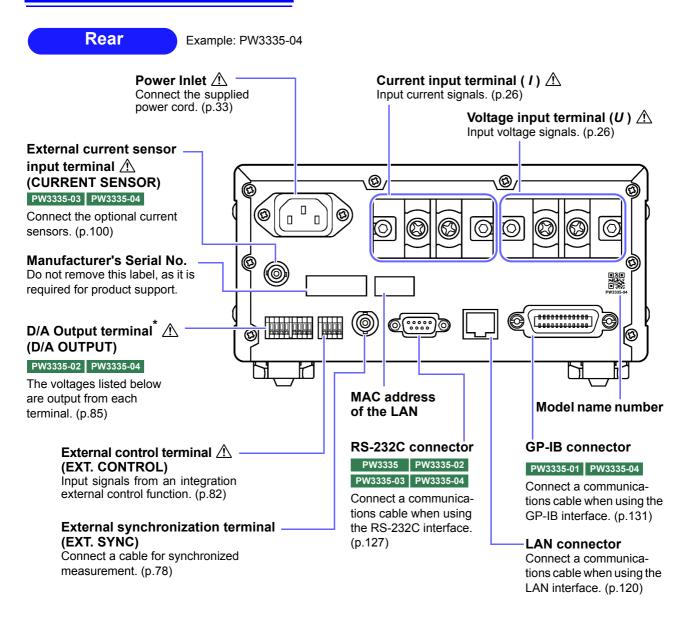
I he follow surement
SYNC
HRM

The following error lamps are lit up when the instrument is unable to perform measurement accurately:

	SYNC	Lights up when a synchronization error occurs, indicating that synchronization cannot be detected. (p.48)
)	HRM	Lights up when a harmonic measurement synchronization error occurs, indicating that the harmonic measurement syn- chronization frequency range was exceeded. (p.71)

# Function setting keys and indicator lamps

0,		•
	MEAS. SET MEAS. SET D/A SET	The lamp will light up if pressed when the following set- tings are being configured: • Synchronization source • Current input method • Range select • CT ratio • VT ratio • Frequency measurement range (zero-cross filter) • Synchronization detection timeout • Integration time, auto-range integration • Number of averaging iterations • Harmonic analysis upper limit order • Synchronized measurement I/O (master, slave) • D/A output PW3335-02 PW3335-04
	INTERFACE INTER- FACE	The lamp will light up if pressed when setting the inter- face. • LAN • RS-232C PW3335 PW3335-02 PW3335-03 PW3335-04 • GP-IB PW3335-01 PW3335-04
	PAGE	<ul> <li>Used to switch among settings configured with</li> <li>MEAS. and INTER- FACE</li> <li>Used with the key lock function.</li> </ul>
	BACK DOWN NEXT	<ul> <li>Used to move among and select settings.</li> <li>Pressing and holding the flashing setting to move successively.</li> </ul>

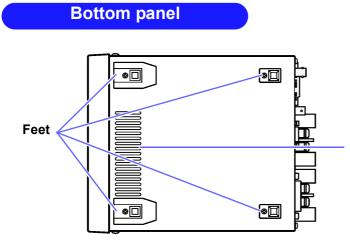


#### \*D/A OUTPUT terminals

The following voltages are output from each terminal. Level output: Level (analog) output is updated at an interval of approximately 200 ms. High-speed level output: The active power for every cycle for the voltage or current set as the synchronization source is output.

Waveform output: The input waveform as sampled at a frequency of approximately 700 kHz is output.

Terminal	Default setting	Description
DA1	V : AC+DC, STD.2	Each D/A output terminal can be set to any of the following:
DA2	A : AC+DC, STD.2	Level output
DA3	W : AC+DC, STD.2	High-speed level output
DA4	PF : AC+DC, STD.2	Waveform output
DA5	V : AC+DC, FASt	See: Appendix 2 Detailed Specifications of Output (p. A2)
DA6	A : AC+DC, FASt	
DA7	W : AC+DC, FASt	

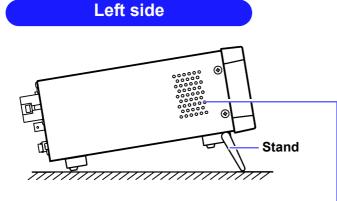


This instrument can be rack-mounded by removing its feet.

See: Appendix 4 Rack Mounting (p. A5)

Parts removed from this instrument should be stored in a safe place to enable future reuse.

Vents Keep clear of obstructions.



# 

**Right side** 

When using the stands

Open the stands until they clicks into place. Be sure to use both stands.

#### When folding up the stands

Fold up the stands until they click into place.

Keep clear of obstructions.

Clean the vents periodically to avoid blockage.



Do not apply heavy downward pressure with the stand extended. The stand could be damaged.

# **1.4 Measurement Workflow**

Install the instrument, connect wires and cords, and turn on the instrument.

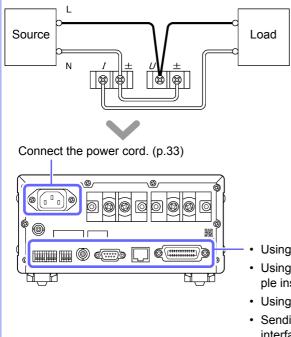
# Installing the Instrument (p.6)

#### CHECKS

- · Are the wires from the measurement targets shut off?
- · Is the instrument turned off, and has the power cord been disconnected?

## **Connecting Wires and the Power Cord**

Connect the measurement lines to the instrument and then connect the power cord to the instrument. Connect wires. (p.26) Example: • Is the instrument connected on the secondary side of



- Is the instrument connected on the secondary side of the circuit breaker?
- Does the circuit being used exceed 1,000 V?
- Does the voltage or current being measured exceed 1,000 V or 30 A, respectively? If so, use VT and CT.
- Are appropriate types of wire being used to connect to the voltage and current input terminals? Use solderless terminals that cover wiring with insulation. Moreover, use wire with adequate dielectric strength and current capacity.
- Has the wiring been shorted?
- Are the input terminals loose?
- Have wires been connected properly?
- Using D/A output(p.85)
- Using synchronized control to conduct measurements with multiple instruments simultaneously (p.78)
- Using external control to control integration (p.61)
- Sending and receiving data with the RS-232C, LAN, and GP-IB interfaces (p.119)

When using one or more current sensors, see "3.8 Using a Current Sensor" (p.100).

## **Turning on the instrument (p.34)**

Before turning on the instrument, verify that the wires have been connected properly one more time. After displaying the initial screen, the instrument will display input values under the current settings.

#### Allow the instrument to warm up for at least 30 minutes.

#### Perform zero-adjustment.

To fulfill the instrument's accuracy specifications, be sure to perform zero-adjustment for the voltage and current measured values.

# **2** Configure settings. (These settings can also be changed during measurement.)

# Setting the current input method (p.38)



Selecting display parameters (p.40)



Selecting voltage and current ranges (p.43)



# Setting the synchronization source (p.48)

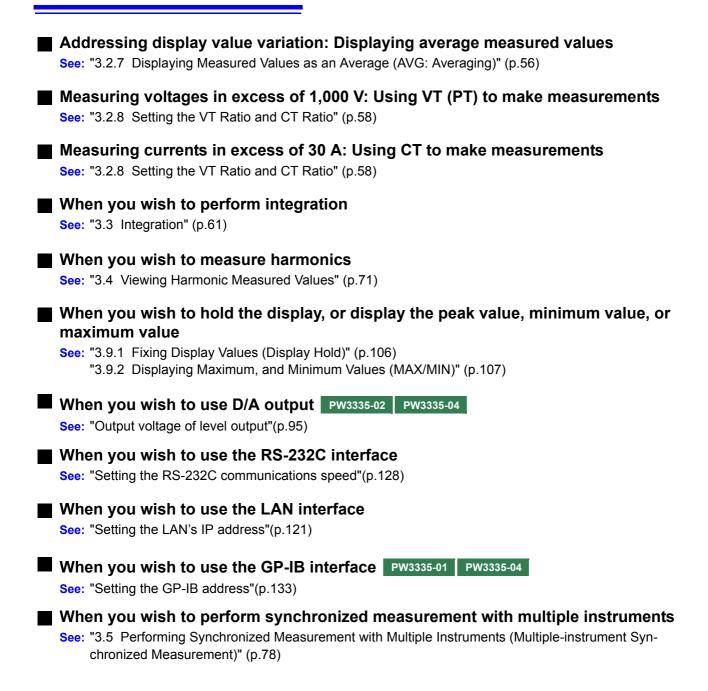


# **Selecting rectifiers (p.42)**



Configure the following settings as necessary:

When SYNC lamp (ERROR) lights up: Setting the frequency measurement range See: "3.2.5 Setting the Frequency Measurement Range (Zero-cross filter)" (p.50)



# **3** Start measurement.

# Activating power to the measurement lines

# Measuring and outputting data

## The instrument will display the measured values. You can change the voltage and current range as well as display parameters during measurement. Example: DC AC 220.56 Voltage AC Current AC k W Active power Power factor When you wish to hold display Displaying maximum and minimum values (p.106) values (p.107) Press HOLD Press HOLD while holding down SHIFT

# Stop measurement.

# **Turning off the instrument**

Turn off power to the measurement lines and after disconnecting the cords from the measurement target, turn off the instrument.

See: "2.4 Turning On the Instrument" (p.34)

#### About measured values

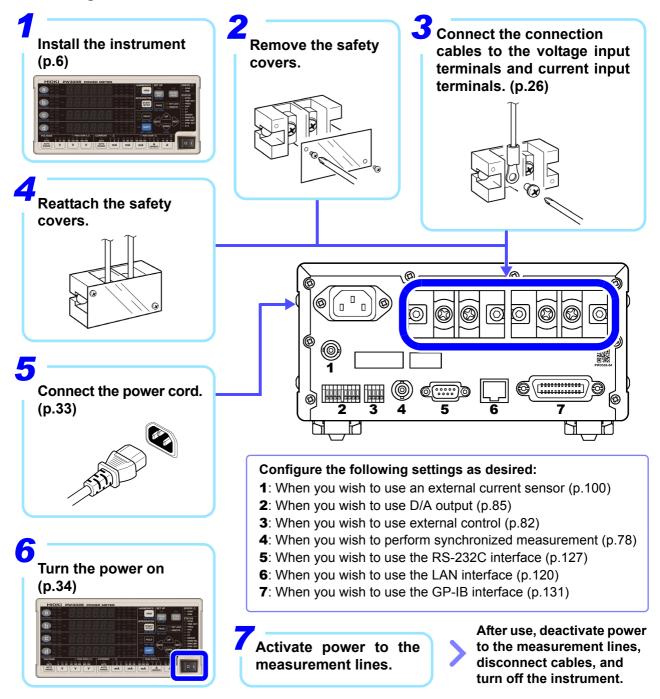
- The instrument's apparent power (S), reactive power (Q), power factor (λ), and phase angle (φ) are calculated based on the measured voltage (U), current (I), and active power (P). For the actual equations used, see "5.5 Calculation Formulas Specifications" (p.163). Values displayed by the instrument may differ from values displayed by measuring instruments that use different operating principles or equations.
- Voltage values that are less than  $\pm 0.5\%$  of the measurement range and current values that are less than  $\pm 0.5\%$  of the measurement range or less than  $\pm 9 \mu A$  will be forcibly displayed as zero. (this is known as zero-suppression).
- Measured values may include an error component in measurements in which a terminal-to-ground voltage with a high frequency is input.
- Display values may exhibit variation in applications in which the frequencies of the voltage and current being measured differ.
- Measured values may include an error component when the instrument is used near a strong magnetic field such as that generated by a transformer or high-current path, a strong electric field generated by a radio or similar device, or a high-frequency magnetic field generated by a high-frequency current.

# Measurement Preparations

# **Chapter 2**

# 2.1 Installation and Connection Procedures

Please read "Operating Precautions" (p.5) carefully before installing or connecting the instrument. Verify that power to the measurement lines has been cut off before connecting the instrument to them.



# 2.2 Connecting the Measurement Lines

Please read "Handling the Cables" (p.7) carefully before installing, connecting the measurement lines, or connecting the instrument.



Verify that power to the measurement lines has been cut off before connecting the instrument to them.

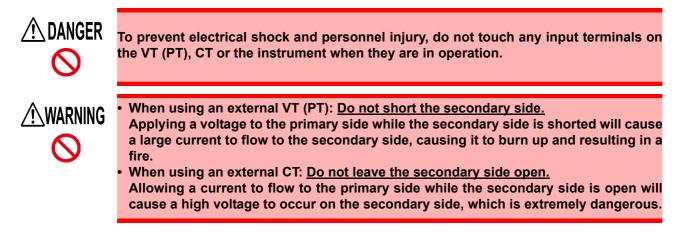
#### To ensure accurate measurement

- When measuring power, the polarity of the voltage and current affects readings, so it is essential to connect the instrument to the measurement lines properly. Accurate measurement will not be possible if these connections are not made properly.
- Route connected cables away from the instrument so that the electromagnetic field emitted by the cables does not affect the instrument's performance.

#### If the measurement target's voltage and current levels exceed the instrument's measurement range

By setting the VT ratio and CT ratio, you can read the measured current value (CT primary-side current) directly.

See: "3.2.8 Setting the VT Ratio and CT Ratio"(p.58)



#### When using a VT (PT) or CT

 Phase differences between an external VT (PT) and CT can introduce a large error component into power measurements.

To ensure accurate power measurement, use a VT (PT) and CT with a small phase error in the frequency band of the circuit being used.

• To ensure safe operation, always ground the load side of the VT (PT) and CT (see figure below)

## Wire materials (Voltage input terminal, Current input terminal)

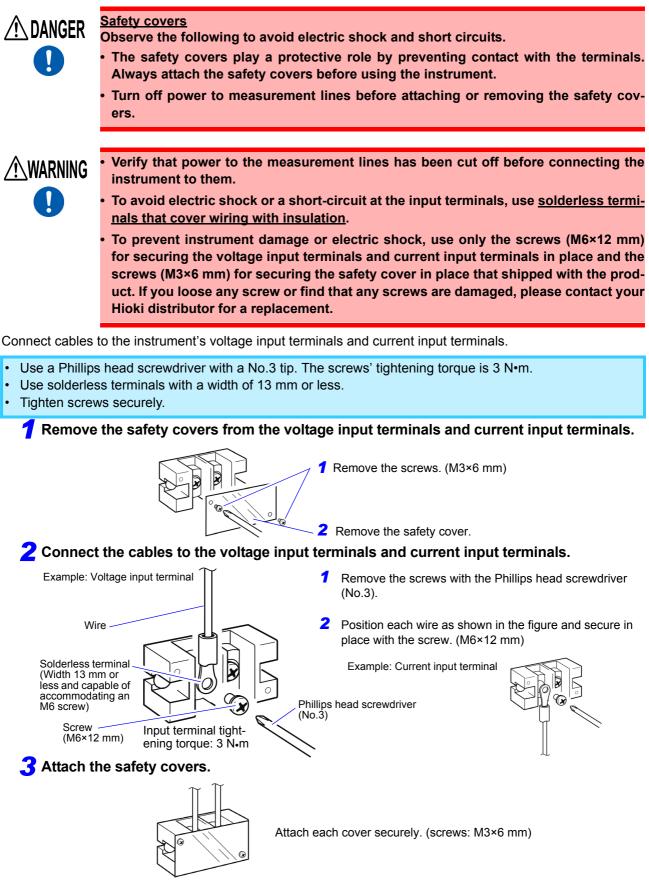


To avoid electric shock or a short-circuit at the input terminals, use <u>solderless termi-</u> nals that cover wiring with insulation. (Screws for voltage input terminals and current input terminals: M6)

To avoid electric shock, use wiring with adequate dielectric strength and current capacity.

# Connecting the measurement lines

Please read "Handling the Instrument" (p.7) carefully before connecting the instrument to the measurement lines.



## **4** Connect the instrument to the measurement lines.

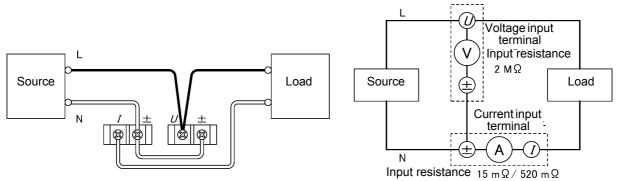
When measuring measurement lines that are within the maximum input range (voltage up to 1,000 V and current up to 30 A)

#### Connect the instrument to the measurement lines directly.

Instrument loss, which is caused by the input resistance of power measuring instruments' voltage and current inputs, increases with the input voltage and input current as well as with certain connection methods, and this in turn causes the error component of measured values to increase. Consequently, it is necessary to consider instrument error as one cause of inaccuracy in the power measured values required by standards such as IEC 62301:2011 (Household electrical appliance – Measurement of standby power). Calculate the instrument loss caused by the PW3335 based on the procedure described in "Example instrument loss calculation and connection method selection" (p.30) and choose the connection method that yields the least instrument loss.

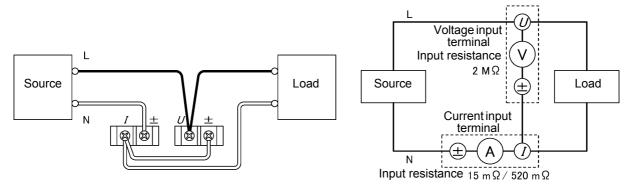
#### Method 1: Connect the current input terminals to the load side.

#### Wiring diagrams



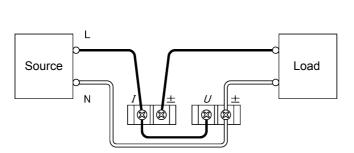
#### Method 2: Connect the voltage input terminals to the load side.

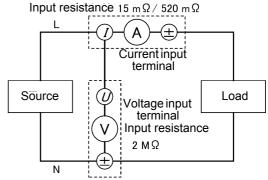
Wiring diagrams



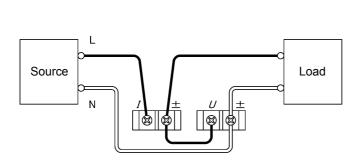
You can connect the instrument's current input terminals to the measurement line's L side (Hi side) as shown in the figure below and perform measurement using either Method 1 (connecting the current input terminals to the load side) or Method 2 (connecting the voltage input terminals to the load side), but these setups are susceptible to the effects of common-mode voltage. To reduce the effects of common-mode voltage, it is recommended to connect the current input terminals to the measurement line's N side (Lo side).

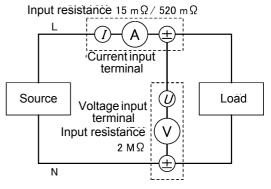
#### Method 1





Method 2





## Example instrument loss calculation and connection method selection

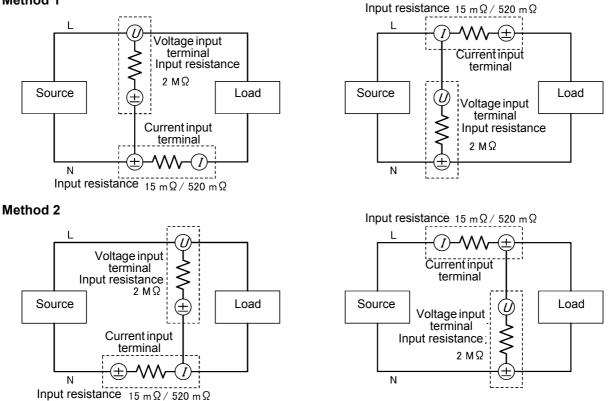
The instrument's voltage input resistance and current input resistance are as follows:

Voltage input resistance: 2 M $\Omega$  ±0.04 k $\Omega$  (same for all ranges)

Current input resistance: For the 1 mA to 100 mA ranges, less than or equal to 520 m $\Omega$ For the 200 mA to 20 A ranges, less than or equal to 15 m $\Omega$ 

Depending on the magnitude of the input voltage and input current, instrument loss (loss caused by the input resistance of the voltage inputs and the input resistance of the current inputs) will affect measured values. Following are examples of how to calculate instrument loss for the PW3335 and an explanation of how to choose the connection method.

#### Method 1



# Example 1: Input voltage of 100 V, current of 8 mA, and active power of 0.08 W (power factor of 0.1) Method 1:

With Method 1, instrument loss is caused by the current input resistance of the current inputs. Instrument loss =  $(Input current)^2 \times (Current input resistance)$ 

- (1) Using the 10 mA range (with a current input resistance of 520 m $\Omega$ ) Instrument loss = (0.008 A)<sup>2</sup> × 520 m $\Omega$  = 0.03328 mW
- (2) Using the 200 mA range (the range with the lowest current input resistance of 15 m $\Omega$ ) Instrument loss = (0.008 A)<sup>2</sup> × 15 m $\Omega$  = 0.00096 mW

Method 2:

With Method 2, instrument loss is caused by the voltage input resistance of the voltage inputs.

Instrument loss = (Input voltage)<sup>2</sup>  $\div$  (Voltage input resistance)

$$(100 \text{ V})^2 \div 2 \text{ M}\Omega = 5 \text{ mW}$$

Connect the instrument using Method 1, which has the lower instrument loss. The instrument loss in this configuration is 0.03328 mW (while using the 10 mA range) or 0.00096 mW (while using the 200 mA range).

Although it is possible to measure a current of 8 mA with the 200 mA range, which has an effective measurement range of 2 mA to 300 mA, measurement accuracy will suffer. To make this measurement at a higher level of accuracy, use a lower range that does trigger a peak value overage (i.e., one for which the **PEAK OVER I** lamp does not light up).

#### Example 2: Input voltage of 3.3 V DC, current of 28 A DC, and active power of 92.4 W DC

Method 1:

Since the input current is 28 A DC, the 20 A range (with an effective measurement range of 0.2 A to 30 A) will be used.

Instrument loss =  $(Input current)^2 \times (Current input resistance)$ 

= (28 A)<sup>2</sup> × 15 mΩ = 11.76 W

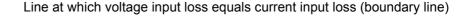
Method 2:

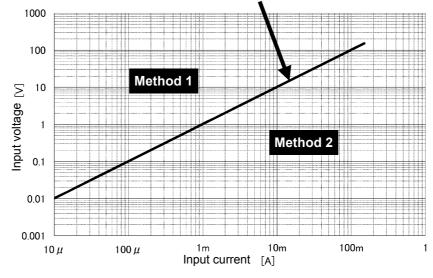
Instrument loss =  $(\text{Input voltage})^2 \div (\text{Voltage input resistance})$ =  $(3.3 \text{ V})^2 \div 2 \text{ M}\Omega = 0.000005445 \text{ W}$ 

Connect the instrument using Method 2, which has the lower instrument loss. The instrument loss in this configuration is 0.000005445 W.

The following figure provides some guidelines for choosing the connection method. The horizontal axis represents input current, and the vertical axis represents input voltage. The straight line on the graph indicates values for which the loss caused by the input resistance of the voltage inputs is equal to the loss caused by the input resistance of the current inputs. Using this line as a boundary, chose Method 1 when the input falls in the area above and to the left of the line, and choose Method 2 when the input falls in the area below and to the right of the line. For example, if the input voltage is 100 V, you would use an input current of 600 mA (in fact, 577.4 mA) as the boundary, choosing Method 1 for currents of less than approximately 600 mA and Method 2 for currents of greater than approximately 600 mA.

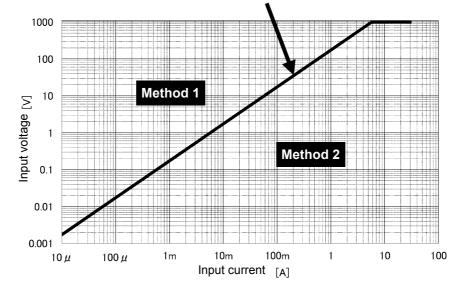
#### Current input resistance: 520 mΩ





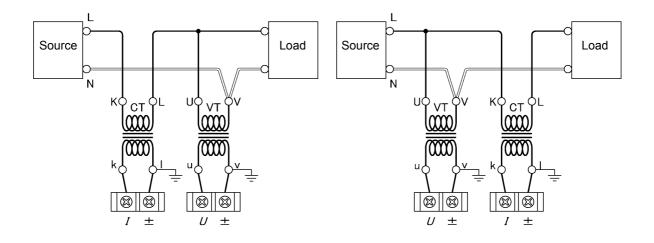


Line at which voltage input loss equals current input loss (boundary line)



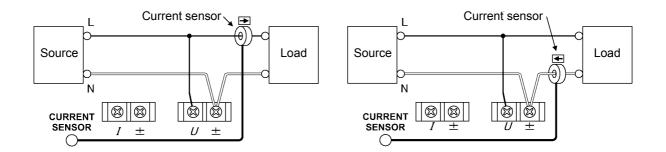
2 When measuring measurement lines that exceed the maximum input voltage (1000 V) or maximum input current (30 A)

Connect the instrument using a VT (PT) and CT.



**3** When measuring measurement lines that exceed the maximum input current (30 A)

Connect the instrument using a optional current sensor. (PW3335-03 or PW3335-04 only)



# 2.3 Connecting the Power Cord

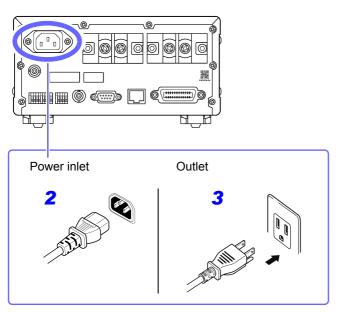


 Before turning the instrument on, make sure <u>the supply voltage matches that indi-</u> <u>cated on the its power inlet</u>. Connection to an improper supply voltage may damage the instrument and present an electrical hazard. <u>Rated supply voltage: 100 V AC to 240 V AC, rated power supply frequency: 50 Hz/</u>

- Rated supply voltage: 100 V AC to 240 V AC, rated power supply frequency: 50 Hz/
- To avoid electrical accidents and to maintain the safety specifications of this instrument, connect the power cord provided only to a 3-contact (two- conductor + ground) outlet.

Turn off the power before disconnecting the power cord.

Rear

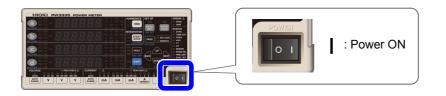


- Check that the instrument's power is turned off.
- **2** Connect a power cord that matches the line voltage to the power inlet on the instrument.
- **3** Plug the other end of the power cord into an outlet.

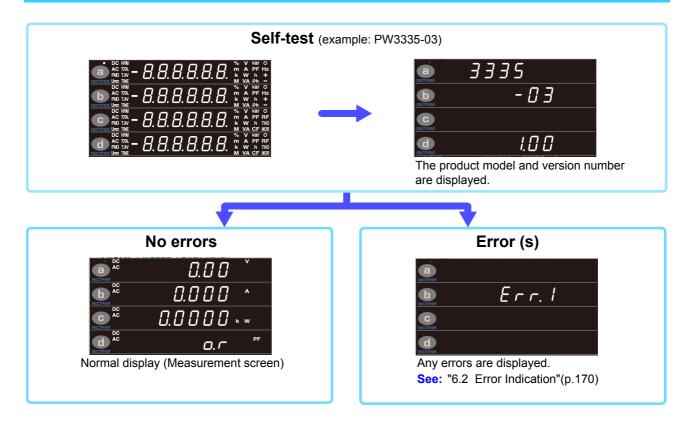
# 2.4 Turning On the Instrument

Turn the POWER switch on ( | ).

When the instrument is turned on, it will start a self-test. During the self-test, all indicators will light up, and then the model and version number will be displayed. Finally, hardware and saved data will be checked.



- Do not press any keys during the self-test.
- Key processing is embedded in the instrument for production and verification purposes. For example, this
  processing includes transitioning to an adjustment mode. If key operation causes a message or indication
  that is not described in this manual to be displayed, immediately cycle the instrument's power.



The current settings when the instrument was last turned off will be restored the next time it is turned on (backup function).

If you're using the instrument for the first time, the default settings will be used. (p.111)

 To ensure good measurement precision, allow the instrument to warm up for at least 30 minutes after turning it on.

# 2.5 Performing Zero-adjustment

Zero-adjustment (offset adjustment) is performed for voltage and current measured values after the instrument has warmed up for approximately 30 minutes in order to ensure that its measurement accuracy specifications are satisfied. During zero-adjustment, the offsets of the instrument's voltage and current internal circuitry are adjusted.

Zero-adjustment should always be performed before starting measurement after the instrument has warmed up.

- Perform zero adjustment when there is no input to the instrument, after deactivating power to measurement lines. If zero-adjustment is performed while there is input to the instrument, the process will not complete normally, and you will be unable to make accurate measurements.
- Optional current sensors 9277, 9278, 9279, CT6841, and CT6843 are not degaussed. Degauss current sensors as described in the instruction manual that came with each current sensor before performing the instrument's zero-adjustment process.
- When using the CT6841/CT6843, perform zero-adjustment for the CT6841/CT6843 using the 1 A range noted on the panel.

Zero-adjustment adjusts offsets within the following ranges:

Voltage circuitry: ±15% of the measurement range

Current direct input circuitry: ±15% of the measurement range

External current sensor input circuitry: ±15% of the measurement range

Operating time: Approx. 30 sec. (No measured values are displayed during zero-adjustment.)



- Deactivate power to measurement lines and ensure that no input is being supplied to the instrument.
- Press SHIFT to place the instrument in

the shift state and then press



During zero-adjustment (approximately 30 sec.), [----] will be displayed.

Once zero-adjustment is complete, the instrument will change to the normal display (Measurement screen) and be ready for measurement.

- Zero-adjustment is performed for all voltage and current ranges, regardless of current input method.
- Settings cannot be changed, and integration cannot be started, during zero-adjustment.
- Zero-adjustment cannot be performed while integration is being performed or during display hold or maximum value/minimum value hold operation.
- To enable high-precision measurement, it is recommended to perform zero-adjustment at an ambient temperature that falls within the range specified in the specifications.
- Turn off power to the measurement lines and perform zero-adjustment with the instrument in the no-input state. The instrument will display [Err.18] if input is present when performing zero-adjustment. If this occurs, remove the input and then repeat the zero-adjustment process.

# 2.6 Activating Power to the Measurement Lines

#### Before activating power to the measurement lines



Before activating power to the measurement lines, turn on the instrument and verify that no errors are displayed.

If any measurement target lines are live before the instrument is turned on, the instrument may be damaged, or an error may be displayed when it is turned on.

See: "2.4 Turning On the Instrument"(p.34), "6.2 Error Indication"(p.170)

The instrument and input terminals may become hot when a large voltage or current is input.

# 2.7 Turning Off the Instrument



Once measurement is complete, turn the **POWER** switch off ( $\bigcirc$ ).

Disconnect the wires.

When power is turned on again, the instrument will start up with the settings that were in effect when it was turned off.



When the instrument is turned off, do not apply voltage or current to the instrument. Doing so may cause the instrument to become hot, resulting in burns or damage to the instrument.

- When the instrument is turned off, the input resistance of the current input terminals will be approximately 500 mΩ.
- If leaving the connections in place after measurement is complete, be sure to conduct a pre-measurement inspection (p.37) before making the next measurement. Such an inspection will enable you to prevent electric shock and measurement errors caused by breaks in cables, short-circuits, instrument failures, and other issues.

# Configuration and Measurement Chapter 3

## Please read "Operating Precautions" (p.5) carefully before using the instrument.

For more information about the measurement process, see "1.4 Measurement Workflow" (p.20).

# 3.1 Pre-Measurement Inspection

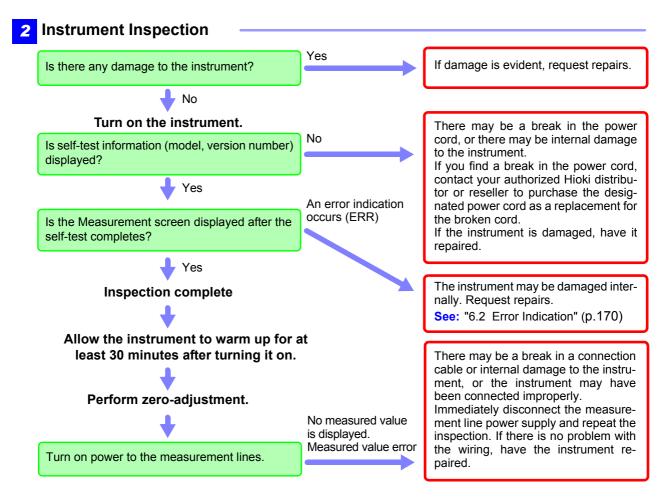
Before using the instrument the first time, verify that it operates normally to ensure that the no damage occurred during storage or shipping. If you find any damage, contact your authorized Hioki distributor or reseller.

## Peripheral Device Inspection

#### When using connection cables

Is the insulation of the probe or connection cable to be used damaged, or is bare metal exposed? Are any of the input terminal screws loose? Metal Exposed? Screws are loose. If there is any damage or the screws are loose, there is a risk of electric shock or short-circuit. Do not use the instrument. Replace the probe or cable with an undamaged equivalent. Securely retighten screws. (p.27)

No Metal Exposed Screws are tight.



#### **Configuring Settings** 3.2

#### 3.2.1 **Selecting the Current Input Method**

PW3335-03 PW3335-04

This section describes how to select the current input method.

The instrument can perform measurement using the current input methods listed below.

The default setting is the current direct input method (setting: OFF).



The external current sensor input terminals are not isolated. You must connect an optional current sensor in order to use them.



Inputting a voltage other than output from an optional current sensor or inputting a primary-side voltage may damage the instrument or cause electric shock, a short-circuit, or bodily injury.



CAUTION When using external current sensor input terminals, disconnect all wiring from the current input terminals. Similarly, when using the current input terminals, disconnect all wiring from the external current sensor input terminals.

The current input method serves to switch the input signals to the instrument's internal circuitry. Improperly configuring the current input method will make it impossible to make accurate measurements.

## Current direct input method

- Connect wires and input current directly to the current input terminals.
- The input terminals are isolated.
- The maximum input current is 30 A, ±100 A peak.

### External current sensor input method (p.100)

- Connect optional current sensors (voltage output) to the external current sensor input terminals to measure current.
- The input terminals are not isolated. Isolation is accomplished by the connected current sensors.
- The maximum input voltage for the external current sensor input terminals is 8 V, ±12 V peak.
- TYPE.1 and TYPE.2 input is supported, depending on the current sensor specifications.

## TYPE.1 current sensors (p.102)

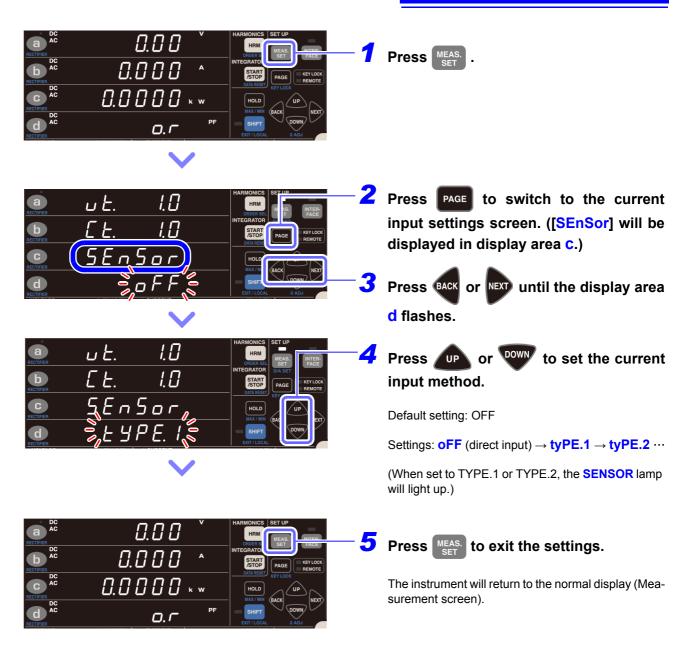
These current sensors can be directly connected to the external current sensor input terminal.

- Model 9661 Clamp on Sensor (rated current: 500 A AC)
- Clamp on Sensor (rated current: 1000 A AC) Model 9669
- Model 9660 Clamp on Sensor (rated current: 100 A AC)
- Model CT9667 Flexible Clamp on Sensor (rated current: 500 A/ 5,000 A AC range switchable)

## TYPE.2 current sensors (p.102)

Connecting these sensors to the external current sensor input terminal requires optional 9555-10 Sensor Unit and L9217 Connection Cord.

- Model 9272-10 Clamp on Sensor (rated current: 20 A/ 200 A AC range switchable)
- Model 9277 Universal Clamp on CT (rated current: 20 A AC/DC)
- Universal Clamp on CT (rated current: 200 A AC/DC) Model 9278
- Model 9279 Universal Clamp on CT (rated current: 500 A AC/DC)
- Model 9709 AC/DC Current Sensor (rated current: 500 A AC/DC)
- Model CT6862 AC/DC Current Sensor (rated current: 50 A AC/DC)
- Model CT6863 AC/DC Current Sensor (rated current: 200 A AC/DC)
- Model CT6865 AC/DC Current Sensor (rated current: 1000 A AC/DC)
- Model CT6841 AC/DC Current Probe (rated current: 20 A AC/DC)
- Model CT6843 AC/DC Current Probe (rated current: 200 A AC/DC)



 The current input method cannot be changed while integration is being performed or during display hold or maximum value/ minimum value display hold operation.

• Auto-range integration mode cannot be used when the current input method is set to TYPE.1 or TYPE.2.

# 3.2.2 Selecting Display Content

This section describes how to select the information shown on the instrument's display.

- · Selecting display parameters
- Selecting rectifiers (p.42)

See: "Appendix 1 Detailed Specifications of Measurement Items (Display Items)" (p. A1)

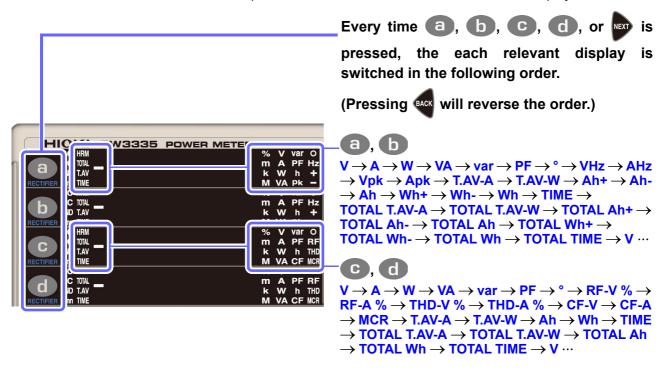
#### **Default settings**

a: Voltage (V), AC+DC

- b: Current (A), AC+DC
- C: Active power (W), AC+DC
- d: Power factor (PF), AC+DC

# Selecting display parameters

This section describes how to select the parameters that are shown on the instrument's display.

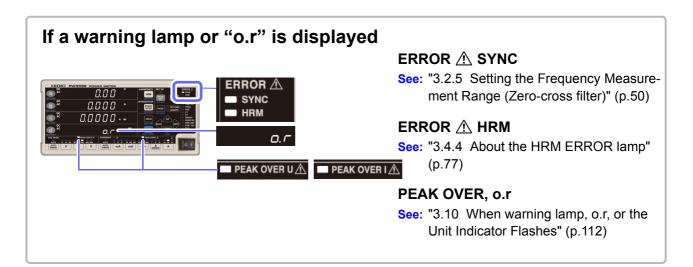


- The voltage and current are displayed from 0.5% to 152% of the range.
- (When input is less than 0.5% of the range, zero-suppression forces a value of zero to be displayed.)
- Active power is displayed from 0% to 231.04% of the range.
- (There is no zero-suppression function.)
- Depending on the rectifier, certain display parameters cannot be measured. In this case, the display will show [----].
- See: "Appendix 1 Detailed Specifications of Measurement Items (Display Items)" (p. A1)
- The polarity symbol at the power factor indicates whether the current waveform lags or leads the voltage waveform.

Symbol [None]: Current waveform lags voltage waveform

Symbol [-]: Current waveform leads voltage waveform

This symbol is linked to those at the reactive power and phase angle. However, if an input level of the voltage or current is 20% or less of the corresponding ranges, an incorrect polarity symbol may be displayed.



# Selecting the rectifier

The instrument provides the five rectifiers listed below. Since data for all rectifiers is processed in parallel internally, the rectifier can be switched during measurement.

1. DC AC	Displays true RMS values for DC only, AC only, or mixed DC and AC voltage and current.
2. DC AC Umn	Displays mean value rectified RMS equivalents for DC only, AC only, or mixed DC and AC volt- age. Current values are displayed as RMS values.
3. DC	Displays simple average values (DC components only) for voltage and current. The calculated value (voltage DC value) × (current DC value) is displayed as the DC component for active power.
<b>4.</b> AC	Displays calculated values given by the following equation as RMS values for the AC component only for voltage and current: $\sqrt{(AC+DC \text{ value})^2 - (DC \text{ value})^2}$ The calculated value given by (active power AC+DC value) - (active power DC value) is displayed
	as the active power value for the AC component only.

Extracts and displays the fundamental wave component only using harmonic measurement.

a RECTIFIER	HRM % V Var O HAMMONICS SET UP TAV — M V PH L LIAL TAV — K W h + H TME M VA PK +
	HRM % V VAR O TON M APF Hz TAV K W h + TWE M VA PK M VA PK ET T
C	HMW % V VAR O TM _ MAX A STATE OF A STATE O
	PEAK OVER UA         CURRENT         A         PEAK OVER IA         A           6         15         30         60         150         300         600         12         5         10         20         50         100         200         1         2         5         10         20         10         20         5         10         20         10         20         5         10         20         8         10         12         5         10         20         10         12         5         10         20         10         12         5         10         20         10         12         5         10         20         10         12         5         10         20         10         12         5         10         20         10         12         5         10         20         10         12         5         10         20         10         12         10         12

5.

**FND** 

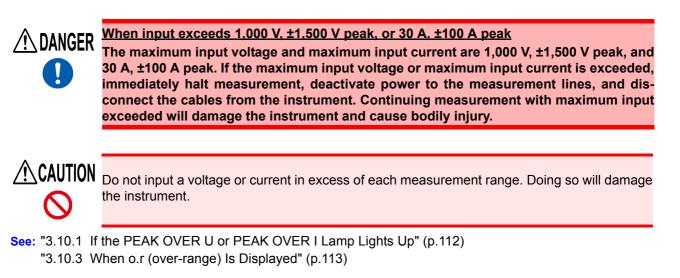
Default setting: AC+DC

Every time (a), (b) C , or C is pressed RECTIFIER RECTIFIER RECTIFIER RECTIFIER after pressing SHIFT to activate the shift state, the display will change as follows:  $\mathsf{AC+DC} \rightarrow \mathsf{AC+DC} \ \mathsf{Umn} \rightarrow \mathsf{DC} \rightarrow \mathsf{AC} \rightarrow \mathsf{FND} \rightarrow$ AC+DC ··· The shift state is canceled approx. 2 seconds after (a), b RECTIFIER RECTIFIER **C**, or **C** is released. RECTIFIER RECTIFIER You can also select the rectifier by pressing or www. (Pressing will reverse the order.) Use we after canceling the shift state so that

zero-adjustment is not performed.

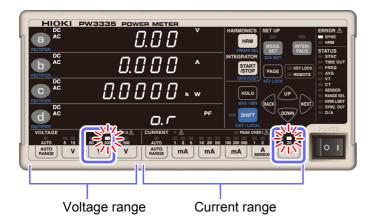
- When the DC rectifier is selected, the voltage (U) and current (I) polarity will also be displayed (as a simple average).
- When the AC+DC or AC rectifier is selected, the voltage and current display values will always be positive.
- Depending on the rectifier, certain display parameters cannot be measured. In this case, the display will show [----].

# 3.2.3 Selecting the Voltage and Current Ranges



# Selecting the desired range

Press the range key to select the desired range. The lamp for the selected range key will light up, and the display value will change to reflect the selected range.



Default settings: 300 V voltage 20 A current

Two or three ranges are assigned to each range key.

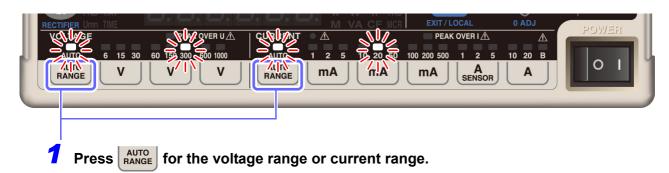
- Allow the following amount of time to elapse before reading measured values after changing the range:
- When the frequency of input set to the synchronization source is 10 Hz or greater Approx. 0.6 sec.
- When the frequency of input set to the synchronization source is less than 10 Hz See: "3.2.6 Setting the Timeout" (p.54)
- If the range changes, the invalid data display [----] will be shown until the data is updated.
- When measuring frequencies of 10 Hz or less, it is necessary to set the timeout to a value other than 0.1 sec.
   See: "3.2.6 Setting the Timeout" (p.54)
- When using external current sensor input (TYPE.1 or TYPE.2) as the current input method, only sensor is valid for selecting the current range. Pressing another range key will cause [tyPE.1] or [tyPE.2], indicating the type of external current sensor, to be displayed, and the range will not be changed.
- Ranges cannot be changed while integration is being performed or during display hold operation.

# Automatically setting the range (auto-range operation)

Selecting auto-range operation causes the range to be switched automatically according to the measured value. This feature is convenient when you do not know the optimal range.

## Setting auto-range operation

See: "Auto-range operation" (p.45)



**2** The AUTO lamp and the lamp for the range being measured will light up.

Canceling auto-range operation

Press any range key or press AUTO RANGE again.

- When the measurement range is set to auto-range operation, the output rate for level and waveform output for D/A output will vary with the range. When measuring lines for which measured values fluctuate excessively, exercise care so as not to mistake range conversions. It is recommended to use a fixed range for this type of measurement.
- Voltage and current are displayed from 0.5% to 152% of the range.
- Active power is displayed from 0% to 231.04% of the range.
- Display range values have an error of ±1 dgt. due to calculation precision.
- When integration is started using auto-range integration, voltage auto-range operation will be canceled, and the range at that point will be fixed. When integration is started using fixed-range integration, voltage and current auto-range operation will be canceled, and the ranges at that point will be fixed.
- Ranges cannot be changed during display hold operation.

## Auto-range operation

During auto-range operation, the range is switched as described below:

Range increased		Range decreased
When the measured	value exceeds	When the measured value is less than 15% of the range, the
150% of the range		range will be switched to the optimal range. (The range will not
When the PEAK OVER I	amp lights up	be decreased when the value would exceed the peak value for
		the next lower range.*)

\* Example:

Assume that the input current changes to an RMS value of 10 mA and the current waveform peak value changes to 400 mA while using the 100 mA range. Since 15% of the 100 mA range is 15 mA, this RMS value should cause the range to be lowered. However, since the current waveform peak value is 400 mA, a peak overage would occur with the 50 mA range. In this case, the range will not be lowered from the 100 mA range.

The voltage and current display range is  $\pm 0.5\%$  to  $\pm 152\%$  of the range.

When the measured value is less than  $\pm 0.5\%$  of the range, the zero-suppression function forces the value to be displayed as zero.

		is displayed is unable to switch ranges. Take the following action to
Error display	Status	Solution and reference for more information
Err. 12	During integration operation ( <b>RUN</b> lamp lit up or flashing)	The range cannot be switched until the integrated value i reset (so that the <b>RUN</b> lamp turns off). <b>See:</b> "Canceling integration (resetting integrated values) (DATA RESET)" (p.65)
Err. 16	During display hold opera- tion ( <b>HOLD</b> lamp lit up)	The range cannot be switched until the display hold is car celed (so that the <b>HOLD</b> lamp turns off). See: "Canceling the display hold state" (p.106)

# Skipping unnecessary ranges (range select function)

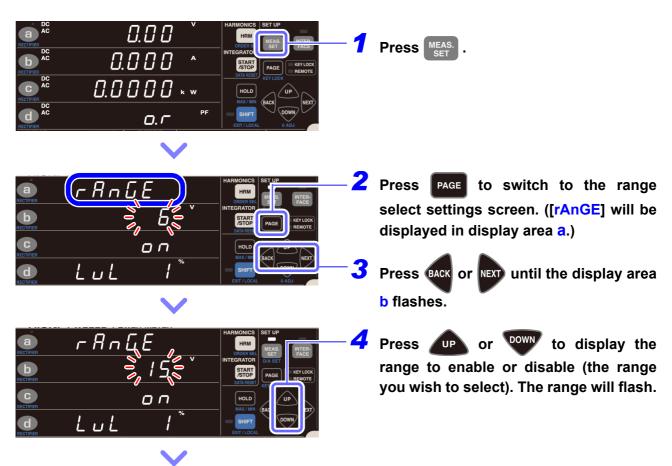
Because the instrument provides a large number of ranges (8 voltage ranges and 14 current ranges), range switching can be time-consuming, particularly during auto-range operation. If you know which ranges you will be using before you begin and wish to switch ranges more quickly, you can use the range select function. The PW3335's range select function makes it possible to limit range switching to a smaller pool of necessary ranges by letting you enable the ranges you wish to use and disable the ranges you do not wish to use (i.e., the ranges you wish to skip).

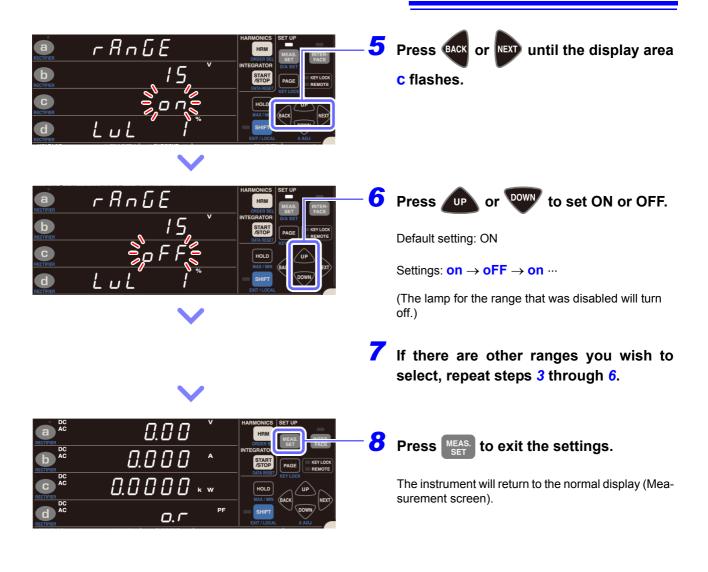
The 1,000 V range, 100 mA range, 20 A range, and 5 A range noted on the external current sensor panel (E.5) cannot be disabled (skipped).

## **Range selection**

Operation	ON (use)	OFF (do not use)
Range selection with range keys	Yes	No
Range switching with auto-range operation	Yes	No (skipped)
Range switching with auto-range integration	Yes	No (skipped)

If any range has been disabled (set to OFF), the **RANGE SEL** lamp will light up. (Default state: All ranges are enabled [ON].)

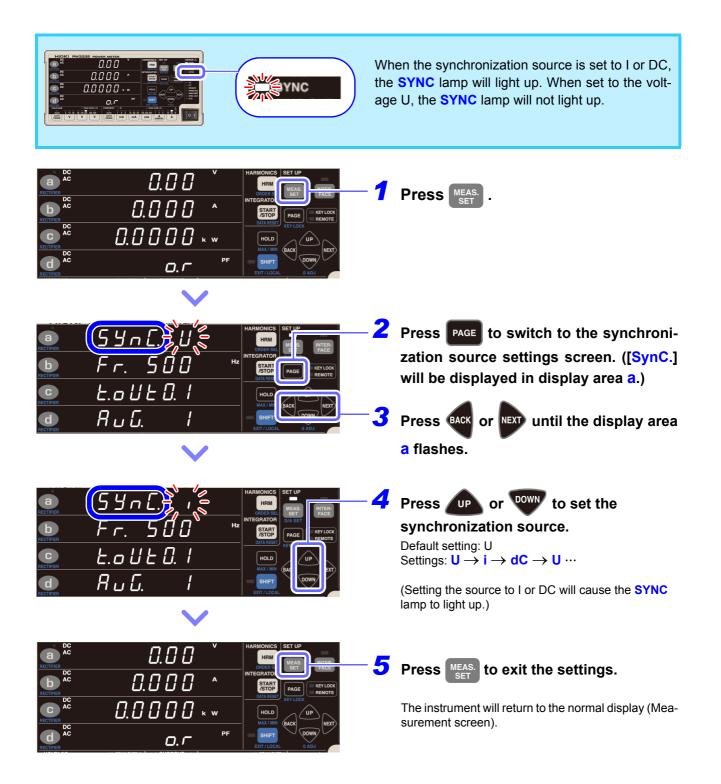




# 3.2.4 Setting the Synchronization Source (SYNC)

This section describes how to set the synchronization source used to determine the cycle (between zerocross events) that will be used as the basis for calculations.

You can select from the following parameters: U, I, DC (fixed at 200 ms)



- Setting the synchronization source to DC when using AC input will cause display values to fluctuate, preventing accurate measurement. Set the synchronization source to a value other than DC when using AC input.
- Input for the parameters selected as synchronization sources must be at least 1% of the range.
- When the **SYNC** lamp (ERROR) is lit up, accurate measurement cannot be performed.
- Even when the SYNC lamp (ERROR) is not lit up, accurate measurement cannot be performed if the synchronization source input signal is in any of the following states:
  - 1. When a signal with a frequency higher than the frequency measurement range (zero-cross filter) is being input
  - 2. When a measured voltage or current of an AC component of an input signal is less than 1% of each relevant range.
  - 3. When a measured voltage or current of an AC component of an input signal is greater than 150% of each relevant range.
  - 4. When a signal with a frequency component within the frequency measurement range (zero-cross filter) other than the measurement signal's fundamental wave frequency is superposed
    - Example: When the frequency measurement rage (zero-cross filter) is 500 Hz, if a signal for which zero-crosses occur at a frequency of less than 500 Hz (a modulation signal, noise, etc.) is input on top of a 50 Hz input signal
  - The synchronization source cannot be changed while integration is being performed or during display hold or maximum value/ minimum value display hold operation.

# 3.2.5 Setting the Frequency Measurement Range (Zero-cross filter)

If the SYNC lamp (ERROR) lights up, change the zero-cross filter setting.

When the synchronization source is set to voltage (U) or current (I), the **SYNC** lamp (ERROR) will light up if the synchronization signal cannot be acquired. When the **SYNC** lamp (ERROR) is lit up, the instrument will not be able to perform accurate measurement.

The instrument incorporates 100 Hz, 500 Hz, 5 kHz, and 100 kHz low-pass filters for use in switching the cutoff frequency (i.e., as a zero-cross filter). These filters also vary with the frequency measurement range.

Additionally, accurate measurement also cannot be performed when using input of a low frequency of less than 10 Hz (with a repeating period of greater than 0.1 sec.) because each input cycle will exceed the instrument's calculation processing interval (causing a timeout). The **SYNC** lamp (ERROR) will also light up at this time. In this case, set the instrument's timeout setting to 1 sec. (for an input frequency of less than 10 Hz) or 10 sec. (for an input frequency of less than 1 Hz). (p.54)



FRROR A HRM STATUS SVNC TIME OUT FREQ AVG VT Accurate measurement cannot be performed if the **SYNC** lamp (ERROR) is lit up.

Setting the timeout to 1 sec. to 10 sec. will cause the **TIME OUT** lamp to light up. The default value is 0.1 sec.

The zero-cross filter is linked to the frequency measurement range. If you are unable to perform frequency measurement, change this zero-cross filter setting. The default setting is 500 Hz. Setting it to 100 Hz, 5 kHz, or 200 kHz will cause the **FREQ** lamp to light up.

Setting	Description	FREQ lamp
100 Hz	Use this setting primarily when measuring standard AC power supply equipment (50 Hz, 60 Hz) and when using the fundamental wave (100 Hz or less) on the secondary side of an inverter as the synchronization signal.	on
500 Hz (Default setting)	Use this setting primarily when measuring standard AC power supply equipment (50 Hz, 60 Hz, 400 Hz) and when using the fun- damental wave on the secondary side of an inverter as the syn- chronization signal.	off
5 kHz	Use this setting when using frequency input in excess of 500 Hz as the synchronization signal.	on
100 kHz	Use this setting when using frequency input in excess of 5 kHz as the synchronization signal.	on



ARTINGAL STATE AND	Press PAGE to switch to the zero-cross filter settings screen. ([Fr.] will be dis- played in display area b.) Press BACK or WEXT until the display area b flashes.
HARMONICS HECTIVER 55, HZ HECTIVER 5, HZ HZ HECTIVER 5, HZ HZ HZ HZ HZ HZ HZ HZ HZ HZ	Press or to set the zero- cross filter (100 Hz/ 500 Hz/ 5 kHz/ 100 kHz). Default setting: 500 Hz
	Settings: $500 \rightarrow 5k \rightarrow 100k \rightarrow 100 \rightarrow 500 \cdots$
AC     AC	Press (SET) to exit the settings. The instrument will return to the normal display (Measurement screen).

## Display of frequency measurements (Displayed as V Hz or A Hz on panel display)

From 0.1000 Hz to 9.9999 Hz

From 10 Hz to 99.999 Hz <u>99.999</u> 9.9999 From 100 Hz to 999.99 Hz From 1 kHz to 9.9999 kHz 99999 . 999 Ч  $\mathbf{Q}$ 100 kHz From 10 kHz to 99.999 kHz 100.00 . 99.999 к

Because measured values become difficult to read near the point at which the display switches, the resolution is lowered by one digit.

Example: If the frequency being measured changes from 1 kHz to 999 Hz, the display resolution for 1 kHz to 9.9999 kHz measurement will remain in effect, and the value will be displayed as 0.9990 kHz. If the frequency being measured then changes again to a value that is less than or equal to 990 Hz, the instrument will switch to the display resolution for 100 Hz to 999.99 Hz and display the value as 990.00 Hz.

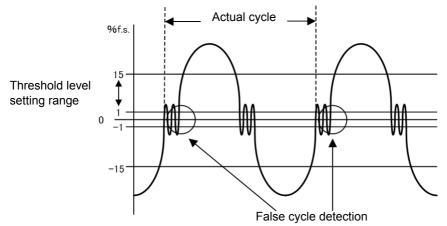
See: Frequency Measurement Specifications (p.146)

- When measuring an AC signal with a frequency lower than 500 Hz, it is recommended to set the frequency measurement range (zero-cross filter) to 100 Hz or 500 Hz to reduce the noise component at 500 Hz and higher. Select the frequency measurement range depending on frequencies of signals to be measured.
- Frequency measurement accuracy is guaranteed for sine wave input that is at least 20% of the frequency measurement source's measurement range. The instrument may not be able to perform frequency measurement accurately for other inputs (when the measurement signal is distorted, when there is a superposed noise component, etc.).
- The frequency measurement range cannot be changed while integration is being performed or during display hold or maximum value/minimum value hold operation.
- If a frequency of a signal to be measured is above the selected frequency measurement range, the instrument may not be able to perform frequency measurement accurately. Change the frequency measurement range to an appropriate one.
  - (Example) If a signal with a frequency above 500 Hz is input into the instrument with the frequency measurement range that is set to 500 Hz, change the frequency measurement range to 5 kHz or higher.

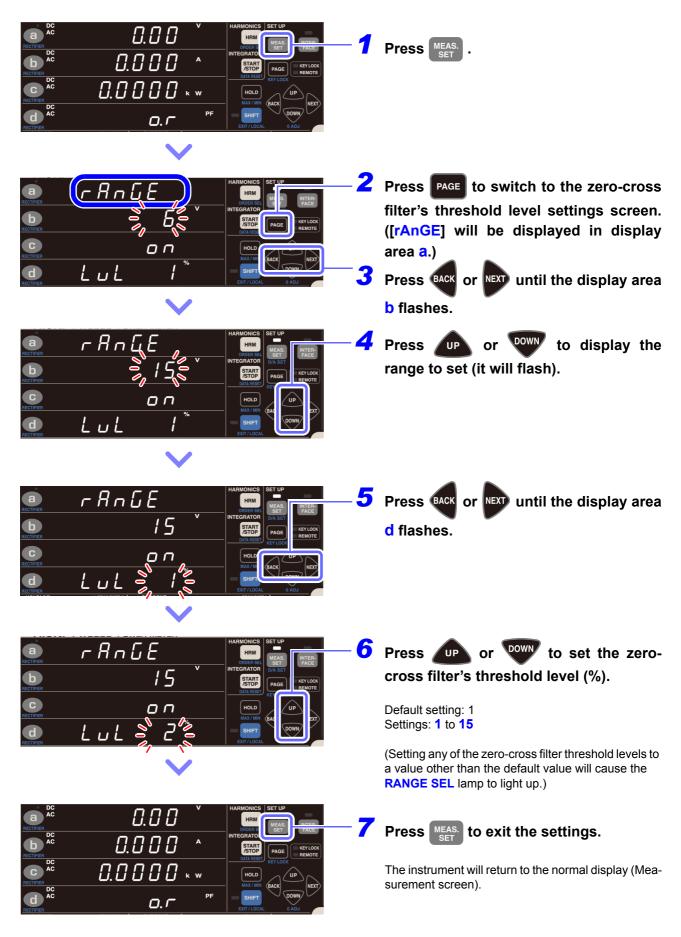
# Significance of changing the zero-cross threshold level

The PW3335 calculates parameters such as RMS values and active power based on one cycle of the synchronization source's input waveform (voltage U or current I). This cycle is obtained by detecting the zerocross interval (the interval from one rising edge until the next cycle's rising edge). Consequently, waveform distortion due to a cause such as zero-cross noise near the rising edge of the input waveform set as the synchronization source can cause detection of a zero-cross other than actual input waveform cycle, compromising the instrument's ability to make accurate measurements. The PW3335 provides the function for setting a threshold value used to judge zero-cross events caused by noise to be false, ignoring them. This threshold value can be set in the range between 1% (default) and 15% of each measurement range, and is applied to both the positive and negative sides. Once a zero-cross event is detected, the subsequent zero-cross events will be ignored unless the input waveform goes across the upper or lower threshold value.

If zero-cross events are excessively detected due to input waveform distortion, the frequency is inaccuratly measured. In that case, adjust the threshold level.



If the measurement of frequency is not performed accurately, neither does the correct detection of phase shift between the voltage and current, the power factor or the reactive power are indicated inaccurately, and the polarity of phase angle incorrectly.



# Setting the zero-cross filter's threshold level

# 3.2.6 Setting the Timeout

Accurate measurement cannot be performed when using input of a low frequency of less than 10 Hz (with a repeating period of greater than 0.1 sec.) because each input cycle will exceed the instrument's calculation processing interval (causing a timeout). The **SYNC** lamp (ERROR) will light up at this time. In this case, set the instrument's timeout setting to 1 sec. (for an input frequency of less than 10 Hz) or 10 sec. (for an input frequency of less than 1 Hz).

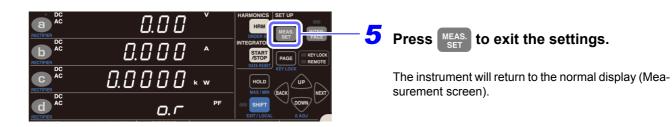


Accurate measurement cannot be performed if the **SYNC** lamp (ERROR) is lit up.

Setting the timeout to 1 sec. to 10 sec. will cause the lamp to light up. The default value is 0.1 sec.

Setting	Description	TIME OUT lamp
0.1 sec.	Use this setting when the frequency of the input set as the synchronization source	off
(Default setting)	is 10 Hz or higher.	-
1 sec.	Use this setting when the frequency of the input set as the synchronization source	on
	is less than 10 Hz.	
10 sec.	Use this setting when the frequency of the input set as the synchronization source	on
10 500.	is less than 1 Hz.	on

	Press MEAS. SET .
RECTIFIER Fr. 500 Hz RECTIFIER EL.000 Hz RECTIFIER EL.000 Hz RECTIFIER HZ RECTIFIE	Press PAGE to switch to the timeout settings screen. ([t.oUt] will be dis- played in display area C.) Press BACK or NEXT until the display area c flashes.
AARMONICS RECTIFER Fr. SU Fr. SU F	Press $\underbrace{\text{UP}}$ or $\underbrace{\text{Pown}}$ to set the timeout (0.1 sec., 1 sec., or 10 sec.). Default setting: 0.1 sec. Settings: $0.1 \rightarrow 1 \rightarrow 10 \rightarrow 0.1 \cdots$



- When the frequency of the input to the set synchronization source is less than 5 Hz, the data update (display update) timing will vary with the frequency of the input to the synchronization source.
   Example: If the frequency of the input to the synchronization source is 0.8 Hz, the data (display) will be updated every 1/0.8 = 1.25 sec.
- If the SYNC lamp (ERROR) lights up when the timeout has been set to a value other than 0.1 sec., the display will be updated once every time the timeout set time elapses.
- The timeout setting cannot be changed while integration is being performed or during display hold or maximum value/minimum value hold operation.
- The instrument is equipped with the high-pass filters to avoid influences from DC components of input signals during detecting cycles. Because the time constants of the high-pass filters are linked to the timeout settings, if the range is changed, or an input voltage or current including a DC component rapidly changes, it will take a time until the measured value stabilizes.

Please wait and read the measured value after the following time. The required time varies depending on the timeout setting.

- When the timeout is set to 0.1 sec.: approximately 0.6 sec.
- When the timeout is set to 1 sec.: approximately 10 sec.
- When the timeout is set to 10 sec.: approximately 40 sec.

# 3.2.7 Displaying Measured Values as an Average (AVG: Averaging)

In averaging operation, the number of averaging iterations for measured values is set, and averaged data is displayed. Used when measured values fluctuate, causing excessive variation in the display, this setting provides a way to reduce variation in display values.

The instrument uses simple averaging to average measured values. The display update interval varies with the number of averaging iterations setting.

Average value = 
$$\frac{\sum_{k=1}^{n} Xk}{\sum_{k=1}^{n} Xk}$$

п

Xk: Measured value every 200 ms (instrument display update rate) n: Number of averaging iterations

#### Number of averaging iterations and display update interval

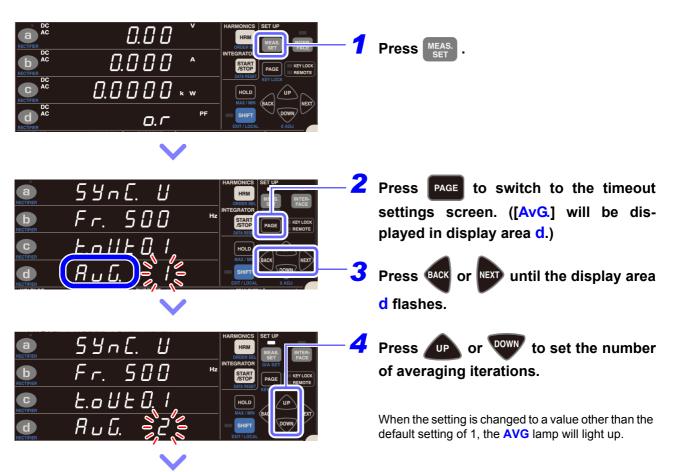
Number of averaging iterations	1 (OFF)	2	5	10	25	50	100
Display update interval	200 msec.	400 msec.	1 sec.	2 sec.	5 sec.	10 sec.	20 sec.

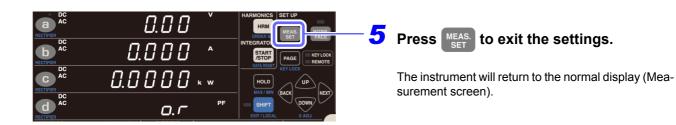
#### Parameters that are averaged

The five parameters of voltage, current, active power, apparent power, and reactive power are averaged, while the power factor and phase angle are calculated form averaged data.

#### Parameters that are not averaged

Voltage frequency, current frequency, current integration, active power integration, integration time, voltage waveform peak value, current waveform peak value, voltage crest factor, current crest factor, time average current, time average active power, voltage ripple rate, current ripple rate, maximum current ratio, all harmonic measurement parameters





- Averaging will restart when there is a change that affects measured values, for example in the range, number of averaging iterations, current input method, VT ratio, or CT ratio.
   Since no average value exists immediately after the start of averaging, the invalid data display [----] will be shown. During this period of time, the AVG lamp will flash.
- If the instantaneous value changes to [o.r] while average values are being displayed, the display will change to [o.r].
- The unit may flash during measurement.
- See: "3.10.4 When the Unit Indicator Flashes" (p.114)
- Averaging processing is performed for voltage, current, active power, apparent power, and reactive power.
- The power factor and phase angle are calculated from the averaged active power and apparent power.

# If the number of average iterations does not flash

This indicates that the number of averaging iterations cannot be changed.

After pressing MEAS. set to exit the setting, perform the following procedure:

Status	Solution and reference for more information
During integration operation ( <b>RUN</b> lamp lit up or flashing)	Averaging cannot be changed until the integrated value is reset (so that the <b>RUN</b> lamp turns off). See: "Canceling integration (resetting integrated values) (DATA RESET)" (p.65)
During display hold operation or maximum value/minimum value hold operation (HOLD, MIN, or MAX lamp lit up)	<ul> <li>Averaging cannot be changed until this operation is canceled (so that the HOLD lamp turns off).</li> <li>See: "Canceling the display hold state" (p.106) <ul> <li>"Switching the display among the maximum, minimum, and instantaneous values" (p.107)</li> </ul> </li> </ul>

# 3.2.8 Setting the VT Ratio and CT Ratio

When inputting a voltage in excess of the instrument's maximum input voltage of 1,000 V or a current in excess of its maximum input current of 30 A, use an external VT (PT) or CT, respectively. This section describes how to set the ratio (VT ratio or CT ratio) when using an external VT or CT. Even when using an external current sensor, it is necessary to set the CT ratio.

By setting the VT ratio and CT ratio, you can read the measured current value (CT primary-side current) directly.



When the VT and CT lamps are lit up (particularly when the VT ratio and CT ratio are set to values less than 1), a voltage or current greater than the displayed measured value may have been input to the instrument. To prevent an electrical accident or short-circuit, do not unnecessarily touch the instrument's input terminal or the measurement lines.

### VT ratio setting range

0.001 to 0.009, 0.010 to 0.099, 0.100 to 0.999, 1.000 to 9.999, 10.00 to 99.99, 100.0 to 999.9 (1,000) (If the VT ratio is set to 0.0, 00.0, or 000.0, the instrument internally multiplies measured values by a VT ratio of 1,000.

#### CT ratio setting range

0.001 to 0.009, 0.010 to 0.099, 0.100 to 0.999, 1.000 to 9.999, 10.00 to 99.99, 100.0 to 999.9 (1,000) (If the CT ratio is set to 0.0, 00.0, or 000.0, the instrument internally multiplies measured values by a CT ratio of 1,000.

# If the VT ratio or CT ratio does not flash

This indicates that the VT or CT ratio cannot be changed.

After pressing MEAS. set to exit the setting, perform the following procedure:

Status	Solution and reference for more information
During integration operation ( <b>RUN</b> lamp lit up or flashing)	The VT and CT ratios cannot be changed until the integrated value is reset (so that the <b>RUN</b> lamp turns off). See: "Canceling integration (resetting integrated values) (DATA RESET)" (p.65
During display hold operation or maximum value/minimum value hold operation (HOLD, MIN, or MAX lamp lit up)	The VT and CT ratios cannot be changed until this operation is canceled (so that the HOLD lamp turns off). See: "Canceling the display hold state" (p.106) "Switching the display among the maximum, minimum, and instantaneous values" (p.107)

# Setting the VT ratio





<u>. 268.00</u>

SEnSor

Γ Ł

1.[]

oFF

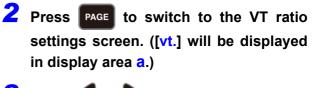
STA

a

b

C

d



- Press eace or very until the digit you wish to set in display area a, which will start flashing.
- **4** Press **A** or **W** to set the VT ratio.

To move the decimal point:

Press every or very until the decimal point flashes, and press very or very.

Default setting: 1.0

Press MEAS. SET .

Setting range: See: "VT ratio setting range" (p.58)



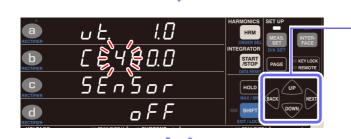
**5** Press MEAS. to exit the settings.

The instrument will return to the normal display (Measurement screen).

# Setting the CT ratio







**2** Press **PAGE** to switch to the VT ratio settings screen. ([Ct.] will be displayed in display area b.)

Press even or ver until the digit you wish to set in display area b, which will start flashing.

Press \_\_\_\_\_ or www to set the CT ratio.

To move the decimal point:

Press **ACK** or **NET** until the decimal point flashes, and press **OP** or **DOWN**.

Default setting: 1.0

Setting range: See: "CT ratio setting range" (p.58)

a DC AC	0.00 °	HARMONICS SET UP HRM MEAS. ORDER S SET FACE
	0.000 ^	
C AC AC	0.0000 * *	
	<b>0</b> . <b>(</b>	EXIT/LOCAL 0 ADJ

**5** Press  $\frac{\text{MEAS.}}{\text{SET}}$  to exit the settings.

Press MEAS. SET .

3

4

The instrument will return to the normal display (Measurement screen).

# 3.3 Integration

The PW3335's integration function can operate in either of two modes: fixed-range integration mode or autorange integration mode.

#### Fixed-range integration mode

Integration operation uses the set measurement range. (When auto-range operation is enabled, integration is fixed to the range in effect at the start of operation.)

#### Auto-range integration mode

Integration operation is performed while the measurement range is controlled through auto-range operation. In this mode, the voltage range is fixed at the start of integration, but the current range is determined using auto-range operation between the 200 mA range and the 20 A range. This capability allows auto-range operation to be used in applications characterized by large changes in current or power, for example when measuring the sequence of operations of a household electronic device as it switches from the standby state to the normal operating state. Additionally, since not only the last integrated value, but also integrated values for each range that was used during integration operation can be displayed when integration is in the stopped state, operators can assess integrated values for each state of the measurement target (for example, standby and normal operation) after a single integration measurement session. Furthermore, auto-range integration can be used in combination with the range select function to shorten the switching time between ranges, allowing more efficient integration measurement.

Measurement ra (Voltage:150 V	v ∣			ariations ir er integrat		egrated va	alues a	nd ranges	used during		Active power integration
Current	Power	40170	, pow	or integrat							display value
В	3 kW		<del></del>	-		_			7		0.12562 Wh
20 A	JKW			   	Ŧ		) ) )		   		889.216 Wh
10 A Range select OFF	1.5 kW										0.00000 Wh
5 A Range select <b>ON</b>	750 W								       		246.325 Wh
2 A Range select OFF	300 W										0.00000 Wh
1 A Range select <b>ON</b>	150 W										23.6477 Wh
500 mA Range select <b>ON</b>	75 W										2.42385 Wh
200 mA Range select <b>ON</b>	30 W								       		0.82532 Wh
Total integrated v	alue								-         		1.16256 kWh
		<b>≜</b>			*	4	- - - -	*	1	•	
	In	tegration start		Whe	/ en s'	/ witching ra	anges			egrati stop	on

The instrument performs integration for the current and active power in the positive direction (Ah+, Wh+), in the negative direction (Ah-, Wh-), and as sums (Ah, Wh) simultaneously and can display the integrated value for each. Integration can be started and stopped, and the integrated value can be reset, using either the instrument's keys or the external control function. Additionally, by setting the integration time, it is possible to perform timer integration in 1-minute units from 1 minute to 10,000 hours (approximately 417 days). Furthermore, it is also possible to display the time average current and time average active power as calculated from the integrated value at that point in time and the integration elapsed time while integration is being performed.

Measured values are integrated as valid data while they fall within the effective measurement range for integration; that is, the integration operation maintains until a peak of measurement values reaches the maximum effective peak voltage or maximum effective peak current (until the **PEAK OVER U** or **PEAK OVER I** lamp lights up).

Maximum effective peak voltage: ±600% of the voltage range (up to ±1,500 V peak for the 300 V, 600 V, and 1,000 V ranges)

Maximum effective peak current: ±600% of the current range (up to ±100 A peak for the 20 A range)

Example: When performing DC current integration using the 1 A range, the current display value (A) will change to [o.r] when 1.52 A is exceeded, but the effective measurement range for current integration (Ah) extends from ±10 mA (1% of the 1 A range) to ±6 A, so the values will be integrated as valid data.

Display parameter	Description
Ah +	Positive current integrated value
Ah -	Negative current integrated value
Ah	Sum of current integrated values
Wh +	Positive active power integrated value
Wh -	Negative active power integrated value
Wh	Sum of active power integrated values
TIME	Integration elapsed time
T.AV A	Time average current (obtained by dividing the sum of current integrated values by the integra- tion elapsed time)
T.AV W	Time average active power (obtained by dividing the sum of active power integrated values by the integration elapsed time)

#### Display parameters and descriptions related to integration

### Displaying the rectifier and integrated values

Internally, the following integrated values are all integrated simultaneously, regardless of the rectifier. Consequently, integrated value data with simultaneity can be obtained simply by switching the display parameter.

Current	(Ah+,	Ah-,	Ah)
---------	-------	------	-----

Rectifier	Integration operation and display
AC+DC AC+DC Umn	The results of integrating current RMS value data (display values) once every display update interval (200 ms) are displayed as integrated values.
DC	The results of integrating sampled instantaneous data separately by polarity are displayed as integrated values.
AC, FND	[] (no integrated data) is shown.

#### Active power (Wh +, Wh -, Wh)

Rectifier	Integration operation and display
AC+DC AC+DC Umn	The results of integrating active power values calculated once for every cycle of the selected synchronization source separately by polarity are displayed as integrated values. This rectifier is used to integrate active power values of cyclic waveforms.
DC	The results of integrating sampled instantaneous data separately by polarity are displayed as integrated values. This rectifier is used to integrate active power values of non-cyclic waveforms such as a DC or others. (When a waveform to be measured includes both a DC and an AC component, the integrated value will not be an integration of only a DC component.)
AC, FND	[] (no integrated data) is shown.

## Displayed integrated values

					•:	Displayed	– : Displa	ays []
Rectifier	Ah+	Ah-	Ah	Wh+	Wh-	Wh	T.AV A	T.AV W
AC+DC, AC+DC Umn	-	-	•*	•	•	•	•*	•
DC	•	•	•	•	•	•	•	•

\* During auto-range integration mode operation, triggers the invalid data ([----]) display.

The display will indicate invalid data [----] if no integrated value exists.

### **Display method**



Press **a** through **d** to select the display parameter. See: "3.2.2 Selecting Display Content" (p.40)

## Display of integration elapsed time

From 0 sec. to 99 hr. 59 min. 59 sec.



From 1,000 hr. to 9,999 hr. 59 min.



From 100 hr. to 999 hr. 59 min.



10,000 hr.



## Method for starting and stopping integration and resetting integrated values

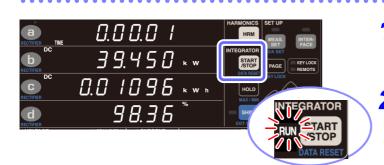
The following four methods are used to start and stop integration and reset integrated values:

- Using (START /STOP
- Using communications (see the Communications Command Instruction Manual)
- Using external control (p.82)
- Using synchronized control (p.78)

This section describes use of START

For more information about integration using communications, external control, or synchronized control, refer to each section indicated above.

# **Starting integration**



# **Stopping integration**

	0.23.53 39.450 kw 39.450 kw k 98.36 <sup>**</sup>	HARMONICS SET UP HRM INTEGRATOR RN STOP Data Rest Hold Hold SHIP SHIP
RECTIFIER	38.36	

Verify that the instrument is in the integration reset state (RUN and EXT lamps off).

2 Press START .

Integration will start, and the **RUN** lamp will light up.

Press (STOP) while the RUN lamp is lit up (indicating that the instrument is performing integration).

Integration will stop, and the **RUN** lamp will flash.

# Starting integration while adding to previous integrated values (additional integration)

Pressing (stopp) while the **RUN** lamp is flashing (indicating that integration is stopped) causes integration to start while adding to previous integrated values.

	0.2 3.5 3	HARMONICS SET UP HRM MEAS. INTER- SET FACE
DC	<i>39</i> .450 <sub>**</sub>	INTEGRATOR D/A SET
DC	15.7033 ***	HOLD
C	98.36 *	

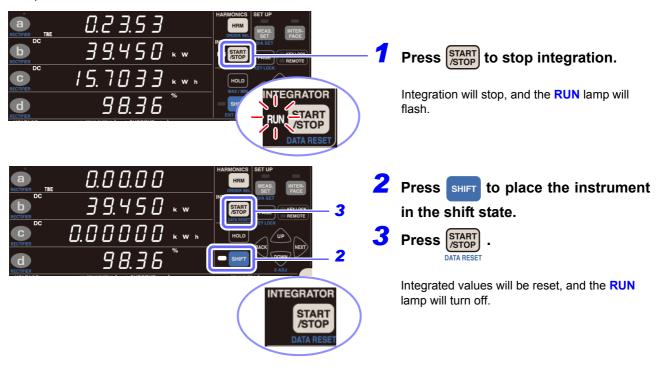
Press **START** while the **RUN** lamp is flashing.

Additional integration will start, and the **RUN** lamp will light up.

As long as the integrated values are not reset, additional integration is repeated.

# Canceling integration (resetting integrated values) (DATA RESET)

Settings cannot be changed while integration is being performed (while the **RUN** lamp is lit up or flashing). To cancel integration, use the following procedure. When integration is canceled, measurement results up to that point will be reset.



# Performing integration after setting an integration time (timer integration)

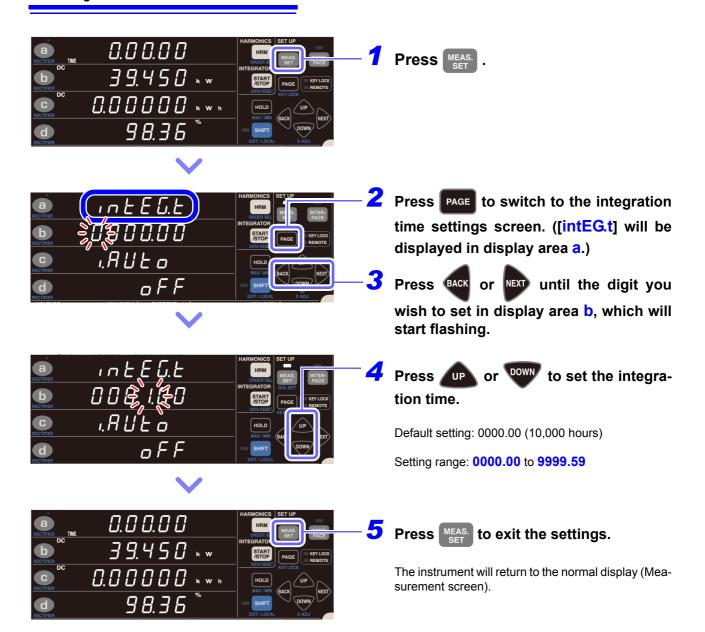
If an integration time has been set, integration is performed for the set period of time only. (Integration is stopped once the set period of time has elapsed.)

The instrument allows the integration time to be set in 1-minute increments from 1 minute to 10,000 hours. If using additional integration, operation will stop once the set time has elapsed after starting additional integration.



Example integration time setting displays

Integration time	Setting display
1 min.	0000.0 /
59 min.	0000.59
1 hr. 8 min.	000 1.08
9,999 hr. 59 min.	9999.59
10,000 hr. (Default setting)	0000.00



# If the integration time does not flash

This indicates that the integration time cannot be changed.

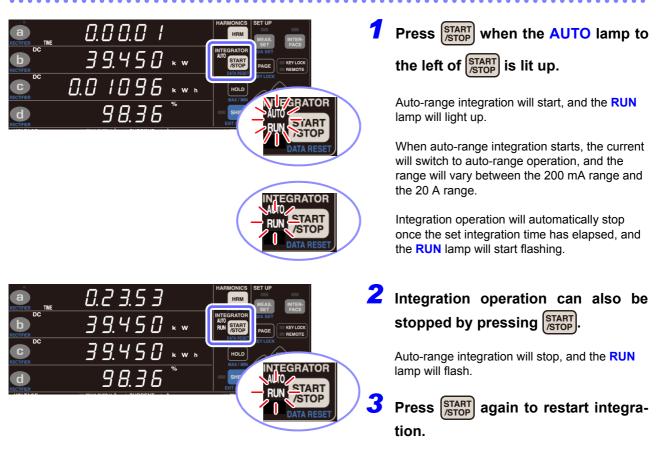
Status	Solution and reference for more information
During integration operation ( <b>RUN</b> lamp lit up or flashing)	The integration time cannot be changed until the integrated value is reset (so that the <b>RUN</b> lamp turns off). See: "Canceling integration (resetting integrated values) (DATA RESET)" (p.65)
During display hold operation or maximum value/minimum value hold operation (HOLD, MIN, or MAX lamp lit up)	<ul> <li>The integration time cannot be changed until this operation is canceled (so that the HOLD lamp turns off).</li> <li>See: "Canceling the display hold state" (p.106)         "Switching the display among the maximum, minimum, and instantaneous values" (p.107)</li> </ul>

After pressing MEAS. to exit the setting, perform the following procedure:

Enabling auto-range integration	
Image: Type: Twe       Image: Constraint of the type: Constraintof type: Constraint of the type: Constraint of	Press MEAS. SET .
ARMONICS SET UP RECITIVER NECTIVER N.AULO RECITIVER N.AULO SPECT	Press PAGE to switch to the current input settings screen. ([i.AUto] will be displayed in display area c.) Press RACK or WEXT until the display area d flashes.
Image: State of the state	Press (MEAS. SET) to exit the settings. The instrument will return to the normal display (Mea- surement screen).

If the current input method is set to TYPE.1 or TYPE.2, the AUTO lamp will not light up, and auto-range integration mode will not function.

# Starting and stopping auto-range integration



RUN lamp will light up.

Supplemental explanation

- (1) When integration starts, the voltage range is fixed.
- (2) The timeout duration changes to 0.1 sec.
- (3) The current range cannot be changed while auto-range operation is in progress. Once integration has stopped, the current range can be changed, and integrated values for the 200 mA range to the 20 A range and the B range can be displayed.
- (4) When the **TOTAL** lamp is lit up on the integration display, the following data is shown in auto-range integration mode:
  - Sum of integrated values for all ranges
  - Sum of integrated times for all ranges
  - Time-averaged value for overall range
- (5) Functionality linked to auto-range integration
  - Maximum and minimum value detection is cleared and restarted when integration starts. Additionally, maximum and minimum value detection is stopped when integration stops. (This operation is the same as for normal integration.)
  - When auto-range integration is enabled, options for the current range you wish to output (200 mA to 20 A, B, total) are shown in the time-average (T.AV) and integrated value (Ah, Wh) fields on the D/A output settings screen.
  - If a power failure occurs during integration, integration will be in the stopped state when power to the instrument is restored. Although integrated values are backed up, the data for maximum and minimum values is cleared, triggering the invalid data display. (This operation is the same as for normal integration.)
  - Some settings cannot be changed while integration is in progress or while integration is stopped. (This operation is the same as for normal integration.)

# Integration precautions

- (1) When integration starts with the 20 A fixed range, the voltage and current auto-range setting will be canceled, and measurement will be fixed to the range in effect when integration started. Set the range so that the PEAK OVER U (overvoltage input alarm) lamp and PEAK OVER I (overcurrent input alarm) lamp do not light up during integration. If the PEAK OVER U lamp or PEAK OVER I lamp lights up during integration, the integrated value will not be accurate. In this case, the Ah or Wh unit will flash until integrated values are reset (DATA RESET). (Even if the current or active power measured value is [o.r] [over-range], measured values falling within the range such that the PEAK OVER U and PEAK OVER I lamps do not light up will be integrated.)
- (2) Equipment constraints due to the integration Some parameters cannot be set or changed in the integration state (when the RUN lamp is lit up) or in the integration stopped state (when the RUN lamp is flashing). If a change is not supported, [Err.12] will be displayed for approximately 1 second.

See: Constraints during integration operation (p.148)

(3) If an integrated value reaches 999,999 MWh, or if the integration elapsed time reaches 10,000 hours, integration will stop, and you will not be able to restart it. ([Err.14] will be displayed for approximately 1 second.) In this case, restart integration after pressing the shift followed by the stop to reset integrated values (causing the RUN lamp to turn off).

See: "Canceling integration (resetting integrated values) (DATA RESET)" (p.65)

- (4) Maximum value and minimum value measurement will also restart when integration starts. If an integration reset is performed, maximum value and minimum value measurement will also restart. Averaging will also restart when integration is reset.
- (5) When a system reset is performed, integration operation will stop, and the instrument will revert to its factory settings.

See: "3.9.4 Initializing the Instrument (System Reset)" (p.110)

- (6) If the power goes out during integration, integration will stop. Integration will not resume when power to the instrument is restored.
- (7) If the timeout is set to 10 sec. and a signal of 1 Hz or less is input, a single measurement may take about 10 sec.
- (8) Before starting integration synchronized measurement, reset integrated values on both the master and slave. To perform a reset that is synchronized to the master, it is necessary for integration operation on the slave to be in the stopped or reset state.
- (9) Starting integration without first performing a reset results in additional integration.
- (10) Synchronization- and external control-based integration cannot be mixed on the slave. Always terminate external control and reset integration when performing synchronization-based integration.
- (11) When the slave's integration time setting is shorter than the master's integration time setting, stop timing cannot be synchronized since the slave's integration will stop first.
- (12) When performing synchronized measurement, once integration start/stop is performed on the slave, it may not be possible to synchronize operation, even if the same operation is performed on the master.
- (13) When performing integrated measurement using synchronized control, a difference of up to 0.7 sec. per hour may occur between the master's integration elapsed time display value (TIME) and the slave's integration elapsed time display value.



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.

- When performing integration for an extended period of time, it is recommended to back up the instrument with an uninterruptible power supply (UPS). The instrument's maximum rated power is 30 VA or less. Ensure that you use a UPS with adequate capacity.
- After power is restored, measured values may be offset for reasons related to the instrument's internal circuitry. In this case, perform zero-adjustment after eliminating all input to the instrument, for example by deactivating power to measurement lines.
- Continuing to input voltage or current signals after an outage has caused the instrument to lose power may damage the instrument.

# 3.3.1 Integrated Value Display Format

The following tables describe the format of integrated values after they have been reset. When the number of digits in an integrated value increases, the number of digits in the format will also increase. Similarly, when the number of digits in an integrated value decreases, the number of digits in the format will also decrease.

No fewer digits may be used than in the format in the integration reset state.

#### **Current integration format**

Current range	1, 2, 5, 10, 20, 50	100, 200, 500	1, 2, 5	10, 20
	[mA]	[mA]	[A]	[A]
Reset value	0.00000 mAh	00.0000 mAh	000.000 mAh	0.00000 Ah

#### Power integration format (150 V range)

Current range	1, 2, 5	10, 20, 50	100, 200, 500	1, 2, 5	10, 20
	[mA]	[mA]	[mA]	[A]	[A]
Voltage range					
150 V	00.0000 mWh	000.000 mWh	0.00000 Wh	00.0000 Wh	000.000 Wh

## Approach to integration reset values

One-tenth of the value of the display format for the current range or active power range is used as the integrated value format at reset.

Example:

	Display format	Integrated value format	Reset value
3 W range	3.0000 W	300.000 mWh	000.000 mWh
9 kW range	9.0000 kW	900.000 Wh	000.000 Wh

Even when a VT ratio and CT ratio are set, 1/10 of the corresponding display format is used as the integrated value format.

Example:

	Display format	Integrated value format	Reset value
600 W range 15 V × 10 (VT) × 200 mA × 20 (CT)	600.00 W	60.0000 Wh	00.0000 Wh

# 3.4 Viewing Harmonic Measured Values

The instrument displays the results of harmonic analysis for voltage, current, and active power.

Since all calculation processing is performed in parallel internally, you can obtain harmonic measured values with simultaneity with other measured values simply by switching display parameters.

Additionally, when the synchronization frequency is 45 Hz to 66 Hz, the instrument can perform harmonic measurement that compliant with IEC 61000-4-7:2002.

# 3.4.1 Setting the Synchronization Source

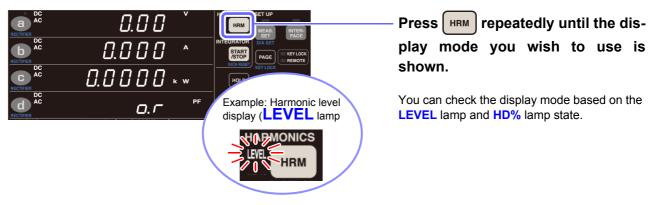
Set the synchronization source for the harmonic measurement to be performed with the instrument as described in "3.2.4 Setting the Synchronization Source (SYNC)" (p.48).

# 3.4.2 Method for Displaying Harmonic Measurement Parameters

The following table summarizes the instrument's harmonic measurement parameters and corresponding display methods:

Display mode	Normal display	Harmonic level display	Harmonic content percentage display
LEVEL lamp	off	on	off
HD% lamp	off	off	on
Measurement items	<ul> <li>Total harmonic voltage distortion</li> <li>Total harmonic current distortion</li> <li>Fundamental wave voltage RMS value</li> <li>Harmonic current RMS value</li> <li>Fundamental wave active power</li> <li>Fundamental wave apparent power</li> <li>Fundamental wave reactive power</li> <li>Fundamental wave power factor</li> <li>Fundamental wave voltage current phase difference</li> </ul>	<ul> <li>Harmonic voltage RMS value</li> <li>Harmonic current RMS value</li> <li>Harmonic active power</li> <li>0th to 50th order</li> </ul>	<ul> <li>Harmonic voltage content percentage</li> <li>Harmonic current content percentage</li> <li>Harmonic active power content percentage</li> <li>Oth to 50th order</li> </ul>

## Switching display modes



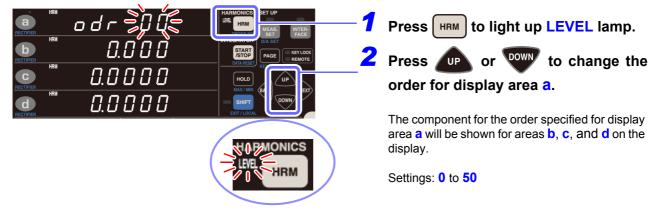
U. 1U

пп

The following two harmonic display methods are available:

## Displaying components for the same order as the display parameter (default state)

Example: If [odr 1] or similar is shown in area a on the display while displaying harmonics



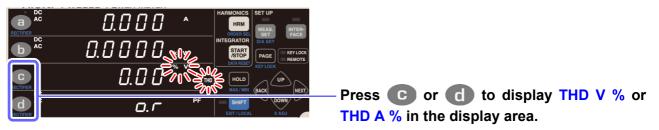
Allocating components for different orders to areas a, b, c, and d on the display (ORDER SEL)

	odr odr odr		HARMONICS LIG <u>HEM</u> JOLERED JOLERED MEAS MEA	-2,4 1	<ul> <li>Press SHIFT to place the instrument in the shift state.</li> <li>Press ORDER SEL</li> <li>Press OP or OP of the change the order.</li> <li>If all display areas indicate [], the "display the same order component" setting will be used.</li> <li>Settings: 0 to 50 → → 0 to 50</li> <li>To move areas a, b, c, or d on the display.</li> <li>Press OF or OF to select the display area you wish to set so that it flashes and then set as desired.</li> <li>Press OF OF SHIFT to exit the Order Setting screen.</li> </ul>
HRM RECTIFIER HRM HRM HRM HRM	10	0.0 0	V INTEGRATOR V INTEGRATOR DATARSS V V	LOCK	By allocating different orders to areas <b>a</b> through <b>d</b> on the display and then setting all the areas to the same measurement

parameter, you can observe changes in each order.

#### Parameters shown with normal display parameters

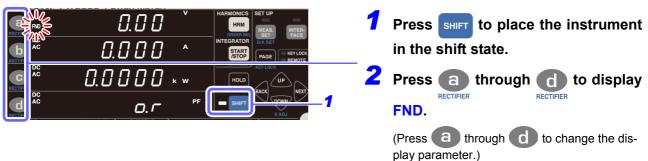
Total harmonic voltage distortion (**THD V %**), total harmonic current distortion (**THD A %**) Example: THD V%



#### Parameters shown as fundamental wave parameters (displayed as RECTIFIER FND)

Fundamental wave voltage RMS value (FND V), fundamental wave current RMS value (FND A), fundamental wave active power (FND W), fundamental wave apparent power (FND VA), fundamental wave reactive power (FND var), fundamental wave power factor (FND PF), fundamental voltage/current phase difference (FND °)

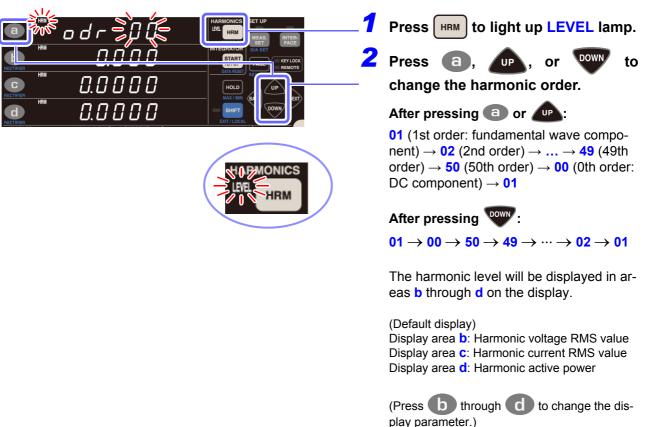
Example: FND V



Measurement parameters displayed using harmonic analysis (harmonic level, content percentage, rectifier FND [fundamental wave component]) are not averaged by the averaging function.

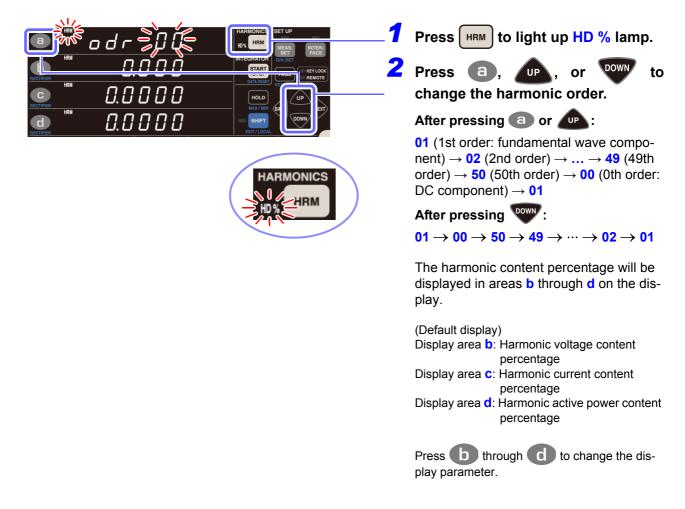
# Parameters shown as harmonic level (LEVEL)

Harmonic voltage RMS value (HRM V), harmonic current RMS value (HRM A), harmonic active power (HRM W)



#### Parameters displayed as harmonic content percentage (HD %)

Harmonic voltage content percentage (HRM V %), harmonic current content percentage (HRM A %), harmonic active power content percentage (HRM W %)

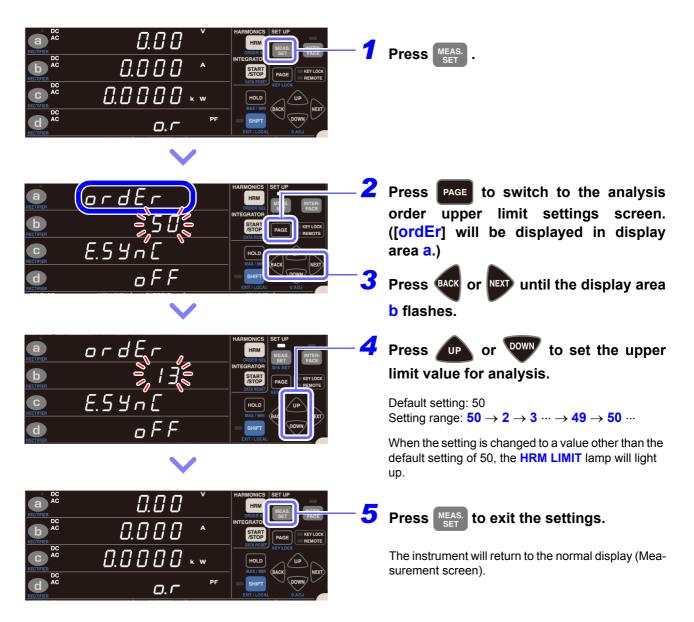


#### Parameters that can be downloaded with communications functionality

Harmonic voltage phase angle, harmonic current phase angle, harmonic voltage/current phase difference These parameters cannot be displayed using keys on the instrument. They can only be downloaded using communications functionality. (See the Communications Command Instruction Manual.)

# 3.4.3 Setting the Harmonic Analysis Order Upper Limit

The instrument allows you to set an upper limit value for the harmonic analysis order. One example of how this setting can be used is to set a limit on the uppermost order during total harmonic distortion (THD) measurement.



The harmonic level and content percentage displays will include data up to the 50th order, even if the upper limit is set to a value other than 50.

# If the upper limit does not flash

Failure of the value to flash indicates that the upper limit value cannot be changed. Take the following action to address the issue:

Status Solution and reference for more information		
During integration operation ( <b>RUN</b> lamp lit up or flashing)	Ine Run jamo jums on	
During display hold operation or maximum value/minimum value hold operation (HOLD, MIN, or MAX lamp lit up)	<ul> <li>The upper limit value cannot be changed until this operation is canceled (so that the HOLD, MIN, or MAX lamp turns off).</li> <li>See: "Canceling the display hold state" (p.106)     "Switching the display among the maximum, minimum, and instantaneous values" (p.107)</li> </ul>	

# 3.4.4 About the HRM ERROR lamp





Accurate harmonic measurement cannot be performed while the **HRM** lamp (ERROR) is lit up.

- The HRM lamp (ERROR) will light up when the instrument receives input outside the synchronization frequency range for harmonic measurement or if it is unable to perform harmonic measurement due to the effects of noise. At that time, the instrument will show the invalid data display [- - - - -].
- Since measurement processing will be reset when integration starts, preventing harmonic analysis from being performed properly during that interval, the HRM lamp (ERROR) will light up momentarily.

# 3.5 Performing Synchronized Measurement with Multiple Instruments (Multiple-instrument Synchronized Measurement)

You can perform synchronized measurement by connecting multiple (up to eight: one master and up to seven slaves) instruments (PW3335) with optional 9165 Connection Cord (BNC cable).

This functionality can be used to perform simultaneous measurement of multiple circuits by operating only the instrument (PW3335) set up as the master (instrument setting of OUT) and thereby controlling the instrument (PW3335) set up as the slave (instrument setting of IN).

The instrument (PW3335) set up as the slave will match the timing of the instrument (PW3335) set up as the master for the following operations:

- Internal calculations
- · Display updates
- Data updates
- Integration start, stop, and reset
- Display hold
- Zero-adjustment
- Key lock

The PW3335 can also be used with the PW3336 and PW3337 series of power meters to perform synchronized measurement.

CAUTION • To avoid damaging the instruments, do not connect or disconnect cables while the instruments are turned on.

 In synchronized measurement, do not input any signal other than those specifically supported by the instrument's synchronized measurement function. Doing so may result in malfunction or damage.



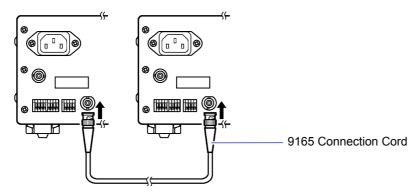
 Use a common ground for instruments (PW3335) that are performing simultaneous measurement. If different grounding is used, a potential difference will occur between the master ground and the slave ground. Connecting the connection cable (for synchronization) while there is such a difference may result in malfunction or damage.

79

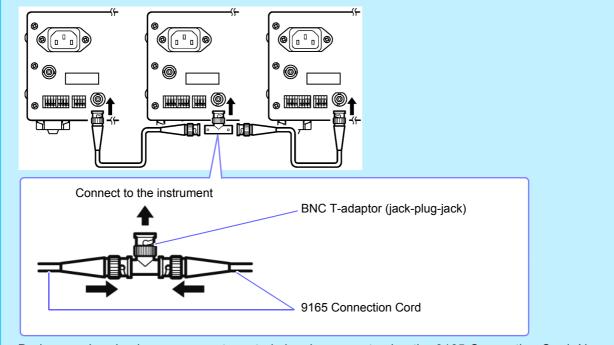
# Connecting 2 instruments (PW3335) with a synchronization cable

You will need: Two instruments, one 9165 Connection Cord

- Verify that both instruments (PW3335) have been turned off.
- 2 Connect the instruments' external synchronization terminals (EXT. SYNC) with the 9165 Connection Cord.



- **3** Turn on the two instruments (PW3335). (The order in which the instruments are turned on does not matter.)
- When performing synchronized measurement with more than three instruments, connect the instrument in
  parallel using a BNC adaptor such as a BNC T-adaptor (jack-plug-jack).



 During synchronized measurement, control signals are sent using the 9165 Connection Cord. Never disconnect the connection cable during synchronized measurement. Doing so will prevent these signals from being properly supplied. 3.5 Performing Synchronized Measurement with Multiple Instruments (Multiple-instrument Synchro-

# Configuring synchronized measurement

You can set the master and slave by configuring the synchronized control input and output settings.

Setting	Description	SYNC.OUT lamp
OFF (Default setting)	Turns off the synchronized control function. The external synchronization terminal (EXT.SYNC) setting is [IN], but input signals are ignored. External synchronized operation is not performed.	off
IN	Sets the instrument as the slave. The external synchronization terminal (EXT.SYNC) is set to [IN], and dedicated synchronization signals can be input. Synchronization signals will be received from the external synchronization terminal (EXT.SYNC), and processing will be per- formed accordingly. When synchronization signals are received from an external source, the <b>SYNC.OUT</b> lamp will flash.	off, flash
OUT	Sets the instrument as the master. The external synchronization terminal (EXT.SYNC) will be set to [OUT], and dedi- cated synchronization signals will be output. Synchronization signals will be output from the external synchronization terminal (EXT.SYNC).	on

Press MEAS. SET

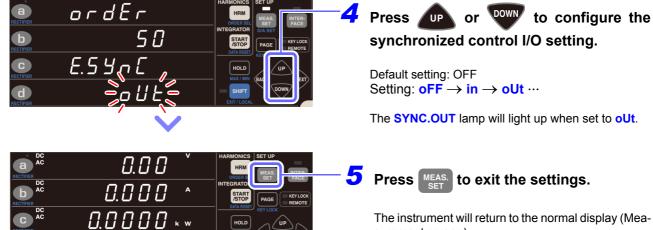




0.0

DC AC

- **2** Press **PAGE** to switch to the synchronized measurement settings screen. ([E.SynC] will be displayed in display area c.)
  - Press BACK or NEXT until the display area d flashes.



The instrument will return to the normal display (Measurement screen).



CAUTION When drawing external synchronization from two or more instruments, be sure to set only one as the oUt power meter. Use of two or more oUt instruments may cause damage or malfunction.

- When an instrument is set to oUt, the synchronization signal is output from the external synchronization terminal (EXT.SYNC) according to the internal processing timing (200 ms).
- When an instrument is set to in, it will wait for the synchronization signal from the power meter set to oUt. If no synchronization signal is received before 210 ms or more elapses, the instrument will display [Err.20]. See: "6.2 Error Indication" (p.170)

#### Synchronized operations

Internal calculations	
Display updates	The slave matches the master's timing (when the number of averaging iterations is 1 [the default setting]).
Data updates	
	Integration starts, stops, and is reset at the same timing as the master on the slave by
Integration start/stop and reset	means of START operation on the master.
Display hold	When <b>HOLD</b> is pressed on the master, the master and slave both enter the hold state. To cancel the display hold state, press <b>HOLD</b> again.
Zero Adjustment Zero-adjustment is performed on the slave in synchronization with zero-adjustme master.	
Key-lock When the key lock is activated on the master, it is also activated on the slave. When the slave is canceled on the master, it is also canceled on the slave.	

- Before starting integration synchronized measurement, reset integrated values on both the master and slave. To perform a reset that is synchronized to the master, it is necessary for integration operation on the slave to be in the stopped or reset state.
- Starting integration without first performing a reset results in additional integration.
- If the number of averaging iterations settings on the master and slave differ from the default setting, display updates will not be synchronized.
- Synchronization and external control-based integration cannot be mixed on the slave. Always terminate external control and reset integration when performing synchronization-based integration.
- When the slave's integration time setting is shorter than the master's integration time setting, stop timing cannot be synchronized since the slave's integration will stop first.
- When performing synchronized measurement, once integration start/stop, display hold, zero-adjustment, or key lock operation is performed on the slave, it may not be possible to synchronize operation, even if the same operation is performed on the master.
- When performing integrated measurement using synchronized control, a difference of up to 0.7 sec. per hour may occur between the master's integration elapsed time display value (TIME) and the slave's integration elapsed time display value.
- Canceling the hold state on the master will cause all hold states (display, maximum value, and minimum value) to be canceled on the slave.

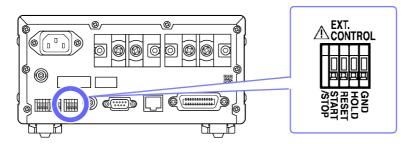
# 3.6 External Control

By connecting an external device to the instrument's external control terminals and sending signals to the instrument from that device, the instrument can be controlled, for example to start and stop integration and reset integrated values.

# External control terminal (EXT.CONTROL)

The external control terminals are input terminals for controlling the instrument by means of either 0/5 V logic signals or short/open contact signals.

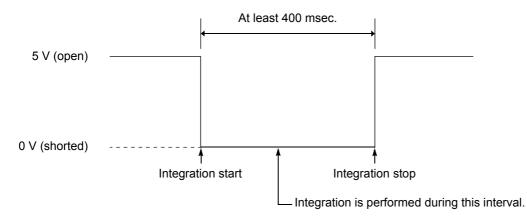
## External control terminals and description of control



Terminal name	Description
START/STOP	Starts/stops integration. When a high (5 V or open) or low (0 V or shorted) signal is input to this terminal, integration starts. When the signal changes from low to high, integration stops.
RESET	Resets integrated values. When this terminal is set to low for at least 200 ms, integrated values are reset during that period.
HOLD	Display hold. Holds the display when this terminal changes from high to low. The display hold is canceled when the terminal changes from low to high.
GND	Connect to the external device's GND terminal.

External control signals are detected using the intervals illustrated in the following timing diagrams, but there may be a delay in the display depending on the input signal frequency, synchronization signal, timeout, and other settings.

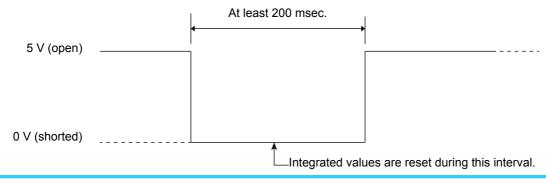
## Integration start/stop (START/STOP terminal)



- When integration is started with external control, it can only be stopped by external control. The integration set time is ignored. If you attempt to stop integration with [START], [Err.11] will be displayed.
- A delay (data update interval) of up to 200 msec. will occur between input of the integration start signal and the actual start of integration.
- The EXT lamp will light up while integration triggered by external control is being performed.

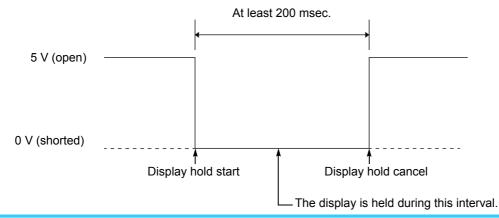


## Integrated value reset (RESET terminal)



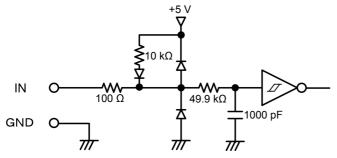
- While integration is being performed (while the **RUN** lamp is lit up), integrated values cannot be reset. Attempting to do so will cause [Err.15] to be displayed.
- A delay (date update interval) of up to 200 msec. will occur between input of the integration reset signal and the actual integration reset.

## **Display hold (HOLD terminal)**



A delay (data update interval) of up to 200 msec. will occur between input of the hold signal and the actual hold.

#### External control terminal internal circuit schematic



# Connecting wires to the external control terminals

Before connecting wires to the terminals, see "Connecting, Input and Measurement" (p.8).

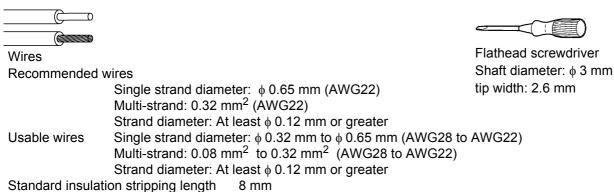


The external control terminals are input terminals for controlling the instrument by means of either short/open contact signals or 0/5 V logic signals. Do not input a voltage in excess of 5 V.

To avoid an electrical accident, use the specified wire type.

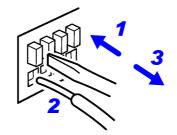
Connect the wires to the terminals for the parameter you wish to control. Connect the GND terminal on the instrument's external control terminals to the Lo (0 V) side of the contact signal or logic signal. See: "External control terminals and description of control" (p.82)

## **Required item:**



- **1** Press down on the button above each of the instrument's external control terminals using a tool, such as a flat head screwdriver.
- **?** While the button is depressed, insert the wire into the electric wire connection hole.
- 3 Release the button. The electric wire is locked in place.

#### **To remove the wire:** Hold the button while pulling the wire out.



# 3.7 Using D/A Output PW3335-02 PW3335-04

The PW3335-02 and PW3335-04 generate voltage output in response to input from the D/A output terminals.

#### Level (analog) output

Converts the instrument's measured values into signal levels and outputs a DC voltage. The output voltage is updated in response to display updates (data updates: approximately every 200 ms). It is possible to record fluctuations over extended periods of time by combining this functionality with a data logger or recorder.

#### High-speed level output

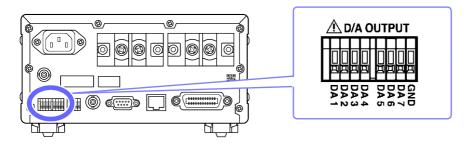
Generates level (analog) output for each cycle of the input voltage and input current. Additionally, it is possible to generate level output for the active power calculated for each cycle of the voltage or current that has been set as the synchronization source. It is possible to observe power consumption and other properties for abruptly fluctuating loads one wave at a time by combining this functionality with a recorder or other instrument.

#### Waveform output

Samples the voltage and current input to the instrument at approximately 700 kHz, performs D/A conversion, and outputs an instantaneous voltage waveform, instantaneous current waveform, and instantaneous power waveform. It is possible to observe equipment rush current and instantaneous power waveforms by combining this functionality with an oscilloscope or other instrument.

When the frequency of input to the set synchronization source is less than 5 Hz, the output update rate for level output and high-speed level output varies with the frequency of the input to the synchronization source. Example: If the frequency of input to the synchronization source is 0.8 Hz, the output update rate will be 1/0.8 = 1.25 sec.

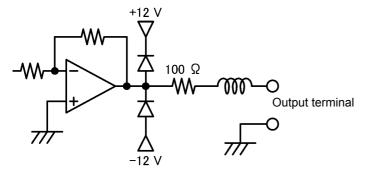
## Output terminals and description of output



## Available output parameters and output voltages (DA1 to DA7)

	Output voltage	Output parameters
Level output	Select from 2 V (STD.2) and 5 V (STD.5).	Voltage (V), Current (A), Active power (W), Apparent power (VA), Reactive power (var), Power factor (PF), Phase angle (°), Voltage frequency (V Hz), Current frequency (A Hz), Time average current (T.AV A), Time average active power (T.AV W), Current integration (Ah, Ah+, Ah-), Active power integration (Wh, Wh+, Wh-), Voltage crest factor (CF V), Current crest factor (CF A), Voltage ripple rate (RF V %), Current ripple rate (RF A %), Total harmonic voltage distortion (THD V %), Total harmonic current distortion (THD A %), Maximum current ratio (MCR)
High-speed level output	Select from 2 V (FASt.2) and 5 V (FASt.5)	Voltage (V), Current (A), Active power (W)
Waveform output	1 V (FASt) Instantaneous voltage and instan- taneous current RMS level Instantaneous power Average level	Instantaneous voltage (V), Instantaneous Current (A), Instantaneous power (W)

## **Output circuits**



The output impedance of each output terminal is approximately 100  $\Omega$ . When connecting a recorder, DMM, or other instrument, use a device with high input impedance (1 M $\Omega$  or greater).

A maximum voltage of approximately ±12 V may be output from D/A output terminals.

# Connecting wires to D/A output terminals

Before connecting wires to the terminals, see "Connecting, Input and Measurement" (p.8).



To avoid damaging the instrument, do not input voltage to the output terminals or short the terminals.

To avoid an electrical accident, use the specified wire type.

Connect wires to the terminals that you have set to output the desired parameters. Connect the instrument's GND terminal to the GND terminal of the data logger, recorder, or other output device. See: "Output terminals and description of output" (p.86)

#### **Required item:**

O		
Wires		Flathead screwdriver
Recommended v	vires	Shaft diameter:
	Single strand diameter:	tip width: 2.6 mm
	Multi-strand:	
	Strand diameter: At least $\phi$ 0.12 mm or greater	
Usable wires	Single strand diameter: $\phi$ 0.32 mm to $\phi$ 0.65 mm (AWG28 to	o AWG22)
	Multi-strand: 0.08 mm <sup>2</sup> to 0.32 mm <sup>2</sup> (AWG28 to AWG22)	
	Strand diameter: At least $\phi$ 0.12 mm or greater	
Standard insulati	on stripping length 8 mm	

Press down on the button above each of the instrument's D/A output terminals using a tool, such as a flat head screwdriver.

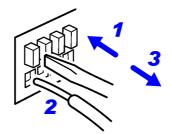
While the button is depressed, insert the wire into the electric wire connection hole.

Release the button.

The electric wire is locked in place.

#### To remove the wire:

Hold the button while pulling the wire out.



# 3.7.1 Level Output, High-speed Level Output, and Waveform Output

The PW3335 provides seven D/A output terminals. You can set each to a desired output parameter to generate voltage output based on the output parameter input.

For example, if you set the output parameter to active power (W), the terminal will output a voltage based on the active power.

Although there are differences for certain output parameters, the basic approach implemented by this functionality is described below.

See: "Appendix 2 Detailed Specifications of Output" (p. A2)

#### Level output

 $2 \mbox{ V DC}$  at  $\pm 100\%$  of the STD.2 set range

5 V DC at ±100% of the STD.5 set range

#### High-speed level output

2 V DC at ±100% of the FASt.2 set range

5 V DC at ±100% of the FASt.5 set range

#### Waveform output

1 V f.s. at 100% of the FASt set range

Terminal	Default setting	Description
DA1	V : AC+DC, STD.2	Each D/A output terminal can be set to any of the following:
DA2	A : AC+DC, STD.2	Level output
DA3	W : AC+DC, STD.2	High-speed level output
DA4	PF : AC+DC, STD.2	Waveform output
DA5	V : AC+DC, FASt	See: "Appendix 2 Detailed Specifications of Output" (p. A2)
DA6	A : AC+DC, FASt	
DA7	W : AC+DC, FASt	

- For more information about D/A output, see "D/A Output Specifications" (p.152)
- Available output methods vary with the output parameter and rectifier.

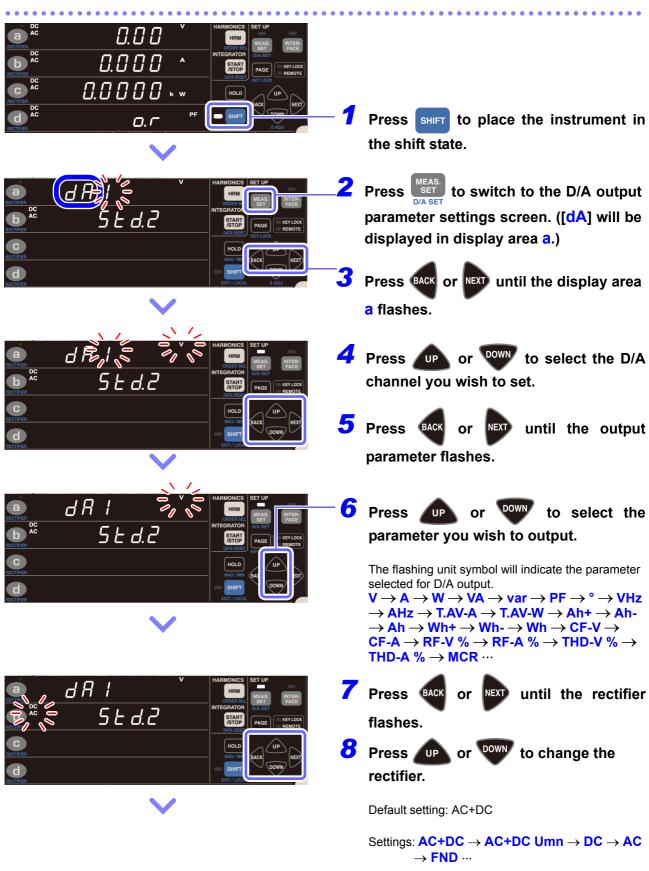
See: "Appendix 2 Detailed Specifications of Output" (p. A2)

- If settings have resulted in a [Lo.] display, output will be 0 V. However, when auto-range integration is enabled, that output is maintained.
- Level is generated for instantaneous values even when display hold or averaging processing is being performed.
- Level output cannot be generated for voltage peak values, current peak values, or harmonic orders.
- Never input a signal to an output terminal. Doing so may damage the instrument.

For the PW3335-02 and PW3335-04, the DA1 to DA7 output parameters are the same as the output parameters for LR8410 Link compatible loggers. For the PW3335 and PW3335-03, the default parameters for the DA1 to DA4 terminals are output parameters for LR8410 Link compatible loggers (DA5 to DA7 cannot be used).

See: "3.11 Connecting the Instrument to Hioki LR8410 Link compatible Logger" (p.115)

# Setting the output parameter, rectifier, and output method for D/A output channels



	HARMONICS SET UP HARMONICS SET UP HARMON	9 10	Press BACK or NEXT until the output method flashes. Press UP or DOWN to change the output method.
	$\checkmark$		The available output parameters vary with the output method and rectifier. Example: For V and AC+DC
a <sup>DC</sup>			Std.2 $\rightarrow$ Std.5 $\rightarrow$ FASt.2 $\rightarrow$ FASt.5 $\rightarrow$ FASt
		-77	Press MEAS. set to exit the settings.

The instrument will return to the normal display (Measurement screen).

#### For Lo. display

RECTIFIER	d R		0	HARMONICS HRM ORDER SEL	SET UP MEAS. INTER- SET FACE
DC AC		Lo.		INTEGRATOR START /STOP DATA RESET	D/A SET
C				HOLD MAX/MIN	
d RECTIFIER				EXIT/LOCAL	DOWN

0.0000. \* \*

0.1

If the Lo. display is active, output will be 0 V.

The display will indicate "Lo." if an unmeasured parameter is specified. Ordinarily, the instrument will output 0 V while the "Lo." Display is active, but if auto-range integration is enabled, that output will be maintained.

Sets the frequency value for the output f.s. (5 V).

## For integrated value (Ah+, Ah-, Ah, Wh+, Wh-, or Wh)

RECTIFIER	dЯ	<i> </i>			A	h	+	HARMONICS HRM ORDER SEL	SET UP MEAS. SET	INTER- FACE
DC RECTIFIER			5	k	A	h		INTEGRATOR START /STOP DATA RESET	D/A SET	KEY LOCK REMOTE
CRECTIFIER								HOLD MAX/MIN		P
d RECTIFIER								EXIT / LOCAL		

Sets the integrated value for the output f.s. (5 V).

 $\begin{array}{l} \text{Default setting: 5 k} \\ \text{Settings: } 5 \ k \rightarrow 500 \ k \rightarrow 5 \ M \rightarrow 500 \ M \\ \rightarrow 500 \ M \rightarrow 5000 \ M \rightarrow 5 \ m \rightarrow 50 \ m \\ \rightarrow 500 \ m \rightarrow 5 \rightarrow 50 \ \rightarrow 500 \ \rightarrow 5 \ k \ \cdots \end{array}$ 

For frequency (V Hz or A Hz)

# Setting D/A output when enabling auto-range integration

During auto-range integration mode operation, you can set the current range (200 mA to 20 A, b, totAL [total]) you wish to output for the following measurement parameters.

Measurement items				Rectifier					
		AC+DC	AC+DC +Umn	DC	AC	FND	Rated output voltage		
Time average current	T.AV A	Lo.*	Lo.*	•	Lo.	Lo.	Relative to ±100% of the range STD.2: ±2 V DC		
Time average active power	T.AV W	•	•	•	Lo.	Lo.	STD.5: ±5 V DC		
Current integration	Ah+ Ah- Ah	Lo.	Lo.	•	Lo.	Lo.	5 V when set value is reached Example: If set to 5 kAh, 5 V DC at 5 kAh		
Active power integration	Wh+ Wh- Wh	•	•	•	Lo.	Lo.	5 V when set value is reached Example: If set to 5 kWh, 5 V DC at 5 kWh		

In the b and totAL ranges, 100% of current is equivalent to 20 A, and 100% of power is equivalent to 100% of the voltage range × 20 A.



First, enable auto-range integration. (p.67)

Press SHIFT to place the instrument in the shift state.

**2** Press MEAS. D/A SET to switch to the D/A output parameter settings screen. ([dA] will be displayed in display area a.)



•: Current range can be set Lo.:No measurement data

Ъ

T.A\

C

d

A

h

## For time average (T.AV A or T.AV W)



d.c

EoEAL

- **3** Press **EACK** or **NEXT** until the parameter flashes.
- **4** Press DOWN to select the ПЬ or parameter you wish to output.

If you select time-average, the current range will be shown in display area d.

**5** Press BACK until the output or method flashes.

**6** Press **DP** or DOWN to select the output method.

The available output method vary with the output parameters and rectifier.

Example: For T.AV W and AC+DC Default setting: STD.2 Settings:  $Std.2 \rightarrow Std.5 \rightarrow Std.2 \cdots$ 

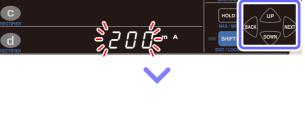
- d8 1 T.AV w 5 E d.2 b d
- 7 Press BACK until the current or range flashes.
- 8 Press en or with to select the current range you wish to output.

Default setting: totAL Settings: totAL  $\rightarrow$  200 mA  $\rightarrow$  500 mA  $\rightarrow$  1 A  $\rightarrow$ 2 A  $\rightarrow$  5 A  $\rightarrow$  10 A  $\rightarrow$  20 A  $\rightarrow$  b  $\rightarrow$ totAL ···



to exit the settings.

The instrument will return to the normal display (Measurement screen).



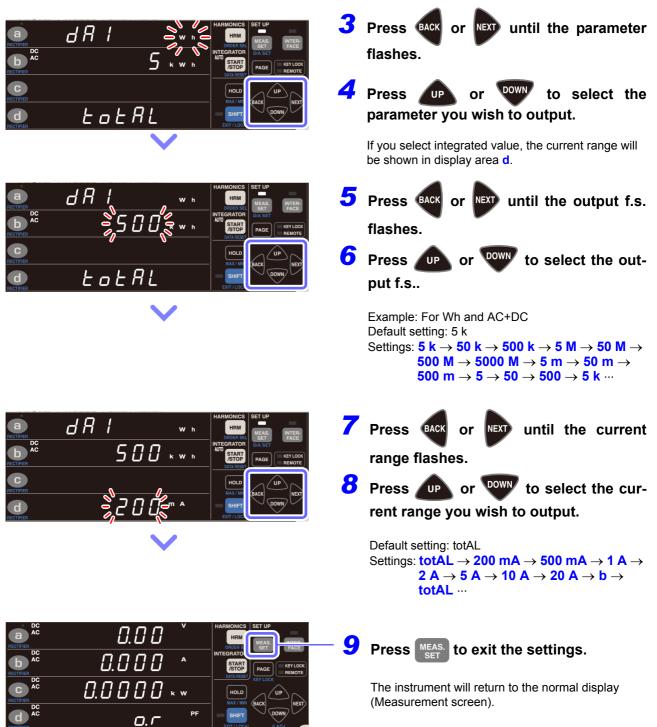
0.00

0.000

0.0000 \* \*

0.0

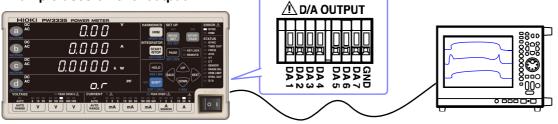
## For integrated value (Ah+, Ah-, Ah, Wh+, Wh-, or Wh)



# Example uses

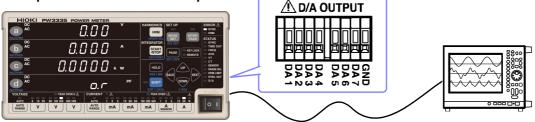
D/A output can be used in combination with a data logger or recorder. For more information about the output voltage, output resistance, response time, and output update rate, see "Chapter 5 Specifications" (p.139).

#### Example uses of level output



- When using a VT ratio or CT ratio, output voltages are determined by multiplying the range value by the VT ratio or CT ratio.
- When the measurement range is set to auto-range operation, the output rate for level output and highspeed level output will also change with changes in the range. When measuring lines characterized by abrupt changes in measured values, exercise care not to mistake the range conversion. It is recommended to use a fixed range in measurement applications such as this.
- Output of 0 V is generated while displaying invalid data.

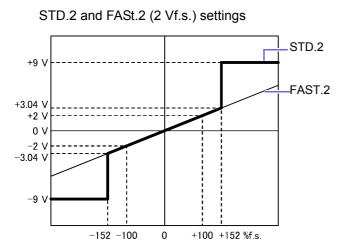
#### Example uses of waveform output



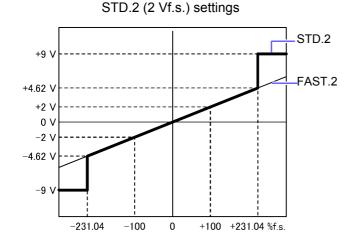
- When using a VT ratio or CT ratio, the value obtained by multiplying the range by the VT ratio or CT ratio serves as the 1 V RMS value.
- When the measurement range is set to auto-range operation, the output rate for waveform output will also change with changes in the range. When measuring lines characterized by abrupt changes in measured values, exercise care not to mistake the range conversion. It is recommended to use a fixed range in measurement applications such as this.
- · Waveform output will change even in the display hold state and during averaging processing.

# Output voltage of level output

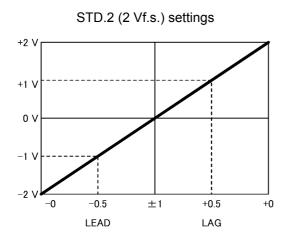
#### Voltage, current

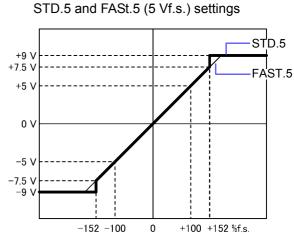


Active power: STD.2 and FASt.2 (2 Vf.s.) settings Apparent power, reactive power:

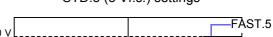


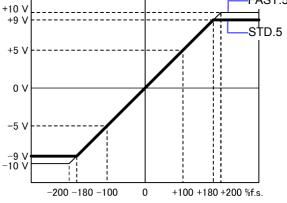




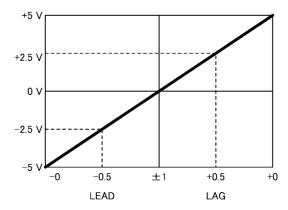


Active power: STD.5 and FASt.5 (5 Vf.s.) settings Apparent power, reactive power: STD.5 (5 Vf.s.) settings

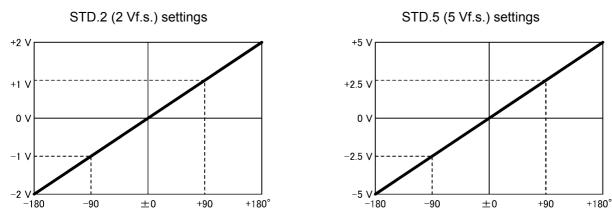




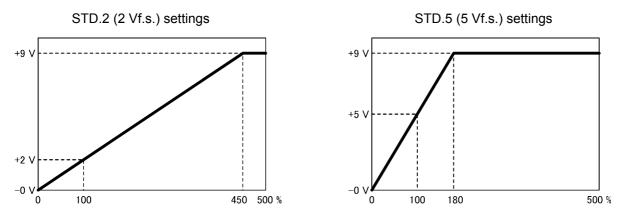




#### Phase angle

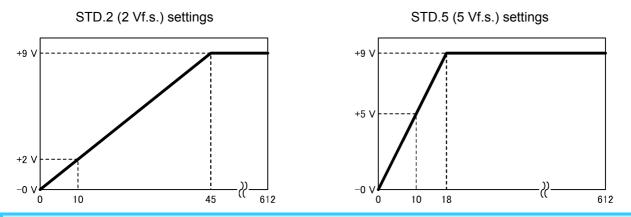


Voltage/ current ripple rate, total harmonic voltage/ current distortion



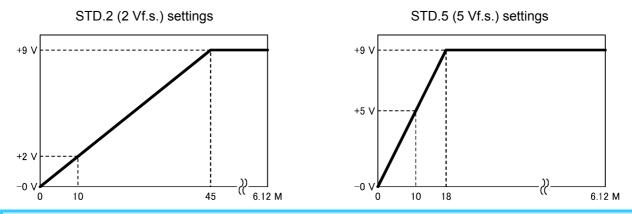
Although the voltage ripple rate, current ripple rate, total harmonic voltage distortion, and total harmonic current distortion are displayed up to 500.00%, level output changes to +9 V at 450% when using the STD.2 (2 V) setting and 180% when using the STD.5 (5 V) setting, voltages in excess of that value are not output.

#### Voltage/ current crest factor



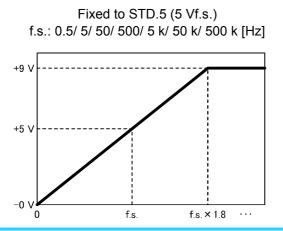
Although the voltage crest factor and current crest factor are displayed up to 612.00, level output changes to +9 V at 45 when using the STD.2 (2 V) setting and 18 when using the STD.5 (5 V) setting, voltages in excess of that value are not output.

#### Maximum Current Ratio



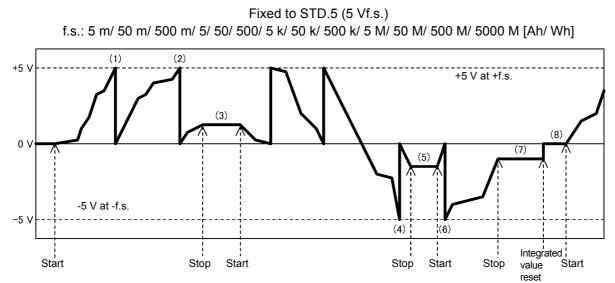
Although the maximum current ratio is displayed up to 6.12 M, level output changes to +9 V at 45 when using the STD.2 (2 V) setting and 18 when using the STD.5 (5 V) setting, voltages in excess of that value are not output.

#### Frequency



Frequency level output (fixed to STD.5) changes to +5 V at the selected f.s. value and +9 V at the frequency that is 1.8 times the f.s. value, voltages in excess of that value are not output. (The default f.s. setting is 500 Hz.)

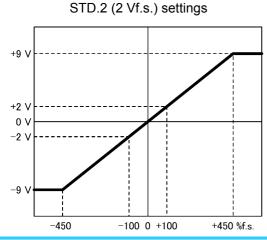
#### Current integration, active power integration



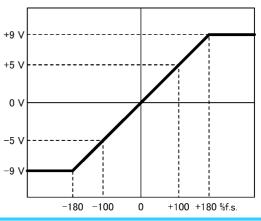
Level output (fixed to STD.5) functions as follows for current integration and active power integration. (The default f.s. setting is 5 k [Ah/ Wh])

(1), (2), (4), (6)	Level output for current integration and active power integration changes to +5 V or -5 V at a whole-number multiple of the selected f.s. value. When the current integration or active power integration value exceeds the selected f.s. value, level output changes to 0 V, and then voltage output continues from 0 V depending on the integrated value. Example: If the f.s. value in the above figure is 5 kWh Level output changes to +5 V or -5 V at whole-number multiples of +5 kWh or -5 kWh (5, 10, 15, etc.). (1) +5 kWh (2) +10 kWh (4), (6) -5 kWh
(3), (5)	When integration stops, the output voltage at that point in time is held. When integration is started in that state, the voltage continues to change from the held output voltage.
(7)	When integration stops, level output is in the integration stopped state. The output voltage at this point is held.
(8)	When integrated values are reset, the output voltage changes to 0 V. When integration is started in that state, the voltage changes from 0 V according to the integrated value and is output.

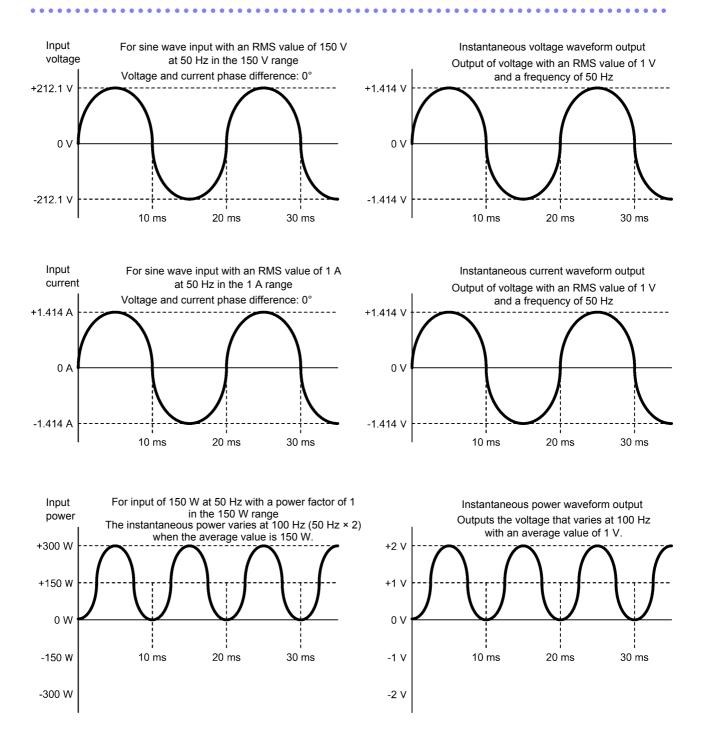
#### Time average current/ active power



STD.5 (5 Vf.s.) settings



The f.s. for level output for time-average current and time-average active power is the current or active power measurement range, and level output changes to +9 V at ±450%f.s. when using STD.2 (2 V) or at ±180%f.s. when using STD.5 (5 V), voltages in excess of that value are not output.



# Output voltage of waveform output

# 3.8 Using a Current Sensor

PW3335-03 PW3335-04

An optional current sensor can be used to measure currents in excess of the instrument's current effective measurement range maximum of 30 A. By setting the instrument's CT ratio based on the rating of the current sensor being used, it is possible to read the CT's primary-side current value directly. (p.58)



The external current sensor input terminals are not isolated (secondary potential). Never connect any input other than isolated input from an optional current sensor to the terminals. Doing so may result in a short-circuit accident or electric shock.

The instrument can use the current sensors listed below. For detailed specifications for current sensors or the 9555-10 Sensor Unit as well as information about how to use the sensors, see the included instruction manual.

# Current sensors (TYPE.1) that are connected directly to the instrument's external current sensor input terminals (current sensor terminals)

The following current sensors are referred to as "TYPE.1" current sensors:

- Model 9661 Clamp on Sensor (rated current: 500 A AC)
- Model 9669 Clamp on Sensor (rated current: 1000 A AC)
- Model 9660 Clamp on Sensor (rated current: 100 A AC)
- Model CT9667 Flexible Clamp on Sensor (rated current: 500 A/5000 A AC)

#### Current sensors (TYPE.2) that are connected to the instrument's external current sensor input terminals (current sensor terminals) using the 9555-10 Sensor Unit and L9217 Connection Cord

The following current sensors are referred to as "TYPE.2" current sensors:

- Model 9272-10 Clamp on Sensor (rated current: 20 A/200 A AC range switchable)
- Model 9277 Universal Clamp on CT (rated current: 20 A AC/DC )
- Model 9278 Universal Clamp on CT (rated current: 200 A AC/DC)
- Model 9279 Universal Clamp on CT (rated current: 500 A AC/DC )
- Model 9709 AC/DC Current Sensor (rated current: 500 A AC/DC )
- Model CT6862 AC/DC Current Sensor (rated current: 50 A AC/DC )
- Model CT6863 AC/DC Current Sensor (rated current: 200 A AC/DC )
- Model CT6865 AC/DC Current Sensor (rated current: 1000 A AC/DC )
- Model CT6841 AC/DC Current Probe (rated current: 20 A AC/DC)
- Model CT6843 AC/DC Current Probe (rated current: 200 A AC/DC )

# Before connecting a current sensor

Please read "Operating Precautions" (p.5) carefully before connecting a current sensor to the instrument.

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ment.	
▲ DANGER	When the clamp sensor is opened, do not short-circuit two wires to be measured by bringing the metal part of the clamp into contact with them, and do not use over bare conductors.
CAUTION	<ul> <li>Do not connect or disconnect connection cords from the current sensor or 9555-10 Sensor Unit while the instrument is turned on. Doing so may damage the instrument, current sensor, or 9555-10 Sensor Unit.</li> <li>Do not input current to the current sensor when it is not connected to the instrument or when the instrument and 9555-10 Sensor Unit are turned off. Doing so may damage the current sensor, instrument, or 9555-10 Sensor Unit.</li> <li>Avoid stepping on or pinching cables, which could damage the cable insulation.</li> <li>Be careful to avoid dropping the current sensors or otherwise subjecting them to mechanical shock, which could damage the mating surfaces of the core and adversely affect mea-</li> </ul>
	<ul> <li>Surement.</li> <li>Do not place the current sensor's core tips around foreign objects or insert foreign objects into the core slits. Doing so may degrade current sensor performance or prevent it from opening and closing properly.</li> </ul>
CAUTION	<ul> <li>When connecting a current sensor to the instrument or 9555-10, disconnect the current sensor from the measurement target and verify that no current is being input.</li> <li>To prevent damage to the connector when disconnecting the current sensor from the instrument or the connection cord from the 9555-10, be sure to release the locking mechanism, grip the head of the BNC connector (not the cord), and pull it out.</li> <li>When using the 9555-10, use the L9217 Connection Cord (which is made of plastic). Using a metal BNC cable may damage the instrument's external current sensor input terminals (which are made of plastic) or the instrument.</li> <li>When not using a current sensor, place the clamp in the closed position. Storing the sensor with the clamp in the open position may allow dirt or dust to accumulate on the mating core surfaces, which could interfere with clamping action.</li> <li>When using external current sensor input terminals, disconnect any lines from the current input terminals. When using the current input terminals.</li> </ul>
	ent's settings can be used to switch between current input terminals (maximum input current 0 A peak) and external current sensor input terminals. Current signals input to input terminals

- that are not set as enabled are ignored.
- The instrument's CT ratio is set based on the current sensor type and rating. If the CT ratio is set improperly, it will be impossible to conduct accurate measurement.
- The measurement accuracy when using a current sensor is obtained by adding the instrument's external current sensor input measurement accuracy and the current sensor's measurement accuracy.
- Depending on the current sensor being used, the instrument's accuracy defined range may be narrower than the current sensor's frequency band.

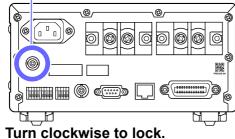
# Connecting a TYPE.1 current sensor

Connect the current sensor directly to one of the instrument's external current sensor input terminal.

Connect the current sensor's BNC connector to a external current sensor input terminal. Align the groove on the BNC connector with the connector guides on the instrument and insert.

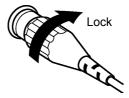
Connector guides on the

External current sensor input terminal



instrument's external current sensor input terminal Connector groove on the current sensor

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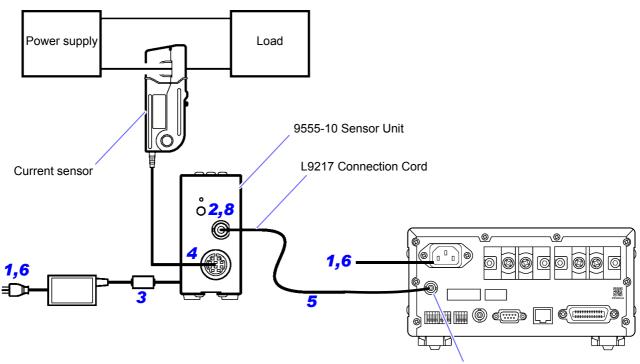
wise to disengage the lock and then pull out.

To remove the connector, turn it counterclock-

# Connecting a TYPE.2 current sensor

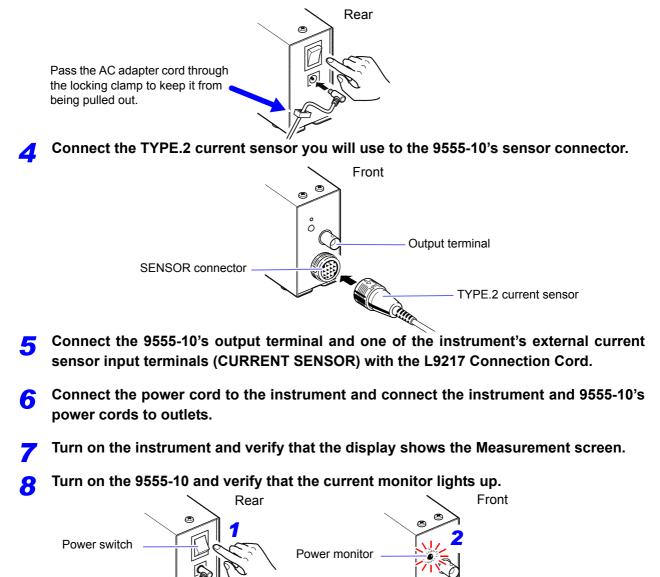
Use the 9555-10 Sensor Unit and L9217 Connection Cord to input current sensor output to the instrument.

(Example connection)



External current sensor input terminal

- **1** Verify that the instrument's power cord as well as the power cord for the AC adapter that came with the 9555-10 are unplugged from their outlets.
- Verify that the instrument and 9555-10 have been turned off.
- **3** Connect the AC adapter that came with the 9555-10 and then connect the power cord to the AC adapter.



- If using the 9277, 9278, or 9279 Universal Clamp on CT, press the 9555-10's DEMAG switch to perform degaussing operation.
- When using the CT6841/CT6843 AC/DC Current Probe, perform zero-adjustment for the current sensor. 1. Set the instrument to the 1 A range noted on the panel.
  - 2. Set the display parameter to A and the rectifier to DC.
  - 3. Turn the zero-adjustment knob (0ADJ) on the CT6841/CT6843 so that the display reads 0 A.
- When using the CT6841/CT6843, the following is added to the current sensor accuracy (by performing the above zero-adjustment procedure):

CT6841: ±20 mA

CT6843: ±200 mA

#### Setting external current sensor input

This section describes how to set the type of current sensor being used, the instrument's CT ratio, and the measurement range.

- See: "3.2.1 Selecting the Current Input Method" (p.38)
  - "3.2.8 Setting the VT Ratio and CT Ratio" (p.58)
  - "3.2.3 Selecting the Voltage and Current Ranges" (p.43)



The instrument cannot automatically detect or set the current sensor type or CT ratio. When using a current sensor, you must set the current sensor type and CT ratio. If you replace the sensor with another unit that has a different rating, you must reconfigure the current sensor type and CT ratio.

- When the current sensor type is set to "Off," input from the current input terminals is enabled, and external
  current sensor input is ignored.
- The panel displays the current measurement ranges when using external current sensor input as 1 A, 2 A, and 5 A. When the auto-range setting is enabled, auto-range operation is performed among the 1 A, 2 A, and 5 A ranges noted on the panel.
- When using the 9660 Clamp on Sensor, use the 100 A range (shown as the 1 A range on the instrument's panel).

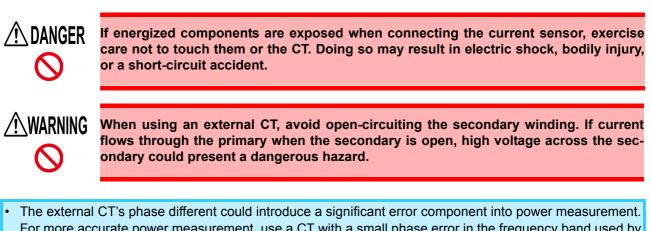
#### Current sensor types and instrument CT ratio settings

Current sensor	Current sensor rating	TYPE	CT ratio
Model 9661 Clamp on Sensor	500 A AC	1	100
Model 9669 Clamp on Sensor	1000 A AC	1	200
Model 9660 Clamp on Sensor	100 A AC	1	100
Model CT9667 Flexible Clamp on Sensor	500 A / 5000 A AC	1	100/ 1000
Model CT6862 AC/DC Current Sensor	50 A AC/DC	2	10
Model CT6863 AC/DC Current Sensor	200 A AC/DC	2	40
Model CT6865 AC/DC Current Sensor	1000 A AC/DC	2	200
Model 9709 AC/DC Current Sensor	500 A AC/DC	2	100
Model 9277 Universal Clamp on CT	20 A AC/DC	2	4
Model 9278 Universal Clamp on CT	200 A AC/DC	2	40
Model 9279 Universal Clamp on CT	500 A AC/DC	2	100
Model 9272-10 Clamp on Sensor	20 A/ 200 A AC	2	4/ 40
Model CT6841 AC/DC Current Probe	20 A AC/DC	2	4
Model CT6843 AC/DC Current Probe	200 A AC/DC	2	40

#### When the measurement target's current exceeds the optional current sensor's rating

Use an external CT.

#### Using an external CT



- The external CT's phase different could introduce a significant error component into power measurement.
   For more accurate power measurement, use a CT with a small phase error in the frequency band used by the circuit.
- When using an external CT, ground the CT's secondary negative terminal to ensure safety.

See: "Current sensor types and instrument CT ratio settings" (p.104)

#### Usage example

Measured current	7,800 A (7.8 kA)
Current sensor	Model 9669 Clamp on Sensor (rated current: 1,000 A AC)
External CT	10:1

Configure the instrument as follows:

Current sensor type: TYPE.1

CT ratio: 2,000 (current sensor's CT ratio of 200) × (external CT's CT ratio of 10) Current measurement range: 10 kA (shown as 5 A range on the instrument's panel)

The current measured value (display value) on the instrument will be [7,800 kA].

### 3.9 Other Functions

### 3.9.1 Fixing Display Values (Display Hold)

You can hold the display of all measured values by pressing **HOLD** (placing the instrument in the display hold state).

#### Activating display hold



#### Canceling the display hold state



### Press **HOLD** while the instrument is in the display hold state.

The instrument will return to the normal display (Measurement screen), and the **HOLD** lamp will turn off.

The following operations are not available when in the display hold state:

Range switching

The instrument will display [Err.16] if any range key is pressed. (p.170) Similarly, the range will not change during auto-range operation. The range will be fixed to the range in effect when the instrument was placed in the hold state. (The range can be switched while auto-range integration is in the stopped state.)

- Setting changes (integration time, number of averaging iterations, VT ratio, CT ratio, etc.) The setting parameter will light up on the Settings screen, and you will not be able to change it.
- The flashing cursor cannot be moved to parameters that cannot be changed while in the hold state.
- To change a setting, press the HOLD to cancel the display hold state (so that the HOLD lamp turns off).

The display hold will be unavailable in the following condition:

During the AVG lamp is blinking

The display hold will become available when the **AVG** lamp that has been blinking lights up, which means that an average data is determined. Measurement values that are not supposed to be averaged such as a peak value will not be subject to the display hold until an average data is determined.

Immediately after the setting such as the range is changed (while [----] is shown on the display)
 The display hold will become available when a measurement value appears on the display on which
 [----] has been shown.



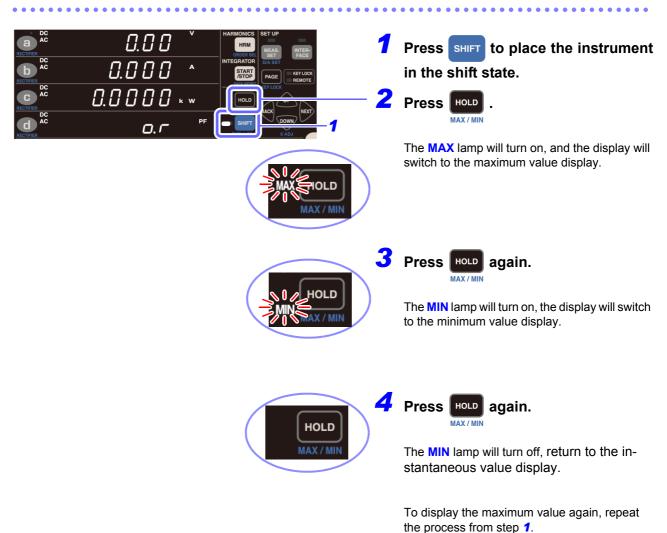
The display of measured values will be fixed when **HOLD** is pressed, and the **HOLD** lamp will light up.

# 3.9.2 Displaying Maximum, and Minimum Values (MAX/MIN)

The instrument continuously measures instantaneous, maximum, and minimum values. The display can be switched to these values with the HOLD key.

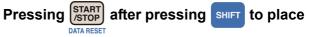
- The maximum value (including waveform peak value) for each measurement parameter is detected and held on the display. (maximum value hold).
- The minimum value (including waveform peak value) for each measurement parameter is detected and held on the display. (minimum value hold).

#### Switching the display among the maximum, minimum, and instantaneous values



#### Clearing maximum and minimum values





the instrument in the SHIFT state will clear the maximum and minimum values and restart their measurement.

Maximum and minimum values are also cleared, and their measurement restarted, at the start of integration.

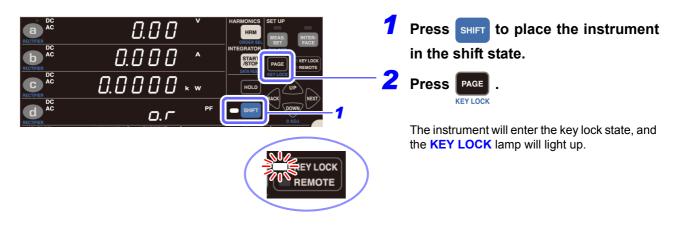
- The following operations are not available when in the maximum value or minimum value hold state:
  - Setting changes (integration time, number of averaging iterations, VT ratio, CT ratio, etc.)
  - The setting parameter will light up on the Settings screen, and you will not be able to change it.
  - The flashing cursor cannot be moved to parameters that cannot be changed while in the hold state.
- To change a setting, press ного to return to the instantaneous value display.
- For parameters other than waveform peak values, the maximum and minimum values are compared using the absolute values of measured values. For waveform peak values, the maximum value for the waveform is shown as the maximum value, and the minimum value of the waveform is shown as the minimum value.
- For integration times, integrated values, and time average values, no maximum values or minimum values are determined. For integration times and integrated values, instantaneous values are directly displayed.
   For time averages, [- - - - ] is displayed.

### 3.9.3 Disabling Control Keys (Key Lock)

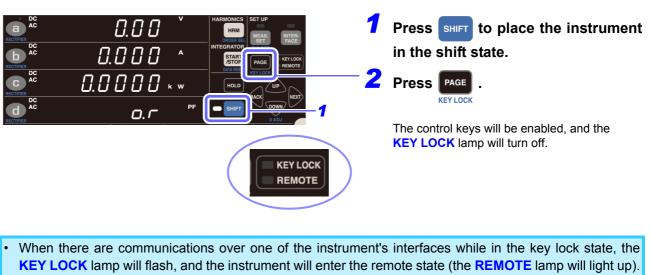
Control keys can be disabled (by placing the instrument in the key lock state) to prevent inadvertent operation during measurement.

#### Enabling the key lock state

The instrument will not accept key lock input while the **KEY LOCK** lamp is lit up.



#### Canceling the key lock state



- While in the remote state, keys are disabled.
- To enable use of the control keys, press SHIFT to cancel the remote state.

EXIT / LOCAL

See: "4.3 Canceling the Remote State (Activating the Local State)" (p.137)

### 3.9.4 Initializing the Instrument (System Reset)

This section describes how to initialize the instrument's settings. Initializing the instrument (performing a system reset) reverts settings to their default values at the time the device was shipped from the factory. The system reset should be performed while the self-test is in progress after turning on the instrument (before the display changes to the normal display).

Disconnect any voltage or current input from the instrument before performing the reset.
The RS-232C communications speed, GP-IB address, LAN-related settings, and LR8410 Link will not be initialized.

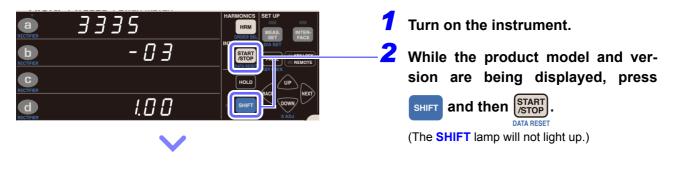
Example: PW3335-03

rESEE

a

b

d



The System Reset screen will be displayed, and settings will be reverted to their default values when the instrument was shipped from the factory.

#### **Factory Settings**

Parameter	Setting
Display area a	AC+DC V
Display area b	AC+DC A
Display area c	AC+DC kW
Display area d	AC+DC PF
Voltage range	300 V range (auto-range off)
Current range	20 A range (auto-range off)
Synchronization source	U
Current input PW3335-03 PW3335-04	Direct input (off)
VT ratio	1 (OFF)
CT ratio	1 (OFF)
Frequency measurement range (zero-cross filter)	500 Hz
Timeout	0.1 sec.
Integration time	0000.00 (10,000 hr.)
Auto-range integration	OFF
Number of averaging iterations (AVG)	1 (OFF)
Harmonic analysis upper limit order	50th
External synchronization function	OFF
Range select	All ranges on
Zero-cross threshold level	1% for all ranges
D/A output PW3335-02 PW3335-04	DA1 V:       AC+DC, STD2         DA2 A:       AC+DC, STD2         DA3 W:       AC+DC, STD2         DA4 PF:       AC+DC, STD2         DA5 V:       AC+DC, FAST         DA6 A:       AC+DC, FAST         DA7 W:       AC+DC, FAST
Integration	Reset state
Display hold	OFF
Maximum value/minimum value display	OFF
Key-lock	OFF
LAN-related settings	IP address:         192.168.1.1           Subnet mask:         255.255.255.0           Default gateway:         0.0.0.0
RS communications speed PW3335 PW3335-02 PW3335-03 PW3335-04	38,400 bps
GP-IB address PW3335-01 PW3335-04	1
LR8410 Link PW3335 PW3335-02 PW3335-03 PW3335-04	PC

LAN, RS-232C, GP-IB, and LR8410 Link settings will not be initialized when a system reset is performed.

### 3.10 When warning lamp, o.r, or the Unit Indicator Flashes

### 3.10.1 If the PEAK OVER U or PEAK OVER I Lamp Lights Up





These lamps will light up if the voltage input or current input waveform peak value exceeds the figures listed below. At this time, the displayed data is not accurate.

• Voltage input waveform peak value: ±600% of the voltage range

When using the 300 V, 600 V, or 1,000 V range, ±1,500 V peak

- Current input waveform peak value: ±600% of the current range
- When using the 20 A range, ±60 A peak

Error display	Status	Solution
PEAK OVER U	When greater than ±1,500 V peak	Stop measurement immediately, deactivate power to measurement lines, and disconnect wires.
	When less than ±1,500 V peak	The internal circuit is not operating properly. Switch to a range for which the <b>PEAK OVER U</b> lamp does not light up. <b>See:</b> "3.2.3 Selecting the Voltage and Current Ranges" (p.43)
PEAK OVER I	When greater than ±60 A peak	Stop measurement immediately, deactivate power to measurement lines, and disconnect wires.
	When less than ±60 A peak	The internal circuit is not operating properly. Switch to a range for which the <b>PEAK OVER I</b> lamp does not light up. <b>See:</b> "3.2.3 Selecting the Voltage and Current Ranges" (p.43)

### **3.10.2 If the CURRENT • Lamp Flashes**





Status	Operation	Solution
Forcibly changes the range to the 200 mA range if current of greater than or equal to ±612 mA peak is inputted continuously for 10 or more seconds when using a range from 1 mA to 100 mA with fixed range, and the <b>CURRENT</b> ● lamp will flash. * If the 200 mA range has been disabled using the range select function, the range will be switched to an enabled range greater than the 200 mA range.	Integration will be forcibly stopped (causing the <b>RUN</b> lamp to flash), and it will not be possible to resume integra- tion operation.	<ul> <li>Instrument protection mode can be canceled by performing any of the following actions, causing the CURRENT • lamp to turn off:</li> <li>Pressing one of the current range keys</li> <li>If integration has stopped, resetting integrated values</li> <li>If integration has been reset, pressing SHIFT key</li> <li>Performing a system reset</li> <li>Performing zero-adjustment (Available only in the integration reset state)</li> <li>Turning the instrument off, and then on again (integrated values will be reset)</li> </ul>

### 3.10.3 When o.r (over-range) Is Displayed

0.7



This indication is displayed when the voltage or current exceeds 152% of the range. When using the voltage 1,000 V range, it is displayed when 1,060.5 V is exceeded.

For active power, **[o.r]** is not displayed until the 231.04% of the power range is exceeded, even if the voltage or current reading is shown as **[o.r]**. The **[o.r]** indication is displayed for parameters calculated using **[o.r]** data.

The [o.r] indicator is displayed under the following conditions:

Apparent power	When [o.r] is displayed for either the voltage or current		
Reactive power	When [o.r] is displayed for the voltage, current, or active power		
Power factor	<ul> <li>When [o.r] is displayed for apparent power</li> <li>When the apparent power is 0</li> </ul>		
Phase angle	When [o.r] is displayed for the power factor		
Frequency measurement	When the reading falls outside the measurement range of 0.1 Hz to 100 kHz		
Voltage waveform peak value	When the reading exceeds 102% of the voltage peak range		
Current waveform peak value	t waveform peak value When the reading exceeds 102% of the current peak range		
Voltage crest factor	<ul> <li>When [o.r] is displayed for the voltage waveform peak value</li> <li>When [o.r] is displayed for the voltage, or the voltage is 0</li> </ul>		
Current crest factor	<ul> <li>When [o.r] is displayed for the current waveform peak value</li> <li>When [o.r] is displayed for the current, or the voltage is 0</li> </ul>		
Voltage ripple rate	<ul> <li>When [o.r] is displayed for the voltage waveform peak value</li> <li>When [o.r] is displayed for the DC voltage, or the DC voltage is 0</li> </ul>		
Current ripple rate• When [o.r] is displayed for the current waveform peak value• When [o.r] is displayed for the DC current, or the DC current is 0			
Maximum current ratio	<ul> <li>When the power factor is 0</li> <li>When [o.r] is displayed for the current crest factor</li> </ul>		

Status	Solution
When [ <b>o.r</b> ] is displayed for the voltage	Switch to a range that does not result in an over-range condition. When <b>[o.r]</b> has been displayed while using the 1,000 V range, stop measurement immediately, deactivate power to measurement lines, and disconnect wires. <b>See:</b> "3.2.3 Selecting the Voltage and Current Ranges" (p.43)
When [ <b>o.r</b> ] is displayed for the current	Switch to a range that does not result in an over-range condition. When <b>[o.r]</b> has been displayed while using the 20 A range, stop measurement immediately, deactivate power to measurement lines, and disconnect wires. <b>See:</b> "3.2.3 Selecting the Voltage and Current Ranges" (p.43)

### 3.10.4 When the Unit Indicator Flashes





Status	Solution
The unit indicator flashes while displaying the average	The average value being displayed contains <b>[o.r]</b> data. If no <b>[o.r]</b> data is present during averaging processing, the unit indicator will not flash. When <b>[o.r]</b> is displayed, internal data for which the voltage or current exceeded 152% of the range, or the active power exceeded 231.04% of the range, will be used as-is in calculating the average value.
The integrated value or time aver- age value unit indicator flashes (TOTAL and T.AV also flash)	Reset integrated values, change the range, and repeat integration. If no <b>PEAK OVER</b> condition occurs during integration, the indicator will not flash. <b>See:</b> "3.3 Integration" (p.61)

### 3.11 Connecting the Instrument to Hioki LR8410 Link compatible Logger

PW3335 PW3335-02 PW3335-03 PW3335-04

Measured values for the instrument's D/A output parameters can be sent wirelessly to an LR8410 Link compatible logger (LR8410, LR8416) using Bluetooth<sup>®</sup>. LR8410 Link compatible loggers can record measured values from the instrument at the same time as multichannel voltage, temperature, and humidity data.

The following Bluetooth<sup>®</sup> serial conversion adapter is required in order to connect the instrument to an LR8410 Link compatible logger:

 $\begin{array}{l} {\sf Bluetooth}^{\textcircled{R}} \mbox{ serial conversion adapter: Parani-SD1000 (from Sena Technologies Inc.)} \\ {\sf Bluetooth}^{\textcircled{R}} \mbox{ Class 1} \end{array}$ 



To prevent electric shock or a short-circuit, verify that power to the measurement lines has been disconnected before connecting the Bluetooth<sup>®</sup> serial conversion adapter to an instrument that is connected to measurement lines.

- Check the instrument's RS-232C communications speed before using the adapter (9600bps/38400bps).
- See: "Setting the RS-232C communications speed" (p.128)
- To ensure safety, be sure to turn off the instrument before connecting it to the adapter. Turn on the instrument after connecting the adapter.
- Refer to the Parani-SD1000 operating precautions for more information about Bluetooth<sup>®</sup> use.
- Because values are displayed at the resolution of the logger being used, they will differ slightly from the
  measured values that are displayed by the instrument. To record values that are closer to the instrument's
  measured values, choose a range that is appropriate for the input.
- For more information about how to configure Hioki LR8410 Link compatible loggers such as the LR8410, see the instruction manual for the logger with which you wish to use the instrument.
- Do not subject the Bluetooth<sup>®</sup> serial conversion adapter to mechanical shocks while it is connected to the instrument. Doing so may damage the adapter.
- When using the instrument's stands, exercise care to ensure that the Bluetooth<sup>®</sup> serial conversion adapter does not come into contact with the surface on which the instrument is sitting.
- Do not send communications commands to the instrument while it is connected with LR8410 Link. Doing so may cause the instrument to malfunction, for example by interrupting communications.

#### Configuring and connecting the adapter

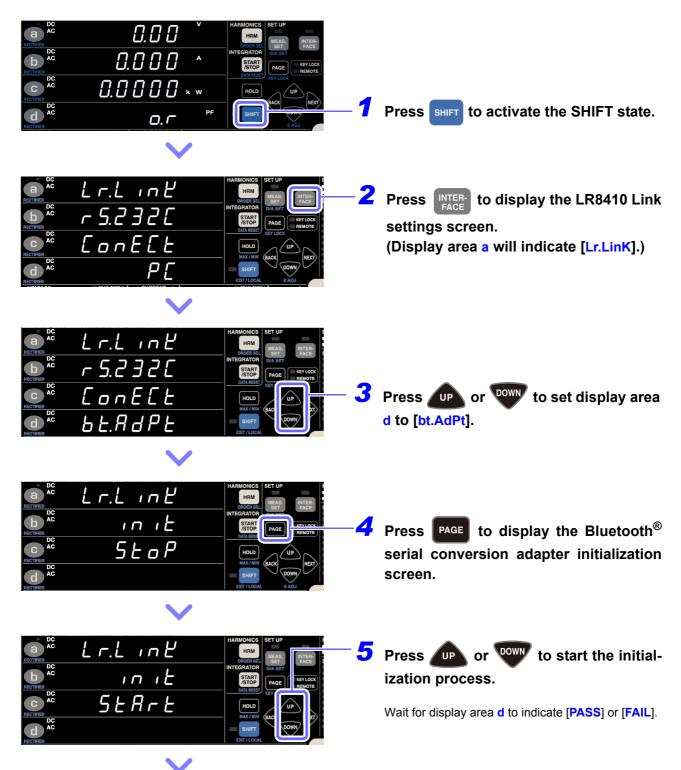
- Verify that the instrument is turned off.
- 2 Set the communications speed for the Bluetooth<sup>®</sup> serial conversion adapter (9600 bps/38400 bps).

Set using the DIP switches on the adapter.

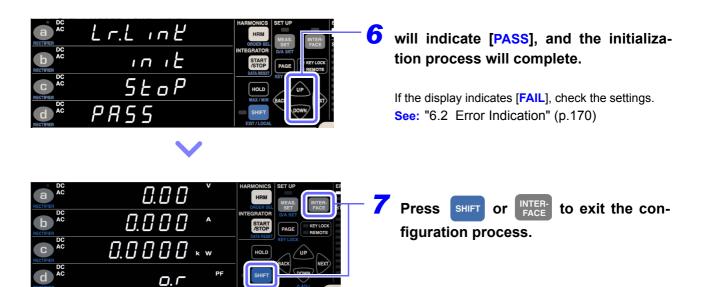
- Connect the Bluetooth<sup>®</sup> serial conversion adapter to the instrument's RS-232C connector (9-pin D-sub connector) and turn the switch on the side of the adapter to "ON."
- Turn on the instrument.

3.11 Connecting the Instrument to Hioki LR8410 Link compatible Logger

#### Configuring the instrument



3.11 Connecting the Instrument to Hioki LR8410 Link compatible Logger



#### **Default settings**

Device name	PW3335#nnnnnnnn:HIOKI (where n indicates the 9-digit serial number)
Operation mode	Mode3 (Causes the adapter to stand by for connections from all Bluetooth <sup>®</sup> devices.)
Pin code	0000
Response	Unused
Escape sequence characters	Not permitted

#### 3.11 Connecting the Instrument to Hioki LR8410 Link compatible Logger

 When using an LR8410 Link compatible logger to automatically save measured values from the instrument, it will not be possible to save accurate measured values if the instrument's measurement range is changed while automatic saving is enabled. Set the instrument's measurement range to an appropriate setting before connecting to the LR8410. Do not use auto-range integration.

• The following parameters can be output to an LR8410 Link compatible logger:

See: "3.7.1 Level Output, High-speed Level Output, and Waveform Output" (p.88)

	LR8410 Link output parameters				
Terminal	PW3335-02 PW3335-04 (with D/A output and RS-232C)	PW3335 PW3335-03 (without D/A output / with RS-232C)	PW3335-01 (without D/A output and RS-232C)		
DA1	Same as D/A output	V: AC + DC (fixed)	Not available		
DA2	Same as D/A output	A: AC + DC (fixed)	Not available		
DA3	Same as D/A output	W: AC + DC (fixed)	Not available		
DA4	Same as D/A output	PF: AC + DC (fixed)	Not available		
DA5	Same as D/A output	Not available	Not available		
DA6	Same as D/A output	Not available	Not available		
DA7	Same as D/A output	Not available	Not available		

 Only the equivalent of level output (updated every 200 ms) is available for output to LR8410 Link compatible loggers. High-speed level output and waveform output are not available.

 The instrument will enter the remote state (with the REMOTE indicator illuminated) when it starts communicating with the logger. To operate the instrument using its keys, do either of the following:

•Cancel the pairing with the instrument in the logger settings and press the instrument's **SHIFT** key to place it in the local state (so that the **REMOTE** indicator is no longer illuminated)

•Turn off the instrument and turn it back on after placing the switch on the side of the adapter in the "OFF" position.

# Connection to a PC

## **Chapter 4**

You can use the instrument's standard LAN interface to connect it to a computer, which can then control it remotely. Additionally, you can also control the instrument with communications commands using the LAN, RS-232C (optional feature), or GP-IB (optional feature) interface or transfer measurement data to a computer with a dedicated application software\*. To use communications features, you must configure the communications conditions on the instrument.

\* The latest version can be downloaded from our web site.



- Use a common ground for both the instrument and the computer. Use of 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 the communications cable, always turn off the instrument and the computer. Failure to do so could result in equipment malfunction or damage.
- After connecting the communications cable, tighten the screws on the connector securely. Failure to secure the connector could result in equipment malfunction or damage.
- For more information about how to control the instrument using communications commands, see the Communications Command Instruction Manual\*.
  - \* The latest version can be downloaded from our web site.
- Use the LAN, RS-232C, or GP-IB interface. Using multiple interfaces simultaneously may cause the instrument to malfunction, for example by interrupting communications.
- Do not send communications commands to the instrument while it is connected with LR8410 Link. Doing so may cause the instrument to malfunction, for example by interrupting communications.

#### Using the LAN Interface (p.120)

- You can control the instrument remotely with an Internet browser. (p.134)
- You can control the instrument using communications commands (see the Communications Command Instruction Manual).
- You can control the instrument by creating a program and connecting to its communications command port via TCP.

#### Using the RS-232C Interface PW3335 PW3335-02 PW3335-03 PW3335-04 (p.127)

- You can control the instrument using communications commands (see the Communications Command Instruction Manual).
- Power is supplied to RS-232C devices that support 9-pin power supply (voltage of +5 V and maximum current of 200 mA).

#### Using the GP-IB Interface PW3335-01 PW3335-04 (p.131)

• You can control the instrument with communications commands (see the Communications Command Instruction Manual).

### 4.1.1 Using the LAN Interface

You can control the instrument remotely with an Internet browser on a computer (p.134) or use command communications. Before doing so, you must configure the instrument's LAN settings and connect it to the computer with a LAN cable.

Use the LAN, RS-232C, or GP-IB interface. Using multiple interfaces simultaneously may cause the instrument to malfunction, for example by interrupting communications.

#### Items to verify before configuring settings and connecting to the instrument

- Always make LAN settings before connecting to the network. If you change settings while connected to the network, IP addresses may overlap or invalid address data may flow over the network.
- The instrument does not support networks on which the IP address is automatically acquired using DHCP.

IP address	Identifies each device connected on a network. Each network device must be set to a unique address. The instrument supports IP version 4, with IP addresses indicated as four decimal octets, example:, "192.168.0.1".
Subnet mask	This setting is for separating the IP address into the network address that indicates the network and the host address that indicates the instrument. On this instrument, the subnet mask is represented as four decimal numbers separated by ". " such as "255.255.255.0."
Default Gateway	When the computer and instrument are on different but overlapping networks (subnets), this IP ad- dress specifies the device to serve as the gateway between the networks. If the computer and instrument are connected one-to-one, no gateway is used, and the instrument's default setting "0.0.0.0" can be kept as is.

#### When Connecting the instrument to an Existing Network

The following items must be assigned in advance by your network administrator. Be sure that there is no conflict with other devices.

IP address	·		·	·
Subnet mask	·		·	·
Default Gateway		·	•	·

#### Connecting multiple instruments to a single computer using a hub

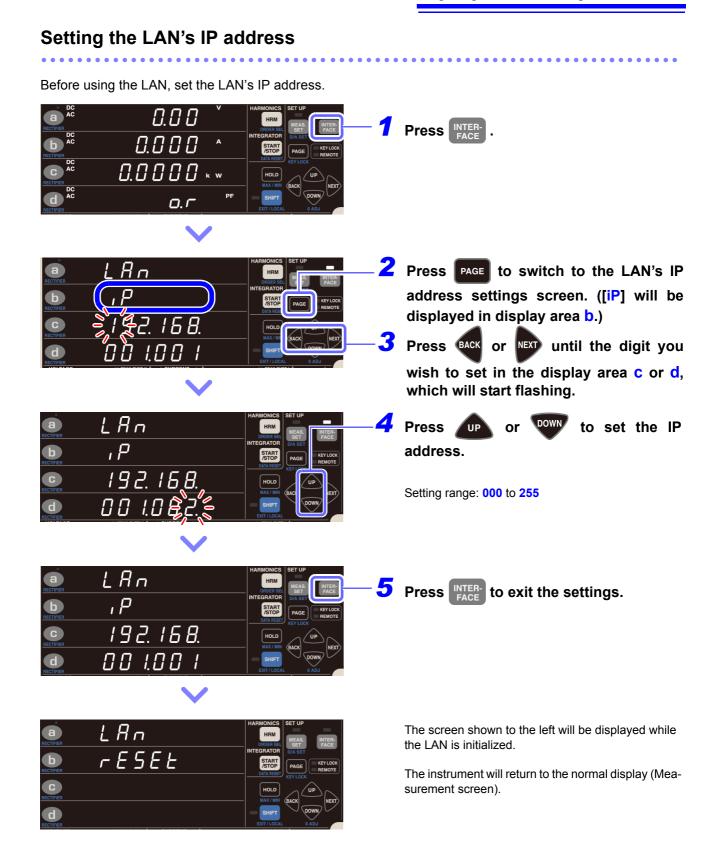
When building a local network with no outside connection, the following private IP addresses are recommended. Example settings: When creating a network with a network address of 192.168.1.0/24

IP address	Computer:192.168.1.1
Instrument:	Assign in order: 192.168.1.2, 192.168.1.3, 192.168.1.4,
Subnet mask	255.255.255.0
Default Gateway	0.0.0.0

#### Connecting one instrument to a single computer using the 9642 LAN Cable

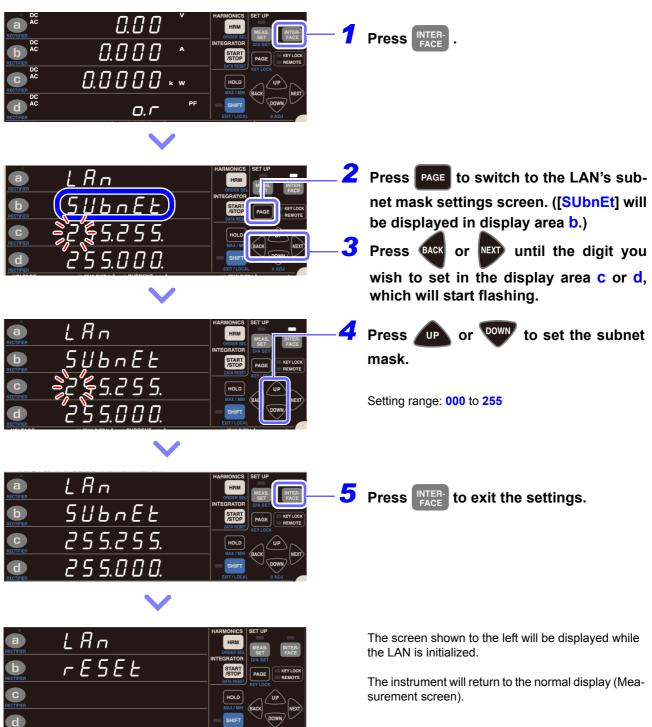
The 9642 LAN Cable can be used with its supplied connection adapter to connect one instrument to one computer, in which case the IP address is freely settable. Use the recommended private IP addresses.

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	0.0.0.0



#### Setting the LAN's subnet mask

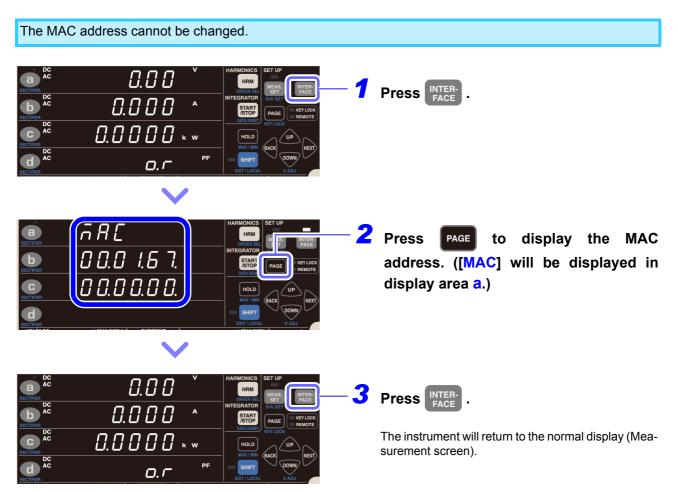
Before using the LAN, set the LAN's subnet mask.



#### Setting the LAN's default gateway Before using the LAN, set the LAN's default gateway. a AC ппп Press INTER-FACE b AC 0.000 0.0000 \*\*\* PF 0.0 **2** Press **PAGE** to switch to the LAN's suba п net mask settings screen. ([GAtE] will b be displayed in display area **b**.) C Press BACK or NEXT until the digit you 3 0.000 d $\Pi$ wish to set in the display area c or d, which will start flashing. LRn a Press UP or **Down** to set the default GREE gateway. b 0.000 C Setting range: 000 to 255 0.000 d LAn a **5** Press **INTER** to exit the settings. GREEb 000.000. C 000.000. d LAn The screen shown to the left will be displayed while **a**) the LAN is initialized. rESEE b The instrument will return to the normal display (Mea-C surement screen). d

#### **Displaying the LAN's MAC address**

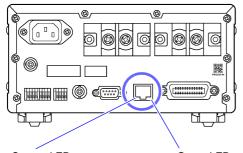
You can check the instrument's MAC address.



#### Connecting the instrument to a computer with a LAN cable

Connect the instrument and PC with a LAN cable. There are two ways to accomplish this connection:

- Connect the instrument to an existing network.
- Connect the instrument to a single PC (p.126)



Orange LED Lights up when the communications speed is 100 Mbps and turns off when the communications speed is 10 Mbps.

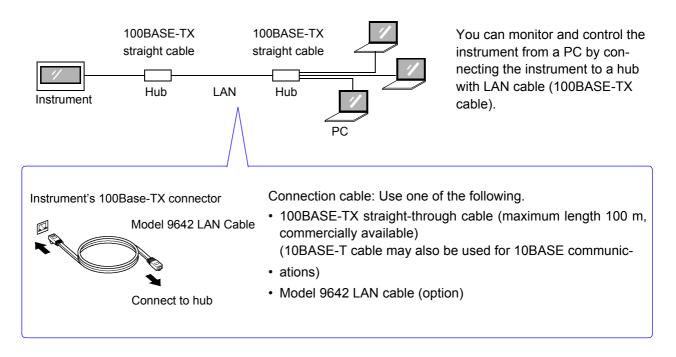
Green LED Lights up when a link is established and flashes when communications are in progress.

- Connect a LAN cable (that is compatible with 100BASE-TX) to the 100BASE-TX connector on the right side of the instrument.
- **2** Connect the LAN cable to the PC.

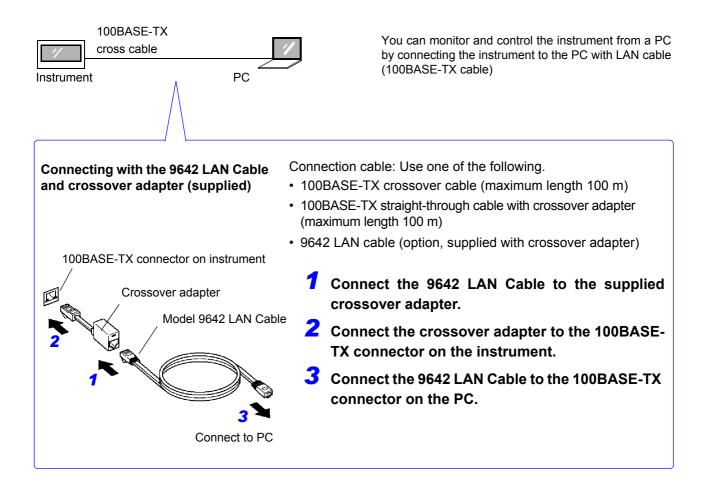
If the green LED fails to light up when the instrument is connected to a LAN, there may be an issue with the instrument, the device you are attempting to connect to the instrument, or the connection cable. If, after reading "Troubleshooting (Communications)" in the Communications Command instruction Manual\*, you think the instrument may be broken or malfunctioning, please contact your authorized Hioki distributor or reseller. If you think the device you are attempting to connect to the instrument may be broken or malfunctioning, please contact your authorized Hioki distributor or reseller. If you think the device you are attempting to connect to the instrument may be broken or malfunctioning, please contact that device's manufacturer.

\* The latest version can be downloaded from our web site.

#### **Connecting the Instrument to a Network**



#### Making Connections Between the Instrument and a PC



This completes the process of connecting the instrument and PC.

### 4.1.2 Using the RS-232C Interface

PW3335 PW3335-02 PW3335-03 PW3335-04

You can use the RS-232C interface to control the instrument using command communications.

#### Items to verify before configuring settings and connecting to the instrument



 Always turn both devices OFF when connecting and disconnecting an interface connector. Otherwise, an electric shock accident may occur.

 Be sure to connect the cable to the target device's RS-232C connector. Connecting the cable to a connector with different electrical specifications may cause electric shock or equipment damage.



 To avoid damage to the instrument, do not short-circuit the terminal and do not input voltage to the terminal.

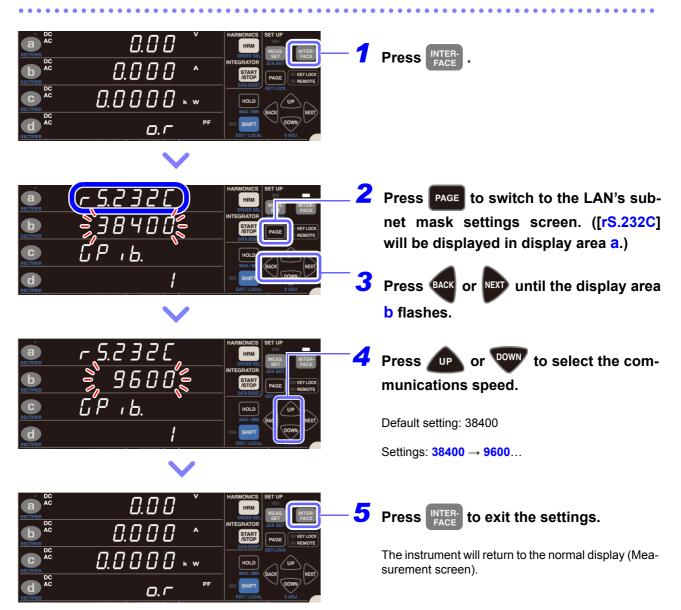
- Use the LAN, RS-232C, or GP-IB interface. Using multiple interfaces simultaneously may cause the instrument to malfunction, for example by interrupting communications.
- To connect a device that does not support power being supplied by the No. 9 pin, do not configure Bluetooth<sup>®</sup>. Doing so may damage the connected device.
- See: "3.11 Connecting the Instrument to Hioki LR8410 Link compatible Logger" (p.115)

#### **Specifications**

Communication Method	Full duplex
	Start-stop synchronization
Communication Speed	9600bps/38400bps
Data Bits	8 bits
Parity	None
Stop bit	1 bit
Message terminator (delimiter)	During Receiving: LF During Sending: CR+LF (can be switched to LF)
Flow control	None
Electrical Specifications	Input voltage level 5 to 15 V : ON -15 to -5 V : OFF Output voltage level +5 V or greater : ON -5 V or less : OFF
Connector	<ul> <li>Pin configuration of the interface connector (pin-contact 9-pin D-sub #4-40 attaching screws) The I/O connector is a DTE (Data Terminal Equipment) configuration. Recommended cable:</li> <li>RS-232C Cable (for a computer)</li> <li>9638 RS-232C Cable (for a D-sub 25-pin connector)</li> <li>See: "Connecting the RS-232C Cable" (p.129) Note: When using a USB-serial converter to connect the instrument to a computer, you may need a gender converter (male/female adapter) and a straight-cross converter.</li> </ul>

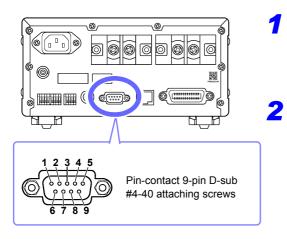
Code used: ASCII code

#### Setting the RS-232C communications speed



#### **Connecting the RS-232C Cable**

Recommended cable: Model 9637 RS-232C Cable (9pin-9pin/1.8 m crossover cable)



### Connect the RS-232C cable to the instrument's RS-232C connector.

Be sure to secure it in place with the screws.

### Set the controller's communications protocol so that it is the same as the instrument's settings.

Configure the controller's settings as follows:

Start-stop synchronization

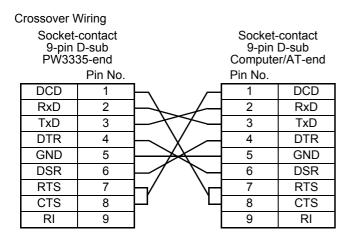
- Communication Speed: 9,600 bps/ 38,400 bps (Use the same setting as the instrument.)
- Stop bit: 1 bit
- Data Bits: 8 bits
- Parity: None
- Flow control: None
- When connecting the instrument to a controller (DTE), use a <u>cross cable</u> that satisfies the specifications of the instrument's connector and the controller's connector.
- When using a USB-serial cable, you may need a gender converter and a straight-cross converter. Obtain
  models that satisfy the specifications for the instrument's connector and the USB-serial cable's connector.

Pin No.	Interchange circuit name		CCITT circuit No.	EIA abbreviation	JIS abbreviation	Common abbreviation
1	Data/channel receive carrier detection	Carrier Detect	109	CF	CD	DCD
2	Received data	Receive Data	104	BB	RD	RxD
3	Transmitted data	Send Data	103	BA	SD	TxD
4	Data terminal ready	Data Terminal Ready	108/2	CD	ER	DTR
5	Signal ground	Signal Ground	102	AB	SG	GND
6	Data set ready	DATA Set Ready	107	CC	DR	DSR
7	Request to send	Request to Send	105	CA	RS	RTS
8	Clear to send	Clear to Send	106	СВ	CS	CTS
9	Ring indicator	Ring Indicator	125	CE	CI	RI

The I/O connector is a DTE (Data Terminal Equipment) configuration. Pin number 2, 3, 5, 7, and 8 are used in the instrument. The other pins are not used.

#### Computer

Use a crossover cable with socket-contact 9-pin D-sub connectors. Recommended cable: Model 9637 RS-232C Cable (1.8 m, 9pin-9pin, crossover cable)



#### Device with D-sub 25-pin connector

Use a crossover cable with a socket-contact 9-pin D-sub and a pin-contact 25-pin D-sub connector. As the figure shows, <u>RTS and CTS pins are shorted together and crossed to DCD in the other connector</u>. Recommended cable: Model 9638 RS-232C Cable (1.8m, 25pin-9pin, crossover cable)

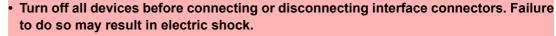
Cro	ossover V	Viring			
Socket-contact 9-pin D-sub PW3335-end Pin No.				25-pin	ontact D-sub ter-end
	DCD	1			
	RxD	2		2	TxD
	TxD	3		3	RxD
	DTR	4	$\vdash$ $\backslash$	4	RTS
	GND	5	$\vdash$ $\checkmark$ $\dashv$	5	CTS
	DSR	6	$\neg \overline{}$	6	DSR
	RTS	7	$\vdash$ $\diagdown$ $\sim$	7	GND
	CTS	8		8	DCD
	RI	9		20	DTR

Note that the combination of a dual pin-contact 25-pin D-sub cable and a 9- to 25-pin adapter cannot be used.

### 4.1.3 Using the GP-IB Interface PW3335-01 PW3335-04

You can use the GP-IB interface to control the instrument using command communications.

#### Items to verify before configuring settings and connecting to the instrument





/!\WARNING

 Be sure to connect the cable to the target device's GP-IB connector. Connecting the cable to a connector with different electrical specifications may cause electric shock or equipment damage.



• To avoid equipment damage, do not short-circuit the connector or input a voltage.



After connecting, be sure to tighten the connector screws. If the connector is not secured, operation may fail to meet specifications, and damage could result.

Use the LAN, RS-232C, or GP-IB interface. Using multiple interfaces simultaneously may cause the instrument to malfunction, for example by interrupting communications.

#### **GP-IB**

- Commands common to IEEE-488-2 1987 (requirement) can be used.
- The instrument complies with the following standard. (Compliance standard: IEEE-488.1 1987<sup>\*1</sup>)
- The instrument has been designed with reference to the following standard. (Reference standard: IEEE-488.2 1987<sup>\*2</sup>)

If the output queue becomes full, a query error will result, and the output queue will be cleared. Consequently, the instrument does not support the output queue clearing and query error output requirements in the deadlocked state<sup>\*3</sup> as defined by IEEE 488.2.

<sup>\*</sup>1 ANSI/IEEE Standard 488.1-1987, IEEE Standard Digital Interface for Programmable Instrumentation

<sup>\*</sup>2 ANSI/IEEE Standard 488.2-1987, IEEE Standard Codes, Formats, Protocols, and Common Commands

<sup>\*</sup>3 Deadlocked state: A state in which processing cannot be continued because the input buffer or output buffer is full.

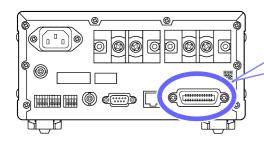
#### Specifications

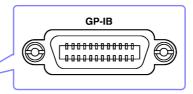
SH1	Supports all source handshake functions.
AH1	Supports all acceptor handshake functions.
Т6	Supports standard talker functions. Supports serial poll functions. Talk only mode is not supported. Supports the talker cancel function by MLA (My Listen Address).
L4	Supports standard listener functions.Listener only mode is not supported.Supports the listener cancel func- tion by MTA (My Talk Address).
SR1	Supports all service request functions.
RL1	Supports all remote/local functions.
PP0	Parallel poll functions are not supported.
DC1	Supports all device clear functions.
DT1	Supports all device trigger functions.
C0	Controller functions are not supported.

Code used: ASCII code

#### Connecting the GP-IB Cable

Recommended cable: Model 9151-02 GP-IB connection cable (2 m)



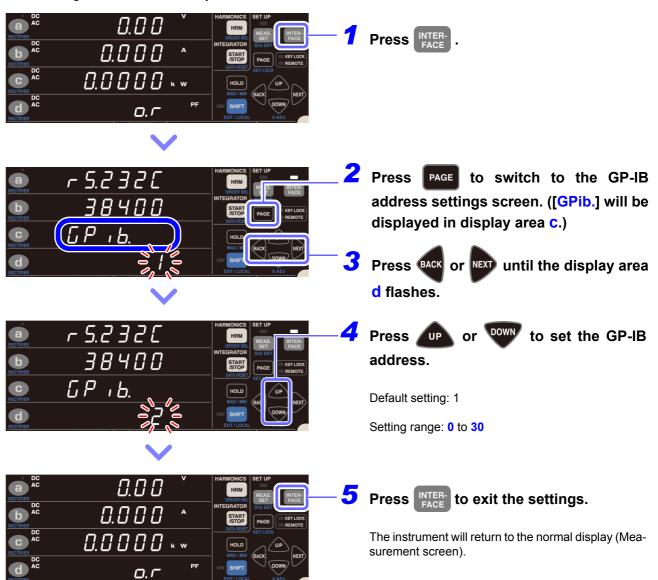


### Connect the GP-IB cable to the GP-IB connector.

Be sure to secure it in place with the screws.

#### Setting the GP-IB address

Before using the GP-IB interface, you must set the GP-IB address.



# 4.2 Operating the Instrument from a PC's Browser (LAN only)

By connecting the instrument to a computer via a LAN, you can operate from the instrument using a PC Web browser such as Internet Explorer<sup>®</sup>.

It is recommended to use IE (Internet Explorer<sup>®</sup>) Version 9 or later.

#### Connecting and configuring the LAN port

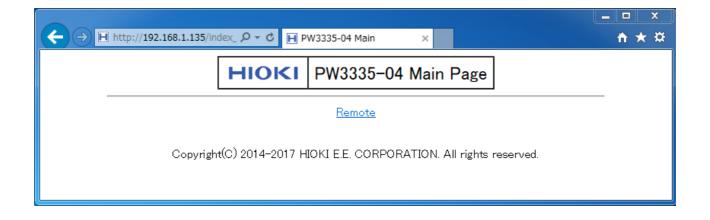
See: "4.1.1 Using the LAN Interface" (p.120)

Enter the instrument's IP address as the Web browser's address field and press the [Enter] key to display the home screen.

Example: "http://192.168.1.2"

	_ <b>D</b> X
← → http://192.168.1.135/	<b>↑</b> ★ ‡
HIOKI PW3335-04	
日本語 English	
Copyright(C) 2014-2017 HIOKI E.E. CORPORATION. All rights reserved.	



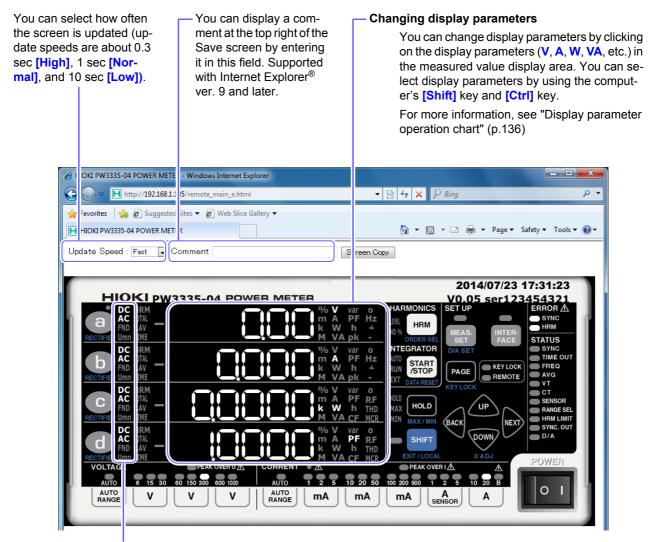


#### Operating the instrument remotely

Selecting [Remote] on the menu displays the Remote Operation screen. The screen shown on the instrument will be shown as-is in the browser window.

The buttons on the control panel correspond go the buttons on the instrument. You can also operate the instrument remotely by clicking the screen with the mouse (the same key operation as the instrument). You can save a PNG-format screenshot by clicking the [Screen copy] button.

You can also zoom in and out on most browsers by using CTRL + "+" to zoom in, CTRL + "-" to zoom out, and CTRL + "0" to select normal size.



#### Changing the rectifier

You can change the displayed rectifier by clicking on the rectifier part (**DC**, **AC**, **FND**, **Umn**) of the measured value display area. You can also select ACDC by holding down the computer's [Shift] key while you click the rectifier part of the display.

#### Instrument keys + computer's [Shift] key

You can place the instrument in the shift state by holding down the computer's [Shift] key while you click on keys on the screen with your mouse.

Example: To select the rectifier

You can set rectifier by clicking the (a) while holding down the computer's [Shift] key.

The key lock state cannot be cancelled remotely.

#### 4.2 Operating the Instrument from a PC's Browser (LAN only)

#### **Display parameter operation chart**

#### Voltage, current, and power parameters

Measurement items			Display item to click	Operation
Voltage	Voltage V		V	Click
Current		А	A	Click
Active pow	er	W	W	Click
Apparent po	wer	VA	VA	Click
Reactive por	wer	var	var	Click
Power fact	or	PF	PF	Click
Phase ang	le	0	0	Click
Frequency	Voltage	VHz	Hz	Click
Frequency	Current	AHz	Hz	[Shift] + Click
Waveform	Voltage	V pk	pk	Click
peak value	Current	A pk	pk	[Shift] + Click
Crest factor	Voltage	CF V	CF	Click
Clest lactor	Current	CF A	CF	[Shift] + Click
Maximum curre	nt ratio	MCR	MCR	Click
Ripple rate	Voltage	RF V%	RF	Click
TTIPPIE TALE	Current	RF A%	RF	[Shift] + Click
Total harmonic	Voltage	THD V%	THD	Click
distortion	Current	THD A%	THD	[Shift] + Click

#### Total integration display

Measurement items		Display item to click	Operation	
Time average current TOTAL T.AV A		T.AV	Click	
Time average activ	e power	TOTAL T.AV W	T.AV	[Shift] + Click
	Positive	TOTAL Ah+	+	Click
Current integration	Negative	TOTAL Ah-	-	Click
	Total	TOTAL Ah	h	Click
	Positive	TOTAL Wh+	+	[Shift] + Click
Active power integration	Negative	TOTAL Wh-	-	[Shift] + Click
integration	Total	TOTAL Wh	h	[Shift] + Click
Integration time TOTAL TIM		TOTAL TIME	TIME	Click

#### Individual current range integration display

Measurement items		Display item to click	Operation	
Time average current T.AV A		T.AV	[Ctrl] + Click	
Time average activ	e power	T.AV W	T.AV	[Shift] + [Ctrl] + Click
	Positive	Ah+	+	[Ctrl] + Click
Current integration	Negative	Ah-	-	[Ctrl] + Click
	Total	Ah	h	[Ctrl] + Click
	Positive	Wh+	+	[Shift] + [Ctrl] + Click
Active power integration	Negative	Wh-	-	[Shift] + [Ctrl] + Click
integration	Total	Wh	h	[Shift] + [Ctrl] + Click
Integration time		TIME	TIME	[Ctrl] + Click

#### Harmonic level and Harmonic content percentage display

Measurement items	Display item to click	Operation	
Harmonic voltage RMS value	HRM V LEVEL	V	Click
Harmonic current RMS value	HRM A LEVEL	A	Click
Harmonic active power	HRM W LEVEL	W	Click
harmonic voltage content percentage	HRM V% HD%	V	Click
harmonic current content percentage	HRM A% HD%	А	Click
harmonic active power content percentage	HRM W% HD%	W	Click

# 4.3 Canceling the Remote State (Activating the Local State)

During communications, **REMOTE** lamp is lit to indicate the remote control state. Control keys are disabled, with the exception of **SHIFT**.

If the remote state is activated while the instrument is displaying the Settings screen, it will automatically switch to the normal display (Measurement screen).

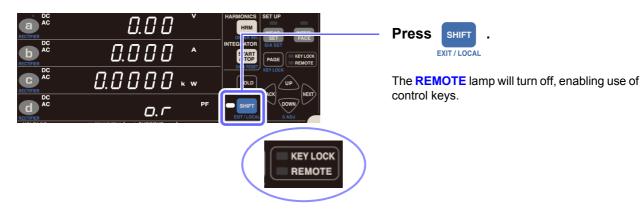
SHIFT key (SHIFT) is disabled if the GP-IB controller has put the instrument into the local lock out state (LLO: Local Lock Out).

In this case, run the **GTL** command of the interface function, or reboot the instrument. Then it returns to the local state.

#### Canceling the remote state

To switch the instrument from the remote state (with the **REMOTE** lamp lit up) to the local state (with panel operation enabled), press **SHIFT**.

The **REMOTE** lamp will turn off, and use of control keys will be enabled.



4.3 Canceling the Remote State (Activating the Local State)

# **Specifications**

# **Chapter 5**

## 5.1 Environmental and Safety Specifications

Operating environment	Indoors, altitude up to 2000 m (6562 ft.), pollution degree 2		
Operating temperature and humidity	0°C to 40°C (32°F to 104°F), 80% RH or less (no condensation)		
Storage temperature and humidity	-10°C to 50°C (14°F to 122°F), 80% RH or less (no condensation)		
Dielectric strength	<ul> <li>4,290 V rms AC (current sensitivity: 1 mA)</li> <li>Between the voltage input terminals and a connection consisting of chassis, interfaces, and output terminals</li> <li>Between the current input terminals and a connection consisting of chassis, interfaces, and output terminals</li> <li>Between the voltage input terminals and current input terminals</li> </ul>		
Maximum rated voltage to earth	Voltage input terminal, Current input terminal Measurement category III 600 V (anticipated transient overvoltage: 6000 V) Measurement category II 1000 V (anticipated transient overvoltage: 6000 V)		
Maximum input voltage	Between the voltage input terminals $U$ and ±: 1000 V, ±1500 V peak For more information about the external current sensors input, see "External Current Sensor Input Specifications (CURRENT SENSOR)" (p.154).		
Maximum input current	Between the current input terminals / and ±: 200 mA to 20 A range 30 A, ±100 A peak 1 mA to 100 mA range 20 A, ±30 A peak		
Standards	Safety EN61010 EMC EN61326 Class A		
Effect of radiated radio-fre- quency electromagnetic field	Current within 0.1 A and external current sensor (using 9661) within 3 A at 10 V/m		

## 5.2 General Specifications

#### Input specifications

Measurement line type	Single-phase 2-wire(1P2W)
Input methods	VoltageIsolated input, resistance voltage division methodCurrentIsolated input, shunt input methodIsolated input from external current sensors (PW3335-03 or PW3335-04 only)
Input resistance (50 Hz/60 Hz)	$ \begin{array}{llllllllllllllllllllllllllllllllllll$
Voltage measurement ranges	AUTO/ 6 V/ 15 V/ 30 V/ 60 V/ 150 V/ 300 V/ 600 V/ 1,000 V
Current measurement ranges	AUTO/ 1 mA/ 2 mA/ 5 mA/ 10 mA/ 20 mA/ 50 mA/ 100 mA/ 200 mA/ 500 mA/ 1 A/ 2 A/ 5 A/ 10 A/ 20 A For more information about external current sensor input, see "External Current Sensor Input Specifications (CURRENT SENSOR)" (p.154).

#### Power ranges: Units; W (active power), VA (apparent power), var (reactive power)

Current/ Voltage	6.0000 V	15.000 V	30.000 V	60.000 V	150.00 V	300.00 V	600.00 V	1.0000 kV
1.0000 mA	6.0000 m	15.000 m	30.000 m	60.000 m	150.00 m	300.00 m	600.00 m	1.0000
2.0000 mA	12.000 m	30.000 m	60.000 m	120.00 m	300.00 m	600.00 m	1.2000	2.0000
5.0000 mA	30.000 m	75.000 m	150.00 m	300.00 m	750.00 m	1.5000	3.0000	5.0000
10.000 mA	60.000 m	150.00 m	300.00 m	600.00 m	1.5000	3.0000	6.0000	10.000
20.000 mA	120.00 m	300.00 m	600.00 m	1.2000	3.0000	6.0000	12.000	20.000
50.000 mA	300.00 m	750.00 m	1.5000	3.0000	7.5000	15.000	30.000	50.000
100.00 mA	600.00 m	1.5000	3.0000	6.0000	15.000	30.000	60.000	100.00
200.00 mA	1.2000	3.0000	6.0000	12.000	30.000	60.000	120.00	200.00
500.00 mA	3.0000	7.5000	15.000	30.000	75.000	150.00	300.00	500.00
1.0000 A	6.0000	15.000	30.000	60.000	150.00	300.00	600.00	1.0000 k
2.0000 A	12.000	30.000	60.000	120.00	300.00	600.00	1.2000 k	2.0000 k
5.0000 A	30.000	75.000	150.00	300.00	750.00	1.5000 k	3.0000 k	5.0000 k
10.000 A	60.000	150.00	300.00	600.00	1.5000 k	3.0000 k	6.0000 k	10.000 k
20.000 A	120.00	300.00	600.00	1.2000 k	3.0000 k	6.0000 k	12.000 k	20.000 k

Default state: voltage range; 300 V, current range; 20 A, power range; 6 kW, voltage/current auto range; OFF Constraints: Constraints apply when changing ranges as a result of instrument protection mode. See "Instrument protection mode" (p.162)

#### **Basic Specifications**

Rated supply voltage	100 V AC to 240 V AC (Voltage fluctuations of $\pm 10\%$ from the rated supply voltage are taken into account.) Anticipated transient overvoltage: 2500 V
Rated power supply frequency	50 Hz/60 Hz
Maximum rated power	30 VA or less
Dimensions	Approx. 210W × 100H × 245D mm (8.27"W × 3.94"H × 9.65"D) (excluding protrusions)
Mass	Approx. 3 kg (105.8 oz.)
Product warranty period	3 years

#### **Display Specifications**

Display	7-segment LED
Number of display parameters	4 (display area a, b, c, and d)
Display resolution	Other than integrated values: 99999 count (5 digits) Integrated values: 999999 count (6 digits)
Display update rate	200 ms $\pm 50$ ms (approx. 5 updates per sec.) to 20 s (varies with number of averaging iterations setting)

### External interface specifications

#### LAN interface (standard equipment)

Connector	RJ-45 connector × 1
Electrical specifications	Compliant with IEEE802.3
Transmission method	10Base-T/ 100Base-TX (automatic detection)
Protocol	TCP/ IP
Functions	HTTP server (remote operation, firmware updates) Dedicated ports (command control, data transfer) Remote control by controller ( <b>REMOTE</b> lamp will light up.) Cancelation of remote operation with <b>LOCAL</b> key ( <b>REMOTE</b> lamp will turn off.)

#### **RS-232C** interface

#### (included with the PW3335, PW3335-02, PW3335-03, and PW3335-04, specify at time of order)

Connector	D-sub 9-pin connector × 1 (Compatible with 9-pin power supply)
Communication method	Full duplex, Start-stop synchronization Stop bits: 1 (fixed) Data length: 8 (fixed) Parity: None Remote control by controller ( <b>REMOTE</b> lamp will light up.) Cancelation of remote operation with <b>LOCAL</b> key ( <b>REMOTE</b> lamp will turn off.) Hardware handshake function
Communication speed	9600bps/ 38400bps
Power supply	OFF/ON (voltage +5 V, maximum 200 mA)
Functionality Command control, data transfers, and LR8410 Link support	

#### GP-IB interface (included with the PW3335-01 and PW3335-04, specify at time of order)

Method	Compliant with IEEE488.1 1987, in reference to IEEE488.2 1987 Interface functions: SH1, AH1, T6, L4, SR1, RL1, PP0, DC1, DT1, C0 Remote control by controller ( <b>REMOTE</b> lamp will light up.) Cancelation of remote operation with <b>LOCAL</b> key ( <b>REMOTE</b> lamp will turn off.)
Address	00 to 30

### **Accessory and Option Specifications**

Accessories	See: "Instrument and accessories" (p.2)
Options	See: "Options (sold separately)" (p.2)

## 5.3 Measurement specifications

### Accuracy

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

f.s. (range)	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.

#### **Basic Measurement Specifications**

Measureme	ent method	Simultaneous voltage and current digital sampling, zero-cross simultaneous calculation		
Sampling fr	requency	Approx. 700 kHz		
A/D converter resolution		16-bit		
Frequency bands		DC, 0.1 Hz to 100 kHz (Reference value of 0.1 Hz $\leq$ f < 10 Hz)		
Synchronization sources (SYNC)		U, I, DC (fixed to 200 ms) (default state: U) When an AC measured value of a signal input to the source is less than 1%f.s. of the set range, operation and accuracy are not defined. When synchronization cannot be detected, the <b>SYNC</b> lamp (ERROR) will light up, and operation and accuracy are not defined. When the synchronization source is DC, accuracy is not defined for input with a cycle that is not divisible by 200 ms. Synchronization timeout setting: 0.1 sec. / 10 sec. (linked to measurement lower limit frequency setting, default state: 0.1 sec.)		
Measurement items		Voltage, current, active power, apparent power, reactive power, power factor, phase angle, frequency, current integration, active power integration, integration time, voltage waveform peak value, current waveform peak value, voltage crest factor, current crest factor, maximum current ratio, time average current, time average active power, voltage ripple rate, current ripple rate Harmonic parameters Harmonic voltage RMS value, harmonic current RMS value, harmonic active power, total harmonic voltage distortion, total harmonic current distortion, fundamental wave voltage, fundamental wave current, fundamental wave active power, fundamental wave apparent power, fundamental wave reactive power, fundamental wave apparent power factor), fundamental wave voltage current phase differ- ence, harmonic voltage content percentage, harmonic current content percentage, harmonic active power content percentage (The following parameters can be downloaded as data with communications but not dis- played): Harmonic voltage phase angle, harmonic current phase angle, harmonic volt- age current phase difference (Default state: display area a; voltage, display area b; current, display area c; active power, display area d; power factor)		
Rectifiers	AC+DC AC+DC Umn DC AC	AC+DC measurementDisplay of true RMS values for both voltage and currentAC+DC measurementDisplay of average value rectified RMS converted values for voltage and true RMS values for currentDC measurementDisplay of simple averages for both voltage and current Display of values calculated by (voltage DC value) × (current DC value) for active powerAC measurementDisplay of values calculated by		
	FND (Default state:	$\sqrt{(AC+DC \text{ value})^2 - (DC \text{ value})^2} \text{ for both voltage and current} \\ Display of values calculated by \\ (AC+DC \text{ value}) - (DC \text{ value}) \text{ for active power} \\ Extraction and display of the fundamental wave component from harmonic measurement} \\ AC+DC \text{ for all display areas})$		
Zero-cross Filter		100 Hz/ 500 Hz/ 5 kHz/ 100 kHz (linked to frequency measurement range, default state: 500 Hz) 100 Hz: 0.1 Hz to 100 Hz 500 Hz: 0.1 Hz to 500 Hz 5 kHz: 0.1 Hz to 5 kHz 100 kHz: 0.1 Hz to 100 kHz The zero-cross filter lower limit setting is linked to the synchronization timeout setting. 10 Hz/ 1 Hz/ 0.1 Hz		

#### Measurement accuracy

For more information about the measurement accuracy for input from external current sensors, see "Measurement accuracy" (p.156).

#### Voltage

Frequency (f)	Input < 50%f.s.	50%f.s. ≤ Input < 100%f.s.	100%f.s. ≤ Input
DC	±0.1% rdg.±0.1%f.s.	±0.1% rdg.±0.1%f.s.	±0.2% rdg.
0.1 Hz ≤ f < 16 Hz	±0.1% rdg.±0.2%f.s.	±0.3% rdg.	±0.3% rdg.
16 Hz ≤ f < 45 Hz	±0.1% rdg.±0.1%f.s.	±0.2% rdg.	±0.2% rdg.
45 Hz ≤ f ≤ 66 Hz	±0.1% rdg.±0.05%f.s.	±0.15% rdg.	±0.15% rdg.
66 Hz < f ≤ 500 Hz	±0.1% rdg.±0.1%f.s.	±0.2% rdg.	±0.2% rdg.
500 Hz < f ≤ 10 kHz	±0.1% rdg.±0.2%f.s.	±0.3% rdg.	±0.3% rdg.
10 kHz < f ≤ 50 kHz	±0.5% rdg.±0.3%f.s.	±0.8% rdg.	±0.8% rdg.
50 kHz < f ≤ 100 kHz	±2.1% rdg.±0.3%f.s.	±2.4% rdg.	±2.4% rdg.

#### Current

Frequency (f)	Input < 50%f.s.	50%f.s. ≤ Input < 100%f.s.	100%f.s. ≤ Input
DC	±0.1% rdg.±0.1%f.s.	±0.1% rdg.±0.1%f.s.	±0.2% rdg.
0.1 Hz ≤ f < 16 Hz	±0.1% rdg.±0.2%f.s.	±0.3% rdg.	±0.3% rdg.
16 Hz ≤ f < 45 Hz	±0.1% rdg.±0.1%f.s.	±0.2% rdg.	±0.2% rdg.
45 Hz ≤ f ≤ 66 Hz	±0.1% rdg.±0.05%f.s.	±0.15% rdg.	±0.15% rdg.
66 Hz < f ≤ 500 Hz	±0.1% rdg.±0.1%f.s.	±0.2% rdg.	±0.2% rdg.
500 Hz < f ≤ 1 kHz	±0.1% rdg.±0.2%f.s.	±0.3% rdg.	±0.3% rdg.
1 kHz < f ≤ 10 kHz	±(0.03+0.07×F)% rdg.±0.2%f.s.	±(0.23+0.07×F)% rdg.	±(0.23+0.07×F)% rdg.
10 kHz < f ≤ 100 kHz	±(0.3+0.04×F)% rdg.±0.3%f.s.	±(0.6+0.04×F)% rdg.	±(0.6+0.04×F)% rdg.

#### Active power

Frequency (f)	Input < 50%f.s.	50%f.s. ≤ Input < 100%f.s.	100%f.s. ≤ Input
DC	±0.1% rdg.±0.1%f.s.	±0.1% rdg.±0.1%f.s.	±0.2% rdg.
0.1 Hz ≤ f < 16 Hz	±0.1% rdg.±0.2%f.s.	±0.3% rdg.	±0.3% rdg.
16 Hz ≤ f < 45 Hz	±0.1% rdg.±0.1%f.s.	±0.2% rdg.	±0.2% rdg.
45 Hz ≤ f ≤ 66 Hz	±0.1% rdg.±0.05%f.s.	±0.15% rdg.	±0.15% rdg.
66 Hz < f ≤ 500 Hz	±0.1% rdg.±0.1%f.s.	±0.2% rdg.	±0.2% rdg.
500 Hz < f ≤ 1 kHz	±0.1% rdg.±0.2%f.s.	±0.3% rdg.	±0.3% rdg.
1 kHz < f ≤ 10 kHz	±(0.03+0.07×F)% rdg.±0.2%f.s.	±(0.23+0.07×F)% rdg.	±(0.23+0.07×F)% rdg.
10 kHz < f ≤ 50 kHz	±(0.07×F)% rdg.±0.3%f.s.	±(0.3+0.07×F)% rdg.	±(0.3+0.07×F)% rdg.
50 kHz < f ≤ 100 kHz	±(0.6+0.07×F)% rdg.±0.3%f.s.	±(0.9+0.07×F)% rdg.	±(0.9+0.07×F)% rdg.

- · Values for f.s. depend on measurement ranges.
- "F" in the tables refers to the frequency in kHz.
- When using the 1 mA/ 2 mA range
  - Add  $\pm 1 \ \mu$ A to 0.1 Hz to 100 kHz measurement accuracy for current. Add ( $\pm 1 \ \mu$ A) × (voltage read value) to 0.1 Hz to 100 kHz measurement accuracy for active power.
- When using the 200 mA/ 500 mA/ 1 A/ 2 A/ 5 A/ 10 A/ 20 A range Add ±1 mA to DC measurement accuracy for current. Add (±1 mA) × (voltage read value) to DC measurement accuracy for active power.
- When using the 1 mA/ 2 mA/ 5 mA/ 10 mA/ 20 mA/ 50 mA/ 100 mA range Add ±10 μA to DC measurement accuracy for current.
   Add (110 μA) × (veltage read velue) to DC measurement accuracy for active power.
- Add (±10 µA) × (voltage read value) to DC measurement accuracy for active power.
  When using the 200 mA/ 500 mA/ 1 A/ 2 A/ 5 A/ 10 A/ 20 A range
  Add ±0.02xE)% rdg, to the measurement accuracy for current and active power for
- Add  $\pm$ (0.02×F)% rdg. to the measurement accuracy for current and active power for which (10 kHz < f ≤ 100 kHz).
- The following input are considered reference values: Values for voltage, current, and active power for which 0.1 Hz  $\leq$  f < 10 Hz. Values for voltage, current, and active power in excess of 220 V or 20 A for which 10 Hz  $\leq$  f < 16 Hz. Values for current and active power in excess of 20 A for which 500 Hz < f  $\leq$  50 kHz.
- Values for current and active power in excess of 10 A for which 50 kHz < f  $\leq$  100 kHz. Values for voltage and active power in excess of 750 V for which 30 kHz < f  $\leq$  100 kHz.

5.3 Measurement specifications

Effective measuring range	Voltage:1% to 150% of the range (1,000 V range, up to 1,000 V)Current:1% to 150% of the rangeActive power:0% to 225% of the range (when using 1,000 V range, up to 150%)However, valid when the voltage and current fall within the effective measurement range.
	Other parameters: Valid within the voltage, current, and active power effective mea- surement range.
Maximum effective peak voltage	±600% of each voltage range However, for 300 V, 600 V, and 1,000 V ranges, ±1,500 V peak
Maximum effective peak current	±600% of each current range However, for 20 A range, ±60 A peak
Guaranteed accuracy period	1 year
Conditions of guaranteed accuracy	Temperature and humidity range: 23°C±5°C (73°F±9°F), 80% RH or less Warm-up time: 30 minutes Input: Sine wave input, power factor of 1, voltage to earth of 0 V, after zero-adjustment; within range in which the fundamental wave satisfies synchronization source conditions
Temperature coefficient	$\pm 0.03\%$ f.s. per °C or less. However, for 1 mA range, $\pm 0.06\%$ f.s. per °C or less.
Effect of power factor	±0.1%f.s. or less (45 to 66 Hz, at power factor = 0) Internal circuitry voltage/current phase difference: ±0.0573°
Effect of common mode voltage	$\pm 0.01\%$ f.s. or less (600 V, 50 Hz/60 Hz, applied between input terminals and enclosure)
Magnetic field interference	<ul> <li>400 A/m, DC and 50 Hz/60 Hz magnetic field</li> <li>Voltage ±1.5% f.s. or less</li> <li>Current ±1.5% f.s. or below value, whichever is greater, or less</li> <li>200 mA/ 500 mA/ 1 A/ 2 A/ 5 A/ 10 A/ 20 A range: ±20 mA</li> <li>1 mA/ 2 mA/ 5 mA/ 10 mA/ 20 mA/ 50 mA/ 100 mA range: ±200 µA</li> <li>Active power ±3.0% f.s. or below value, whichever is greater, or less</li> <li>200 mA/ 500 mA/ 1 A/ 2 A/ 5 A/ 10 A/ 20 A range: (Voltage influence quantity)×(±20 mA)</li> <li>1 mA/ 2 mA/ 5 mA/ 10 mA/ 20 mA/ 50 mA/ 100 mA range: (Voltage influence quantity)×(±200 µA)</li> </ul>
Effect of self-heating	With input of at least 15 A to current input terminals Current AC input signal $\pm (0.025+0.005\times(I-15))$ %rdg. or less DC input signal 200 mA/ 500 mA/ 1 A/ 2 A/ 5 A/ 10 A/ 20 A range $\pm ((0.025+0.005\times(I-15))$ % rdg.+(0.5+0.1×(I-15))mA) or less 1 mA/ 2 mA/ 5 mA/ 10 mA/ 20 mA/ 50 mA/ 100 mA range $\pm ((0.025+0.005\times(I-15))$ % rdg.+(5+1×(I-15))µA) or less I: Current read value (A) Active power (above current influence quantity) × (voltage read value) or less The effects of self-heating will continue to manifest themselves until the input resistance temperature falls, even if the current value is low.

### Voltage Measurement Specifications (U: Displayed as V on panel display)

Measurement types	Rectifiers: AC+DC, DC, AC, FND, AC+DC Umn
Effective measuring range	±1% to ±150% of the range. However, up to ±1,500 V peak value and 1,000 V RMS value
Display range	Up to $\pm 152\%$ of the range. However, zero-suppression when less than $\pm 0.5\%$
Polarity	Displayed when using DC rectifier
Over-range display	Displays [o.r] (over-range) when input exceeds $\pm 152\%$ of the range or $\pm 1,060.5$ V.
Peak exceeded warning	The <b>PEAK OVER U</b> lamp will light up for which the input voltage peak value exceeds $\pm 1,500$ V or $\pm 600\%$ of the range.

Measurement types	Rectifiers: AC+DC, DC, AC, FND, AC+DC Umn
Effective measuring range	±1% to ±150% of the range
Display range	Up to $\pm 152\%$ of the range. However, zero-suppression when less than $\pm 0.5\%$ or less than $\pm 9~\mu$ A.
Polarity	Displayed when using DC rectifier
Over-range display	Displays [o.r] when input exceeds ±152% of the range.
Peak exceeded warning	The <b>PEAK OVER I</b> lamp will light up for which the input current peak value exceeds ±60 A or ±600% of the range.

### **Current Measurement Specifications (I: Displayed as A on panel display)**

### Active Power Measurement Specifications (P: Displayed as W on panel display)

Measurement types	Rectifiers: AC+DC, DC, AC, FND, AC+DC Umn
Effective measuring range	$\pm 0\%$ to $\pm 225\%$ of the range. However, valid when the voltage and current fall within the effective measurement range.
Display range	±0% to ±231.04% of the range (no zero-suppression)
Polarity	Positive: Power consumption (no polarity display); negative: generation or regenerated power
Over-range display	Displays [ <b>o.r</b> ] when input exceeds ±231.04% of the range. However, for 1000 V range, displays [ <b>o.r</b> ] when input exceeds ±161.196%.

#### Apparent Power Measurement Specifications (S: Displayed as VA on panel display)

Measurement types	Rectifiers: AC+DC, AC, FND, AC+DC Umn
Effective measuring range	As per voltage and current effective measurement ranges.
Display range	0% to 231.04% of the range (no zero-suppression) When using the AC+DC or AC rectifier, displays S as  P  when  P  > S.
Over-range display	Displays [o.r] when displaying [o.r] for either voltage or current.
Invalid data display	Displays [] when using the DC rectifier.

### Reactive Power Measurement Specifications (Q: Displayed as var on panel display)

Measurement types	Rectifiers: AC+DC, AC, FND, AC+DC Umn
Effective measuring range	As per voltage, current, and active power effective measurement ranges.
Display range	±0% to ±231.04% of the range (no zero-suppression)
Polarity	Polarity is assigned according to the lead/lag relationship of the voltage waveform rising edge and the current waveform rising edge. +: When current lags voltage (no polarity display) -: When current leads voltage
Polarity effective range	With the AC+DC, AC, or AC+DC Umn rectifier: Sine-wave input equivalent to at least 20% of the measurement range, frequency of 10 Hz to 20 kHz, phase difference of ±(1° to 179°)
Over-range display	Displays [o.r] when displaying [o.r] for the voltage, current, or active power.
Invalid data display	Displays [] when using the DC rectifier.

#### 5.3 Measurement specifications

### Power Factor Measurement Specifications (λ: Displayed as PF on panel display)

Measurement types	Rectifiers: AC+DC, AC, FND, AC+DC Umn
Effective measuring range	As per voltage, current, and active power effective measurement ranges
Display range	±0.0000 to ±1.0000
Polarity	Polarity is assigned according to the lead/lag relationship of the voltage waveform rising edge and the current waveform rising edge. +: When current lags voltage (no polarity display) -: When current leads voltage
Polarity effective range	With the AC+DC, AC, or AC+DC Umn rectifier: Sine-wave input equivalent to at least 20% of the measurement range, frequency of 10 Hz to 20 kHz, phase difference of $\pm(1^{\circ}$ to 179°)
Over-range display	Displays [ <b>o.r</b> ] when [ <b>o.r</b> ] is displayed for the voltage or current. Displays [ <b>o.r</b> ] when the apparent power is 0.
Invalid data display	Displays [] when using the DC rectifier.

### Phase Angle Measurement Specifications ( $\varphi$ : Displayed as ° on panel display)

Measurement types	Rectifiers: AC, FND
Effective measuring range	As per voltage, current, and active power effective measurement ranges
Display range	+180.00 to -180.00
Polarity	Polarity is assigned according to the lead/lag relationship of the voltage waveform rising edge and the current waveform rising edge. +: When current lags voltage (no polarity display) -: When current leads voltage
Polarity effective range	With the AC rectifier: Sine-wave input equivalent to at least 20% of the measurement range, frequency of 10 Hz to 20 kHz, phase difference of ±(1° to 179°)
Over-range display	Displays [o.r] when displaying [o.r] for the power factor.
Invalid data display	Displays [] when using the AC+DC, AC+DC Umn, or DC rectifier.

#### Frequency Measurement Specifications (f: Displayed as V Hz or A Hz on panel display)

Number of measurement channels	2
Measurement method	Calculated from input waveform period (reciprocal method)
Measurement ranges	100 Hz/ 500 Hz/ 5 kHz/ 100 kHz (linked to zero-cross filter)
Measurement accuracy	$\pm 0.1\%$ rdg. $\pm 1$ dgt. However, for 1 mA range, $\pm 0.2\%$ rdg. $\pm 1$ dgt. (for the minimum frequency range setting that satisfies the measurement frequency)
Effective measuring range	0.1 Hz to 100 kHz For sine wave input that is at least 20% of the measurement source's measurement range Measurement lower limit frequency setting: 0.1 sec. / 1 sec. / 10 sec. (linked to synchro- nization timeout setting)
Display format	0.1000 Hz to 9.9999 Hz, 9.900 Hz to 99.999 Hz, 99.00 Hz to 999.99 Hz, 0.9900 kHz to 9.9999 kHz, 9.900 kHz to 99.999 kHz, 99.00 kHz to 100.00 kHz
Over-range display	Displays [o.r] when input falls outside the measurement range.
Default state	Frequency range: 500 Hz

### Integration Measurement Specifications

Integration operation modes	<ul> <li>Switchable between fixed-range integration and auto-range integration.</li> <li>Fixed-range integration <ul> <li>Integration can be performed for all voltage and current ranges.</li> <li>The voltage and current ranges are fixed once integration starts.</li> <li>Other settings continue to be in effect.</li> <li>The current range keys are disabled.</li> </ul> </li> <li>Auto-range integration <ul> <li>Integration can be performed for all voltage ranges.</li> <li>The current is set to auto-range operation using ranges from 200 mA to 20 A.</li> <li>(The current AUTO lamp will light up.)</li> <li>If the operating mode is set to auto-range integration, the AUTO lamp to the left of the START/STOP key will light up.</li> <li>When integration starts, the voltage range is fixed, and the timeout value is set to 0.1 s.</li> <li>The integrated value for each range can be displayed by switching the current range (200 mA to 20 A) while integration is stopped.</li> </ul> </li> </ul>							
Measurement items and display	Simultaneous integration of the following 6 parameters: Positive current integrated value (displayed as Ah+ on panel display) Negative current integrated value (displayed as Ah- on panel display) Sum of current integrated values (displayed as Ah on panel display) Positive active power integrated value (displayed as Wh+ on panel display) Negative active power integrated value (displayed as Wh- on panel display) Sum of active power integrated value (displayed as Wh- on panel display) Sum of active power integrated values (displayed as Wh- on panel display) When the TOTAL lamp is lit up on the integration display In auto-range integration mode, the sum of integrated values for all ranges is dis- played. In fixed-range integration mode, the integrated value for the range being shown is displayed. When the TOTAL lamp is turned off on the integration display The integrated value for the range being shown is displayed.							
Measurement types	Rectifiers: AC+DC, AC+DC Umn         Current:       Displays the result of integrating current RMS value data (display values) once every display update interval as an integrated value.         Active power:       Displays the result of integrating active power values by polarity calculated once every cycle for the selected synchronization source as integrated values.         Rectifier:       DC         Displays the result of integrating instantaneous data obtained by sampling both current and active power by polarity as integrated values (these values are not integrated values for the DC component when active power contains both DC and AC components)         •: Displayed -: Displays []         Rectifier       Ah+       Ah       Wh+       Wh         AC+DC, AC+DC Umn       -       -       •       •       •         * In auto-range integration mode, [] will be displayed.       * In auto-range integration mode, []       *							
Integration time	1 min. to 10,000 hr., settable in 1 min. blocks Default value: 10,000 hr. (0000.00 display)							
Integration time accuracy	±0.01% rdg. ±1 dgt.							
Integration measurement accuracy	(Current or active power m			• <i>•</i> · ·	-	. ±1 dgt.)		
Effective measuring range	Until <b>PEAK OVER U</b> lamp or <b>PEAK OVER I</b> lamp lights up. However, the range is defined only if the input voltage and current are 1% or more of the corresponding ranges.							
Display resolution	999999 (6 digits + decimal	point)						
Peak exceeded warning	If <b>PEAK OVER U</b> lamp or <b>PEAK OVER I</b> lamp lights up during integration operation, the unit ( <b>Ah</b> , <b>Ah</b> +, <b>Ah</b> -, <b>Wh</b> , <b>Wh</b> +, <b>Wh</b> -) will flash.							
Invalid data display	Displays [] when usir	ng the AC	or FND r	ectifier.				

#### 5.3 Measurement specifications

Integration status display	During integration operation When stopped Integrated value reset	RUN lamp lights up (during external control operatio RUN lamp flashing (during external control operatio RUN lamp off (during external control operatio	on, EXT lamp lights up)
Functions	Stopping integration based on integration time setting (timer) Stopping/starting integration and resetting integrated values based on external control Displaying the integration elapsed time (displayed as <b>TIME</b> on panel display) Additional integration by repeatedly starting/stopping integration Backing up integrated values and the integration elapsed time during power outages Stopping integration when power returns		
Default state	Integration time: 10,000 hr., inte Auto-range integration: OFF	egration operation with the integrat (Fixed-range integration)	ed value in the reset state
External control	Input signal level: 0 to 5 V (hi	gh-speed CMOS level) or shorte	d [Lo]/open [Hi]
	Functions	External control signal	External control terminal
	Starts integration	$Hi \rightarrow Lo$	START/STOP
	Stops integration	$Lo \rightarrow Hi$	START/STOP
	Resets integrated values	Lo interval of at least 200 ms	RESET
Constraints	During integration operation and while integration is stopped, the following operational constraints apply until integrated values are reset: •: Setting and changes allowed -: Setting and changes not allowed		
	Item	During integration operation of	or while integration is stopped
	Measurement range		_ ge integration, auto-range ermine the current range.
	Measurement range Current input method switching		
	Current input method switching Frequency measurement range	operation is used to dete	
	Current input method switching Frequency measurement range (Zero-Cross Filter)	operation is used to dete	ermine the current range.
	Current input method switching Frequency measurement range (Zero-Cross Filter) Timeout Integration time Synchronization source	operation is used to dete	ermine the current range
	Current input method switching Frequency measurement range (Zero-Cross Filter) Timeout Integration time Synchronization source Zero Adjustment	operation is used to dete	ermine the current range. - -
	Current input method switching Frequency measurement range (Zero-Cross Filter) Timeout Integration time Synchronization source Zero Adjustment D/A output parameters	operation is used to dete	ermine the current range.
	Current input method switching Frequency measurement range (Zero-Cross Filter) Timeout Integration time Synchronization source Zero Adjustment D/A output parameters Number of averaging iterations	operation is used to dete	ermine the current range e integration is stopped.)
	Current input method switching Frequency measurement range (Zero-Cross Filter) Timeout Integration time Synchronization source Zero Adjustment D/A output parameters Number of averaging iterations VT ratio	operation is used to dete	ermine the current range
	Current input method switching Frequency measurement range (Zero-Cross Filter) Timeout Integration time Synchronization source Zero Adjustment D/A output parameters Number of averaging iterations VT ratio CT ratio	operation is used to dete	ermine the current range
	Current input method switching Frequency measurement range (Zero-Cross Filter) Timeout Integration time Synchronization source Zero Adjustment D/A output parameters Number of averaging iterations VT ratio CT ratio RS-232C transfer speed	operation is used to dete	ermine the current range e integration is stopped.)
	Current input method switching Frequency measurement range (Zero-Cross Filter) Timeout Integration time Synchronization source Zero Adjustment D/A output parameters Number of averaging iterations VT ratio CT ratio RS-232C transfer speed GP-IB address	operation is used to dete	ermine the current range e integration is stopped.)
	Current input method switching Frequency measurement range (Zero-Cross Filter) Timeout Integration time Synchronization source Zero Adjustment D/A output parameters Number of averaging iterations VT ratio CT ratio RS-232C transfer speed GP-IB address LAN	operation is used to deter	e integration is stopped.)
	Current input method switching Frequency measurement range (Zero-Cross Filter) Timeout Integration time Synchronization source Zero Adjustment D/A output parameters Number of averaging iterations VT ratio CT ratio RS-232C transfer speed GP-IB address LAN Harmonic analysis order upper lim	operation is used to deter	e integration is stopped.)

## Voltage Waveform Peak Value Measurement Specifications (Upk: Displayed as V pk on panel display)

Measurement method Measures the voltage waveform's peak value (for both positive and negative polarity) based on sampled instantaneous voltage values.

#### Range configuration

Range configuration								
Voltage range	6 V	15 V	30 V	60 V	150 V	300 V	600 V	1000 V
Voltage peak range	36.000 V	90.000 V	180.00 V	360.00 V	900.00 V	1.8000 kV	3.6000 kV	6.0000 kV
Measurement accur		$\pm 2.0\%$ f.s. at DC and when 10 Hz $\leq$ f $\leq$ 1 kHz (f.s.: voltage peak range). Provided as reference value when 0.1 Hz $\leq$ f < 10 Hz and when 1 kHz < f.						
Effective measuring	range ±	ange $\pm 5\%$ to $\pm 100\%$ of voltage peak range, however, up to $\pm 1,500$ V						
Display range	U R	Up to $\pm 102\%$ of voltage peak range, however, the value 0 will be displayed if the voltage RMS value triggers the instrument's zero suppression function.				f the voltage		
Over-range display	D	Displays [o.r] when input exceeds ±102% of the voltage peak range.						
Default state	V	Voltage peak range: 1.8 kV						

## Current Waveform Peak Value Measurement Specifications (lpk: Displayed as A pk on panel display)

Measurement metho				n's peak value us current val		sitive and neg	ative polarity)
Range configuration							
Current range	1 mA	2 mA	5 mA	10 mA	20 mA	50 mA	100 mA
Current peak range	6.0000 mA	12.000 mA	30.000 mA	60.000 mA	120.00 mA	300.00 mA	600.00 mA
Current range	200 mA	500 mA	1 A	2 A	5 A	10 A	20 A
Current peak range	1.2000 A	3.0000 A	6.0000 A	12.000 A	30.000 A	60.000 A	120.00 A
lleasurement accura	Pro	$\pm 2.0\%$ f.s. at DC and when 10 Hz $\le$ f $\le$ 1 kHz (f.s.: current peak range). Provided as reference value when 0.1 Hz $\le$ f $<$ 10 Hz and when 1 kHz $<$ f. The above measurement accuracy is multiplied by 2 for the 1 mA range.					
Effective measuring	range ±5%	<b>ge</b> ±5% to ±100% of current peak range, however, up to ±60 A					
Display range		Up to $\pm 102\%$ of current peak range, however, the value 0 will be displayed if the curre RMS value triggers the instrument's zero suppression function.				ed if the current	
Over-range display	Dis	Displays [o.r] when input exceeds ±102% of the current peak range.					
Default state	Cur	Current peak range: 120 A					

#### Voltage Crest Factor Measurement Specifications (Ucf: Displayed as CF V on panel display)

Measurement method	Calculates the ratio of the voltage waveform peak value to the voltage RMS value.
Effective measuring range	As per voltage and voltage waveform peak value effective measurement ranges.
Display range	1.0000 to 612.00 (no polarity)
Over-range display	Displays [o.r] when [o.r] is displayed for the voltage waveform peak value. Displays [o.r] when [o.r] is displayed for the voltage or the voltage is 0.

## Current Crest Factor Measurement Specifications (Icf: Displayed as CF A on panel display)

Measurement method	Calculates the ratio of the current waveform peak value to the current RMS value.
Effective measuring range	As per current and current waveform peak value effective measurement ranges.
Display range	1.0000 to 612.00 (no polarity)
Over-range display	Displays [ <b>o.r</b> ] when [ <b>o.r</b> ] is displayed for the current waveform peak value. Displays [ <b>o.r</b> ] when [ <b>o.r</b> ] is displayed for the current or the current is 0.

#### Time Average Current Measurement Specifications (T.AV I: Displayed as T.AV A on panel display)

Measurement method	Calculates the average by dividing the current integrated value by the integration time.
Measurement accuracy	(Current measurement accuracy) + (±0.01% rdg. ±1 dgt.)
Effective measuring range	As per the current integration effective measurement range.
Display range	±0% to ±612% of the range (no [o.r] display)
Polarity	Has polarity when using the DC rectifier.
Peak exceeded warning	If the integrated value includes data from when the <b>PEAK OVER I</b> lamp lit up, the unit <b>A</b> will flash.
Invalid data display	Displays [] when using the AC or FND rectifier. If the auto-range integration mode rectifier is AC+DC or AC+DC Umn, [] will be displayed.
Display types	<ul> <li>When the <b>TOTAL</b> lamp is lit up</li> <li>In auto-range integration mode, the time-average value for the overall range is displayed.</li> <li>When the <b>TOTAL</b> lamp is turned off, or when using fixed-range integration mode The time-average value for the range being shown is displayed.</li> </ul>

5.3 Measurement specifications

#### Time Average Active Power Measurement Specifications (T.AV P: Displayed as T.AV W on panel display)

Measurement method	Calculates the average by dividing the active power integrated value by the integration time.
Measurement accuracy	(Active power measurement accuracy) + (±0.01% rdg. ±1 dgt.)
Effective measuring range	As per the active power integration effective measurement range.
Display range	±0% to ±3,745.4% of the range (no [o.r] display)
Polarity	Yes
Peak exceeded warning	If the integrated value includes data from when the <b>PEAK OVER U</b> or <b>PEAK OVER I</b> lamp lit up, the unit <b>W</b> will flash.
Invalid data display	Displays [] when using the AC or FND rectifier.
Display types	<ul> <li>When the TOTAL lamp is lit up</li> <li>In auto-range integration mode, the time-average value for the overall range is displayed.</li> <li>When the TOTAL lamp is turned off, or when using fixed-range integration mode</li> <li>The time-average value for the range being shown is displayed.</li> </ul>

## Voltage Ripple Rate Measurement Specifications (Urf: Displayed as RF V % on panel display)

Measurement method	Calculates the AC component (peak to peak [peak width]) as a proportion of the voltage DC component.
Effective measuring range	As per voltage and voltage waveform peak value effective measurement ranges.
Display range	0.00 to 500.00
Polarity	None
Over-range display	Displays [ <b>o.r</b> ] when [ <b>o.r</b> ] is displayed for the voltage waveform peak value. Displays [ <b>o.r</b> ] when [ <b>o.r</b> ] is displayed for the voltage or the voltage is 0.

## Current Ripple Rate Measurement Specifications (Irf: Displayed as RF A % on panel display)

Measurement method	Calculates the AC component (peak to peak [peak width]) as a proportion of the current DC component.
Effective measuring range	As per current and current waveform peak value effective measurement ranges.
Display range	0.00 to 500.00
Polarity	None
Over-range display	Displays [ <b>o.r</b> ] when [ <b>o.r</b> ] is displayed for the current waveform peak value. Displays [ <b>o.r</b> ] when [ <b>o.r</b> ] is displayed for the current or the current is 0.

#### Maximum Current Ratio Measurement Specifications (MCR)

Measurement method	Calculates the ratio of the current crest factor to the power factor.
Effective measuring range	As per power factor (voltage, current, active power) and current crest factor (current, current waveform peak value) effective measurement ranges.
Display range	1.0000 to 6.1200 M
Polarity	None
Over-range display	Displays [ <b>o.r</b> ] (MCR > 10) when [0.0000] is displayed for the power factor. Displays [ <b>o.r</b> ] (MCR > 10) when [ <b>o.r</b> ] is displayed for the current crest factor.

### Harmonic Measurement Specifications

Measurement method	Zero-cross simultaneous calculation method Uniform thinning between zero-cross events after processing with a digital antialiasing filter Interpolation calculations (Lagrange interpolation) When the synchronization frequency falls within the 45 Hz to 66 Hz range IEC 61000-4-7:2002 compliant Gaps and overlaps may occur if the measurement frequency is not 50 Hz or 60 Hz. When the synchronization frequency falls outside the 45 Hz to 66 Hz range No gaps or overlap will occur.			
Synchronization source	Conforms to synchronization source (SYNC) for the basic measurement specifications.			
Measurement items	<ul> <li>Harmonic voltage RMS value, harmonic voltage content percentage, harmonic voltage phase angle, harmonic current RMS value, harmonic current content percentage, harmonic current phase angle, harmonic active power, harmonic active power content percentage, harmonic voltage current phase difference, total harmonic voltage distortion, total harmonic current distortion, fundamental wave voltage, fundamental wave current, fundamental wave active power, fundamental wave apparent power, fundamental wave reactive power, fundamental wave power factor, fundamental wave voltage current phase difference</li> <li>(The following parameters can be downloaded as data with communications but not displayed:)</li> <li>Harmonic voltage phase angle, harmonic current phase angle, harmonic voltage current phase difference</li> </ul>			
FFT processing word length, number of FFT points	32 bits, 4,096 points			
Window function	Rectangular			
Analysis window width	Frequency (f)	Window width		
	$45 \text{ Hz} \le f < 56 \text{ Hz}$	178.57 ms to 222.22 ms (10 cycles)		
	56 Hz ≤ f < 66 Hz	181.82 ms to 214.29 ms (12 cycles)		
	Frequencies other than the above	185.92 ms to 214.08 ms		
Data undata rata	Depende op window width			
Data update rate	Depends on window width.			
Maximum analysis order	Synchronization frequency range: 10			
	Synchronization frequency (f) range	Analysis order		
	$10 \text{ Hz} \le f < 45 \text{ Hz}$	50th		
	45 Hz ≤ f < 56 Hz 56 Hz ≤ f ≤ 66 Hz	50th 50th		
	66 Hz < f ≤ 100 Hz	50th		
	100 Hz < f ≤ 200 Hz	40th		
	200 Hz < f ≤ 300 Hz	25th		
	300 Hz < f ≤ 500 Hz	15th		
	500 Hz < f ≤ 640 Hz	11th		
Analysis order upper limit setting	2nd to 50th (default state: 50th)			
Measurement accuracy	f.s.: Measurement range			
-	Frequency (f)	Voltage, Current, Active power		
	DC	±0.4% rdg. ±0.2%f.s.		
	10 Hz ≤ f < 30 Hz	±0.4% rdg. ±0.2%f.s.		
	30 Hz ≤ f ≤ 400 Hz	±0.3% rdg. ±0.1%f.s.		
	400 Hz < f ≤ 1 kHz	±0.4% rdg. ±0.2%f.s.		
	1 kHz < f ≤ 5 kHz	±1.0% rdg. ±0.5%f.s.		
	5 kHz < f ≤ 8 kHz ±4.0% rdg. ±1.0%f.s.			
	<ul> <li>When using the 1 mA/ 2 mA range Add ±1 μA to 10 Hz to 8 kHz measurement accuracy for current. Add (±1 μA) × (voltage read value) to 10 Hz to 8 kHz measurement accuracy for active power.</li> <li>When using the 200 mA/ 500 mA/ 1 A/ 2 A/ 5 A/ 10 A/ 20 A range</li> </ul>			
	<ul> <li>When using the 1 mA/ 2 mA/ 5 mA Add ±10 µA to DC measurement a</li> </ul>	<ul> <li>b) to DC measurement accuracy for active power.</li> <li>v/ 10 mA/ 20 mA/ 50 mA/ 100 mA range</li> <li>iccuracy for current.</li> </ul>		
	Add (±10 µA) × (voltage read value	e) to DC measurement accuracy for active power		

5.3 Measurement specifications

#### D/A Output Specifications (included with PW3335-02 and PW3335-04, specify at time of order)

Number of output channels	7
Configuration	16-bit D/A converter (polarity + 15 bits)
Output parameters	Output parameters for all channels Select from: Voltage, current, active power, apparent power, reactive power, power fac- tor, phase angle, frequency, total harmonic voltage distortion, total harmonic current distortion, voltage crest factor, current crest factor, time average current, time average active power, voltage ripple rate, current ripple rate, current integration, active power in- tegration, maximum current ratio The rectifier can be selected. Harmonic-order output is not supported.
Output accuracy	<ul> <li>f.s.: Relative to the output voltage rated value for each output parameter</li> <li>Level output: (Output parameter measurement accuracy) + (±0.2%f.s.)</li> <li>High-speed level output: (Output parameter measurement accuracy) + (±0.2%f.s.)</li> <li>Waveform output: (Output parameter measurement accuracy) + (±1.0%f.s.)</li> <li>Instantaneous voltage, instantaneous current: RMS value level</li> <li>Instantaneous power: Average value level</li> </ul>
Output frequency band	Waveform output, high-speed level output At DC or 10 Hz to 30 kHz, accuracy is as defined above.
Conditions of guaranteed accuracy	Temperature and humidity range :23°C±5°C (73°F±9°F), 80% RH or less Warm-up time: 30 minutes, after zero-adjustment
Output voltage	The output level, output speed, and waveform output can be selected. Level output 2 Vf.s.(STD.2):±2 V DC at full scale (f.s.), linked to display updates Level output 5 Vf.s.(STD.5):±5 V DC at full scale (f.s.), linked to display updates High-speed level output 2 Vf.s.(FAST.5) ±2 V DC at full scale (f.s.), linked to synchronization interval High-speed level output 5 Vf.s.(FAST.5) ±5 V DC at full scale (f.s.), linked to synchronization interval Waveform output 1 Vf.s.(FAST.5) Available selections vary with the output parameter. Voltage, current, active power Select from: STD.2/ STD.5/ FAST.2/ FAST.5/ FAST However, specifying FAST.2 or FAST.5 forcibly sets the rectifier to AC+DC. Apparent power, reactive power, power factor, phase angle, total harmonic voltage distortion, total harmonic current distortion, voltage ripple rate, current ripple rate, voltage cerest factor, current crest factor, time average current, time average active power, maximum current ratio Select from: STD.2/ STD.5 Frequency, current integration, active power, reactive power, time average current, time average active power: Measurement range For time average current or time average active power, setting to TOTAL range causes current to voltage range × 20 A. Power factor: ±0.0000 (±1.000): DCO V) Phase angle: ±180.00° Voltage ripple rate, current ripple rate, total harmonic voltage distortion, total harmonic current distortion: 100.00% Voltage ripple rate, current rest factor: 10.000 Maximum current ratio: Selected from the following: 0.5 Hz/ 5 Hz/ 50 Hz/ 50 Hz/ 50 KHz/ 500 KHz Current integration, active power integration: Selected from the following: 5 m/ 50 m/ 500 m/ 5/ 50/ 500 / 5 k/ 500 k/ 5 M/ 50 M/ 500 M/ 5000 M [Ah/Wh] Error output: Level output of approx. ±9 V DC is generated when the output parameter display is [o,r] or when the PEAK OVER U or PEAK OVER I lamp lights up. Output to foll bin gracementer of the following: 5 m/ 50 m/ 500 m/ 5/ 500 / 5 k/ 500 k/ 5 M/ 50 M/ 500 M/ 5000 M [Ah/Wh]
	Selected from the following: 5 m/ 50 m/ 500 m/ 5/ 50/ 500/ 5 k/ 50 k/ 500 k/ 5 M/ 50 M/ 500 M/ 5000 M [Ah/Wh] Error output: Level output of approx. ±9 V DC is generated when the output parameter

Maximum output voltage	Approx. ±12 V DC					
Output update rate	<ul> <li>Level output (STD.2/ STD.5): Same as the data update period. Update rate is unrelated to number of averaging iterations setting and display hold operation.</li> <li>High-speed level output (FAST.2/ FAST.5): AC Updated once every cycle for the input waveform set as the synchronization source. However, voltage and current are only updated once every cycle for input signals from 45 to 66 Hz. DC Updated at the set timeout time interval.</li> <li>Waveform output (FAST): Approx. 1.43 µs (approx. 700 kHz)</li> </ul>					
Response time	<ul> <li>Level output (STD.2/ STD.5):</li> <li>0.6 sec. or less (when the input changes abruptly from 0% to 90%, or from 100% to 10%, the time required in order to satisfy the accuracy range with a synchronization timeout setting of 0.1 s)</li> <li>High-speed level output: (FAST.2/ FAST.5)</li> <li>2 ms or less</li> <li>Waveform output (FAST):</li> <li>0.2 ms or less</li> </ul>					
Temperature coefficient	±0.05%f.s./°C or less					
Output resistance	100 Ω ±5 Ω					
Default state	D/A channel 1U, AC+DC, STD.2 (voltage level, STD.2)D/A channel 2I, AC+DC, STD.2 (current level, STD.2)D/A channel 3P, AC+DC, STD.2 (active power level, STD.2)D/A channel 4 $\lambda$ , AC+DC, STD.2 (power factor, STD.2)D/A channel 5u, FAST (instantaneous voltage waveform)D/A channel 6i, FAST (instantaneous current waveform)D/A channel 7p, FAST (instantaneous power waveform)Frequency f.s. 500 HzIntegrated values f.s. 5 k [Ah/Wh]					

5.3 Measurement specifications

## External Current Sensor Input Specifications (CURRENT SENSOR) (included with PW3335-03 and PW3335-04, specify at time of order)

Terminal	Isolated BNC terminals				
Input method	Isolated input from a voltage-output current sensor (instrument's external current sen- sor input terminals are not isolated)				
Maximum input voltage	8 V, ±12 V peak				
Input resistance	287 kΩ ±10 kΩ				
Current sensor type switching	OFF / TYPE.1 / TYPE.2 When set to off, input from the external current sensor input terminal is ignored.				
Current sensor options	Supported current sensors TYPE.1 9661 Clamp on Sensor (rating: 500 A AC) 9669 Clamp on Sensor (rating: 1,000 A AC) 9660 Clamp on Sensor (rating: 100 A AC) CT9667 Flexible Clamp on Sensor (rating: 500 A/ 5,000 A AC) TYPE.2 9555-10 Sensor Unit L9217 Connection Cord 9272-10 Clamp on Sensor (rating: 20 A/ 200 A AC) 9277 Universal Clamp on CT (rating: 20 A AC/DC) 9278 Universal Clamp on CT (rating: 200 A AC/DC) 9279 Universal Clamp on CT (rating: 500 A AC/DC) 9279 Universal Clamp on CT (rating: 500 A AC/DC) 9709 AC/DC Current Sensor (rating: 500 A AC/DC) CT6862 AC/DC Current Sensor (rating: 500 A AC/DC) CT6863 AC/DC Current Sensor (rating: 20 A AC/DC) CT6865 AC/DC Current Sensor (rating: 20 A AC/DC) CT6841 AC/DC Current Probe (rating: 20 A AC/DC) CT6843 AC/DC Current Probe (rating: 20 A AC/DC)				
Current measurement range	AUTO/ 1 A/ 2 A/ 5 A (range noted on panel) Can be read directly by manually setting the CT ratio.				
Constraints	Auto-range integration not supported.				
Default state	External current sensor: OFF, current measurement range: 5 A, AUTO range: OFF				
<b>. .</b> .					

#### Power range configuration

## When using a current sensor with a rating of 20 A (with the CT ratio set to 4) 9272-10 (20 A): TYPE.2; 9277: TYPE.2; CT6841: TYPE.2

Range noted	d Current Voltage range								
on panel	range	6.0000 V	15.000 V	30.000 V	60.000 V	150.00 V	300.00 V	600.00 V	1.0000 kV
1 A	4.0000 A	24.000	60.000	120.00	240.00	600.00	1.2000 k	2.4000 k	4.0000 k
2 A	8.0000 A	48.000	120.00	240.00	480.00	1.2000 k	2.4000 k	4.8000 k	8.0000 k
5 A	20.000 A	120.00	300.00	600.00	1.2000 k	3.0000 k	6.0000 k	12.000 k	20.000 k
·	Units: W (active power), VA (apparent power), var (reactive power)								active power)

When using a current sensor with a rating of 50 A (with the CT ratio set to 10) CT6862: TYPE.2

Range noted	Current	Voltage range							
on panel	range	6.0000 V	15.000 V	30.000 V	60.000 V	150.00 V	300.00 V	600.00 V	1.0000 kV
1 A	10.000 A	60.000	150.00	300.00	600.00	1.5000 k	3.0000 k	6.0000 k	10.000 k
2 A	20.000 A	120.00	300.00	600.00	1.2000 k	3.0000 k	6.0000 k	12.000 k	20.000 k
5 A	50.000 A	300.00	750.00	1.5000 k	3.0000 k	7.5000 k	15.000 k	30.000 k	50.000 k
	Units: W (active power), VA (apparent power), var (reactive power								active power)

## When using a current sensor with a rating of 200 A (with the CT ratio set to 40) 9272-10 (200 A): TYPE.2; 9278: TYPE.2; CT6863: TYPE.2; CT6843: TYPE.2

Range noted	Current		Voltage range						
on panel	range	6.0000 V	15.000 V	30.000 V	60.000 V	150.00 V	300.00 V	600.00 V	1.0000 kV
1 A	40.000 A	240.00	600.00	1.2000 k	2.4000 k	6.0000 k	12.000 k	24.000 k	40.000 k
2 A	80.000 A	480.00	1.2000 k	2.4000 k	4.8000 k	12.000 k	24.000 k	48.000 k	80.000 k
5 A	200.00 A	1.2000 k	3.0000 k	6.0000 k	12.000 k	30.000 k	60.000 k	120.00 k	200.00 k

Units: W (active power), VA (apparent power), var (reactive power)

When using a current sensor with a rating of 500 A (with the CT ratio set to 100) 9661: TYPE.1; CT9667 (500 A): TYPE.1; 9279: TYPE.2; 9709: TYPE.2

Range noted	Current	Voltage range							
on panel	range	6.0000 V	15.000 V	30.000 V	60.000 V	150.00 V	300.00 V	600.00 V	1.0000 kV
1 A	100.00 A	600.00	1.5000 k	3.0000 k	6.0000 k	15.000 k	30.000 k	60.000 k	100.00 k
2 A	200.00 A	1.2000 k	3.0000 k	6.0000 k	12.000 k	30.000 k	60.000 k	120.00 k	200.00 k
5 A	500.00 A	3.0000 k	7.5000 k	15.000 k	30.000 k	75.000 k	150.00 k	300.00 k	500.00 k

Units: W (active power), VA (apparent power), var (reactive power)

When using a current sensor with a rating of 1,000 A (with the CT ratio set to 200) 9669: TYPE.1: CT6865: TYPE.2

Range noted	Current	Voltage range							
on panel	range	6.0000 V	15.000 V	30.000 V	60.000 V	150.00 V	300.00 V	600.00 V	1.0000 kV
1 A	200.00 A	1.2000 k	3.0000 k	6.0000 k	12.000 k	30.000 k	60.000 k	120.00 k	200.00 k
2 A	400.00 A	2.4000 k	6.0000 k	12.000 k	24.000 k	60.000 k	120.00 k	240.00 k	400.00 k
5 A	1.0000 kA	6.0000 k	15.000 k	30.000 k	60.000 k	150.00 k	300.00 k	600.00 k	1.0000 M
								<b>``</b>	

Units: W (active power), VA (apparent power), var (reactive power)

When using a current sensor with a rating of 5,000 A (with the CT ratio set to 1000) CT9667 (5,000 A): TYPE.1

Range noted	Current	Voltage range							
on panel	range	6.0000 V	15.000 V	30.000 V	60.000 V	150.00 V	300.00 V	600.00 V	1.0000 kV
1 A	1.0000 kA	6.0000 k	15.000 k	30.000 k	60.000 k	150.00 k	300.00 k	600.00 k	1.0000 M
2 A	2.0000 kA	12.000 k	30.000 k	60.000 k	120.00 k	300.00 k	600.00 k	1.2000 M	2.0000 M
5 A	5.0000 kA	30.000 k	75.000 k	150.00 k	300.00 k	750.00 k	1.5000 M	3.0000 M	5.0000 M

Units: W (active power), VA (apparent power), var (reactive power)

When using	When using the 9660 (TYPE.1) (rated current: 100 A; with the CT ratio set to 100)									
Range noted	Current	Voltage range								
on panel	range	6.0000 V	15.000 V	30.000 V	60.000 V	150.00 V	300.00 V	600.00 V	1.0000 kV	
1 A	100.00A	600.00	1.5000 k	3.0000 k	6.0000 k	15.000 k	30.000 k	60.000 k	100.00 k	
	Units: W (active power), VA (apparent power), var (reactive power)									

#### Measurement accuracy External current sensor input instrument measurement accuracy only

#### Voltage

Frequency (f)	Input < 50%f.s.	50%f.s. ≤ Input < 100%f.s.	100%f.s. ≤ Input
DC	±0.1% rdg.±0.1%f.s.	±0.1% rdg.±0.1%f.s.	±0.2% rdg.
0.1 Hz ≤ f < 16 Hz	±0.1% rdg.±0.2%f.s.	±0.3% rdg.	±0.3% rdg.
16 Hz ≤ f < 45 Hz	±0.1% rdg.±0.1%f.s.	±0.2% rdg.	±0.2% rdg.
45 Hz ≤ f ≤ 66 Hz	±0.1% rdg.±0.05%f.s.	±0.15% rdg.	±0.15% rdg.
66 Hz < f ≤ 500 Hz	±0.1% rdg.±0.1%f.s.	±0.2% rdg.	±0.2% rdg.
500 Hz < f ≤ 10 kHz	±0.1% rdg.±0.2%f.s.	±0.3% rdg.	±0.3% rdg.
10 kHz < f ≤ 50 kHz	±0.5% rdg.±0.3%f.s.	±0.8% rdg.	±0.8% rdg.
50 kHz < f ≤ 100 kHz	±2.1% rdg.±0.3%f.s.	±2.4% rdg.	±2.4% rdg.

#### Current (external current sensor input)

Frequency (f)	Input < 50%f.s.	50%f.s. ≤ Input < 100%f.s.	100%f.s. ≤ Input
DC	±0.1% rdg.±0.2%f.s.	±0.1% rdg.±0.2%f.s.	±0.3% rdg.
0.1 Hz ≤ f < 16 Hz	±0.1% rdg.±0.2%f.s.	±0.3% rdg.	±0.3% rdg.
16 Hz ≤ f < 45 Hz	±0.1% rdg.±0.2%f.s.	±0.3% rdg.	±0.3% rdg.
45 Hz ≤ f ≤ 66 Hz	±0.1% rdg.±0.1%f.s.	±0.2% rdg.	±0.2% rdg.
66 Hz < f ≤ 500 Hz	±0.1% rdg.±0.2%f.s.	±0.3% rdg.	±0.3% rdg.
500 Hz < f ≤ 1 kHz	±0.1% rdg.±0.2%f.s.	±0.3% rdg.	±0.3% rdg.
1 kHz < f ≤ 10 kHz	±(0.03+0.07×F)% rdg.±0.2%f.s.	±(0.23+0.07×F)% rdg.	±(0.23+0.07×F)% rdg.
10 kHz < f ≤ 100 kHz	±(0.3+0.04×F)% rdg.±0.3%f.s.	±(0.6+0.04×F)% rdg.	±(0.6+0.04×F)% rdg.

#### Active power

Frequency (f)	Input < 50%f.s.	50%f.s. ≤ Input < 100%f.s.	100%f.s. ≤ Input
DC	±0.1% rdg.±0.2%f.s.	±0.1% rdg.±0.2%f.s.	±0.3% rdg.
0.1 Hz ≤ f < 16 Hz	±0.1% rdg.±0.2%f.s.	±0.3% rdg.	±0.3% rdg.
16 Hz ≤ f < 45 Hz	±0.1% rdg.±0.2%f.s.	±0.3% rdg.	±0.3% rdg.
45 Hz ≤ f ≤ 66 Hz	±0.1% rdg.±0.1%f.s.	±0.2% rdg.	±0.2% rdg.
66 Hz < f ≤ 500 Hz	±0.1% rdg.±0.2%f.s.	±0.3% rdg.	±0.3% rdg.
500 Hz < f ≤ 1 kHz	±0.1% rdg.±0.2%f.s.	±0.3% rdg.	±0.3% rdg.
1 kHz < f ≤ 10 kHz	±(0.03+0.07×F)% rdg.±0.2%f.s.	±(0.23+0.07×F)% rdg.	±(0.23+0.07×F)% rdg.
10 kHz < f ≤ 50 kHz	±(0.07×F)% rdg.±0.3%f.s.	±(0.3+0.07×F)% rdg.	±(0.3+0.07×F)% rdg.
50 kHz < f ≤ 100 kHz	±(0.6+0.07×F)% rdg.±0.3%f.s.	±(0.9+0.07×F)% rdg.	±(0.9+0.07×F)% rdg.

Values for f.s. depend on measurement ranges.

- "F" in the tables refers to the frequency in kHz.
- To obtain the current or active power accuracy, add the current sensor's accuracy to the above current and active power accuracy figures.
- The effective measurement range and frequency characteristics conform to the current sensor's specifications.
- The following input are considered reference values: Values for voltage, current, and active power for which 0.1 Hz ≤ f < 10 Hz. Values for voltage and active power in excess of 220 V for which 10 Hz ≤ f < 16 Hz. Values for voltage and active power in excess of 750 V for which 30 kHz < f ≤ 100 kHz.</li>
   When using the CT6841/CT6843, add ±2 mV to the CT6841/CT6843 accuracy after
- performing CT6841/CT6843 zero adjustment using the 1 A range noted on the panel.

Current effective measur- ing range	$\pm 1\%$ to $\pm 150\%$ of the range. However, the effective measurement range depends on the current sensor's specifications.
Maximum effective peak current	The following data reflects the specifications of the instrument alone. In fact, the maxi- mum effective peak current depends on the current sensor's specifications. TYPE.1: ±600% of each current range TYPE.2: ±600% of each current range However, the maximum effective peak current is limited to ±400% for the 5 A range noted on the panel.
Peak exceeded warning	If the maximum effective peak current is exceeded, the <b>PEAK OVER I</b> lamp will light up.

Temperature coefficient			nt range)	
Effect of power factor	Instrument: ±0.15%f.s. or less (45 to 66 Hz with power factor = 0) Internal circuit voltage/current phase difference: ±0.0859° Add the current sensor phase accuracy to the internal circuit voltage/current phase dif- ference noted above.			
Current waveform peak value measurement speci- fications	Measurement accuracy ±2.0% at DC or 10 Hz ≤ f	ut-specific specifications only $\leq$ 1 kHz (f.s.: current peak range) r 0.1 Hz $\leq$ f < 10 Hz and 1 kHz < f. ccuracy to the above.		
	Current range noted on panel	1 A	2 A	5 A
	Current range	1 A × CT ratio	2 A × CT ratio	5 A × CT ratio
	Current peak range	(1 A × CT ratio) × 6	(2 A × CT ratio) × 6	(5 A × CT ratio) × 6
Harmonic measurement	Effective measuring range ±5% to ±100% of current However, when using the ±66.666% of the current p External current sensor input	5 A range noted on beak range (±400%)	of the current range	).
accuracy	-			ıy
	Frequency (f)	Voltage, Current, Act	ive power	
	DC	±0.4% rdg.±0.2	%f.s.	
	10 Hz ≤ f < 30 Hz	±0.4% rdg.±0.29	%f.s.	
	30 Hz ≤ f ≤ 400 Hz	±0.3% rdg.±0.1		
	400 Hz < f ≤ 1 kHz	±0.4% rdg.±0.29		
	1 kHz < f ≤ 5 kHz	±1.0% rdg.±0.5%		
	5 kHz < f ≤ 8 kHz	±4.0% rdg.±1.0		
	Values for f.s. depend on			
	To obtain the current or a the above current and action			ensor's accuracy to
	<ul> <li>When using the CT6841/ performing CT6841/CT68 panel.</li> </ul>			

## 5.4 Functional Specifications

### Auto-range (AUTO)

Functions	Automatically changes the voltage and current range according to the input.
Operation	<ul> <li>Pressing the AUTO key turns on the auto-range function (causing the AUTO lamp to light up). Pressing the AUTO key again turns the auto-range function off, as does pressing any range key (causing the AUTO lamp to turn off).</li> <li>Range up: The range is increased when input exceeds 150% of the range or when the peak is exceeded.</li> <li>Range down: The range is decreased when input falls below 15% of the range. However, the range is not decreased when the peak is exceeded at the lower range.</li> <li>The input level is monitored, and the range is switched over multiple ranges.</li> <li>Range select can be used to disable ranges so that they are not selected.</li> </ul>
Default state	Voltage/ current AUTO range: OFF

#### Range select and zero-cross filter's threshold level settings

Functions	Selects whether to enable (turn on) or disable (turn off) individual voltage and current ranges. Sets the zero-cross filter's threshold level for voltage and current ranges.		
Range select	Enabled (use): Disabled (do not use)	Ranges can be selected with the range keys. Range switching occurs using auto-range operation. Range switching occurs during auto-range integration. : Ranges cannot be selected with the range keys. Range switching does not occur using auto-range operation. Range switching does not occur during auto-range integration.	
Zero-cross filter's threshold level	Set from 1% to 15% (	in 1% intervals).	
Display	When there is a range that has been disabled or for which the zerocross threshold level is a value other than 1%: The <b>RANGE SEL</b> lamp will light up.		
Default state	All voltage and currer	t ranges.: ON, zero-cross filter's threshold level: 1%	

### Averaging (AVG)

Functions	Averages the voltage, current, active power, apparent power, and reactive power. (Other than harmonic measurement parameters.) The power factor and phase angle are calculated from averaged data. Averaging is not performed for parameters other than those listed above.							
Method	Simple averaging							
Number of averaging iterations and display up- date interval	Number of averaging iterations	1 (OFF)	2	5	10	25	50	100
date interval	Display update interval	200 ms	400 ms	1 s	2 s	5 s	10 s	20 s
Display	The <b>AVG</b> lamp will light up when the number of averaging iterations is set to a value other than 1 (off). From the start of averaging until the first average value is displayed, the <b>AVG</b> lamp will flash, and all measured values will be shown as [] (invalid data).							
Over-range warning	When the data being averaged includes an [o.r] value, the corresponding unit will flash.							
Start of averaging	<ol> <li>Averaging is started or restarted at the following times:</li> <li>After the instrument starts up</li> <li>After zero-adjustment operation is complete.</li> <li>After settings related to averaging, for example the number of averaging iterations or the range, are changed</li> </ol>							
Default state	Number of averaging	iterations	: 1 (OFF)					

Scaling	(VT. CT)
ocanng	(•··, •·/

Functions	Applies user-defined VT and CT ratio settings to measured values.
VT ratio setting range	OFF (1.0) 0.001 to 0.009, 0.010 to 0.099, 0.100 to 0.999, 1.000 to 9.999, 10.00 to 99.99, 100.0 to 999.9, 1000. (setting: 0)
CT ratio setting range	OFF (1.0) 0.001 to 0.009, 0.010 to 0.099, 0.100 to 0.999, 1.000 to 9.999, 10.00 to 99.99, 100.0 to 999.9, 1000. (setting: 0)
Display	The <b>VT</b> lamp will turn on when the VT ratio is set to any value other than 1 (off). The <b>CT</b> lamp will turn on when the CT ratio is set to any value other than 1 (off).
Error warnings	The display will show <b>S.Err</b> (scaling error) when the VT ratio or CT ratio setting causes the full-scale value for active power, apparent power, or reactive power to exceed 99,999 M.
Default state	VT ratio: 1.0 (OFF), CT ratio: 1.0 (OFF)

#### Hold functions Hold (HOLD)

Hold (HOLD)				<b>C</b> (1 P		
Functions	point in time. • Measurement data a • Peak exceeded and • Internal calculations tinue.	<ul> <li>Measurement data acquired by communications is also fixed at that point in time.</li> <li>Peak exceeded and other warning lamps will still light up.</li> <li>Internal calculations (including integration and integration elapsed time) will con-</li> </ul>				
Operation				causes the <b>HOLD</b> lamp to light nction (causing the <b>HOLD</b> lamp		
Default state	Hold display: OFF					
Backup	The hold function is ba (The hold value is not l ment starts up.)	cked up. backed up, a	ind display of the ini	tial data is held when the instru-		
Constraints	During hold operation,	the following	operational constra	aints apply:		
		-		I –: Setting and changes not allowed		
	Item		Duri	ng hold operation		
	Measurement range	Measurement range		However, during auto-range integration, auto-range op- eration is used to determine the current range.		
	Current input method swit	Current input method switching		-		
	Frequency measurement (Zero-cross filter)	Frequency measurement range (Zero-cross filter)		-		
	Timeout	Timeout		-		
	Integration time	Integration time		-		
	Synchronization source	Synchronization source		-		
	Zero-adjustment	Zero-adjustment		_		
	Maximum value/minimum	value hold	•			
	Display parameters			•		
	D/A output parameters	D/A output parameters		•		
		Number of averaging iterations		-		
	VT ratio	VT ratio		-		
	CT ratio		-			
	RS-232C transfer speed		•			
		GP-IB address		•		
	LAN Harmonic analysis order u	inner limit		-		
External control	1 0	0	,	shorted (low)/open (high)		
	Functions		al control signal	External control terminal		
	Hold on		$Hi \rightarrow Lo$	HOLD		
	Hold off (canceled)		$Lo \rightarrow Hi$			

#### Maximum value/ minimum value hold (MAX/MIN HOLD)

Functions	power integration, integration ela active power values) as well as m	measured values (except current integration, active psed time, time average current, and time average aximum and minimum values for the voltage wave- peak and holds them on the display.
	data's absolute values is held (so	f the maximum value and minimum value for the o that both positive and negative polarity values are pply to the voltage waveform peak value or the cur-
	Peak exceeded and other warnin	g lamps will still light up.
	<ul> <li>Internal calculations (including in tinue.</li> </ul>	ntegration and integration elapsed time) will con-
	The maximum and minimum valumum value measurement during	es during integration are detected (maximum/mini- the integration interval).
	<ul> <li>Analog output and waveform output</li> </ul>	out are not held.
Maximum value and mini- mum value detection oper- ation	<ul> <li>restarts. (However, if the instructive ress, the display will indicate []</li> <li>Internal data is cleared and depressed (including via external of 3. Internal data is cleared and details)</li> </ul>	letection restarts when the <b>DATA RESET</b> key is control). ection restarts when integration is started. mum values stops when integration stops. en the range is changed.
Display switching		the display as follows: Maximum value $\rightarrow$ minimum ing the MAX and MIN lamp to light up as appropri-
Default state	Maximum value/minimum value hol	d display: OFF
Backup		e hold function is backed up. (Maximum and mini- d detection operation restarts when the instrument
Constraints	constraints apply:	imum value hold display, the following operational
	•:Setting	and changes allowed —: Setting and changes not allowed
	Item	During maximum value/ minimum value hold display
	Measurement range	•
	Current input method switching	-
	Frequency measurement range (Zero-cross filter)	-
	Timeout	_
	Integration time	_
	Synchronization source	-
	Zero Adjustment	-
	Hold	_
	Display parameters	•
	D/A output parameters	•
	Number of averaging iterations	—
	VT ratio	-
	CT ratio	-
	RS-232C transfer speed	•
	GP-IB address	•
	LAN Harmonic analysis order upper limit	
	namonic analysis order upper infill	_

### Zero Adjustment (0 ADJ)

Functions	Zeroes out the voltage and current input offset.		
Compensation range	Voltage: Current: External current sensor input:	±15%f.s. or less ±15%f.s. or less ±15%f.s. or less	
Compensation operation time	Approx. 30 sec.		
Method	Press the <b>0</b> ADJ key.		
Constraints	No measured values are displa Integration cannot be started of Zero-adjustment cannot be per Zero-adjustment cannot be per mum value hold operation. Settings cannot be changed du	luring zero-adjustment. rformed during integration. rformed during display hold or maximum value or mini-	

### Synchronized control

Functions	The timing of calculations; display updates; data updates; integration start, stop, and re- set events; display hold operation; key lock operation; and zero-adjustment operation for the slave PW3335, PW3335-01, PW3335-02, PW3335-03, or PW3335-04 is synchro- nized with the master PW3335, PW3335-01, PW3335-02, PW3335-03, or PW3335-04. Synchronization with the PW3336, PW3336-01, PW3336-02, PW3336-03, PW3337, PW3337-01, PW3337-02, and PW3337-03 is also supported. An error will be displayed if unable to perform synchronized control (and the display will continue until the error is cleared).
Terminal	BNC terminal × 1 (non-isolated)
Terminal name	External synchronization terminal (EXT.SYNC)
I/O settings	<ul> <li>OFF/ In/ OUT</li> <li>OFF: Synchronized control function off (signals input to the external synchronization terminal (EXT.SYNC) are ignored)</li> <li>IN: The external synchronization terminal (EXT.SYNC) is set to input, and a dedicated synchronization signal can be input (slave). The SYNC. OUT lamp will flash when a synchronization signal is received.</li> <li>OUT: The external synchronization terminal (EXT.SYNC) is set to output, and a dedicated synchronization signal can be output (master). The SYNC. OUT lamp will light up when the terminal is set to OUT.</li> </ul>
I/O signal levels	High level: +5 V; low level: 0 V (high-speed CMOS level)
Number of units for which synchronized control can be performed	Up to 7 slaves per master (total of 8 units including the PW3336/PW3337 series)
Default state	Synchronized control: OFF

### Key-lock (KEY LOCK)

Functions	Disables key input in the measurement state, except for the <b>KEY LOCK</b> key.
Operation	Pressing the <b>KEY LOCK</b> key enables the key lock function (causing the <b>KEY LOCK</b> lamp to light up).
Constraints	The key lock state will be canceled when the instrument is placed in the remote state (and the <b>REMOTE</b> lamp will light up) by communications.
Backup	Yes (The key lock state will continue in effect when the instrument starts up.)
Default state	Key-lock: OFF

### Backup

Functions	Backs up settings and integration data if the instrument is turned off and if a power out-
	age occurs.

### System Reset

Functions	Initializes the instrument's settings.
Operation	The system will be reset if the <b>DATA RESET</b> key is pressed after the instrument is turned on.
Constraints	Communications-related settings (communications speed, address, and LAN-related settings) are not initialized.

### Instrument protection mode

Functions	Forcibly changes the range to the 200 mA range to prevent the instrument's current in- put circuitry from producing heat if current of greater than or equal to $\pm$ 612 mA peak is inputted continuously for 10 or more seconds when using a range from 1 mA to 100 mA with fixed range. When using a range from the 200 mA range to the 20 A range, the user is prevented from switching to a range from the 1 mA to the 100 mA range while inputting a current that is greater than or equal to $\pm$ 612 mA peak.	
Operation	The <b>CURRENT</b> • lamp will flash. Integration will be forcibly stopped (causing the <b>RUN</b> lamp to flash), and it will not be possible to resume integration operation. Other functions can be used. If the 200 mA range has been disabled using the range select function, the range will be switched to an enabled range greater than the 200 mA range.	
Cancellation method	<ul> <li>Instrument protection mode can be canceled as described by performing any of the following actions, causing the CURRENT  <ul> <li>lamp to turn off:</li> </ul> </li> <li>Pressing one of the current range keys</li> <li>If integration has stopped, resetting integrated values</li> <li>If integration has been reset, pressing the EXIT key</li> <li>Performing a system reset</li> <li>Performing zero-adjustment</li> </ul>	

## 5.5 Calculation Formulas Specifications

#### Basic measurement parameter calculation formulas

### (1) Voltage calculation formulas

Item (RECTIFIER)	Calculation formulas	
RMS value (AC+DC)	$U = \sqrt{\frac{1}{M} \sum_{s=0}^{M-1} (u_s)^2}$	
Average value rectification RMS value converted value (AC+DC Umn)	$U_{\rm mn} = \frac{\pi}{2\sqrt{2}} \frac{1}{M} \sum_{\rm s=0}^{\rm M-1}  u_{\rm s} $	
Simple average value (DC)	$U_{\rm DC} = \frac{1}{M} \sum_{\rm s=0}^{\rm M-1}  u_{\rm s}$	
AC component RMS value (AC)	$U_{\rm AC} = \sqrt{(U)^2 - (U_{\rm DC})^2}$	
Fundamental wave component RMS value (FND)	$U_1$ from harmonic calculation formula	
Waveform peak value	$U_{\rm pk} = \begin{bmatrix} U_{\rm pk +} : u_{\rm s} & \text{Maximum value from M values} \\ U_{\rm pk -} : u_{\rm s} & \text{Minimum value from M values} \\ \end{bmatrix}$ Displays the maximum absolute value from the above with its polarity.	
Total harmonic distortion	$U_{\rm thd}$ from harmonic calculation formula	
Ripple rate	$U_{\rm rf} = \frac{ (U_{\rm pk+} - U_{\rm pk-}) }{2 \times  U_{\rm DC} } \times 100$	
Crest factor	$U_{\rm cf} = \left  \frac{U_{\rm pk}}{U} \right $	
M: Number of samples between sync	shronized timing points; s: Sample point number	

### (2) Current calculation formulas

Item (RECTIFIER)	Calculation formulas
RMS value (AC+DC)	$I = \sqrt{\frac{1}{M} \sum_{s=0}^{M-1} (i_s)^2}$
Simple average value (DC)	$I_{\rm DC} = \frac{1}{M} \sum_{\rm s=0}^{\rm M-1} i_{\rm s}$
AC component RMS value (AC)	$I_{\rm AC} = \sqrt{(I)^2 - (I_{\rm DC})^2}$
Fundamental wave component RMS value (FND)	$I_1$ from harmonic calculation formula
Waveform peak value	$I_{\rm pk} = \begin{bmatrix} I_{\rm pk +} : i_{\rm s} & \text{Maximum value from M values} \\ I_{\rm pk -} : i_{\rm s} & \text{Minimum value from M values} \\ \end{bmatrix}$ Displays the maximum absolute value from the above with its polarity.
Total harmonic distortion	<i>I</i> <sub>thd</sub> from harmonic calculation formula
Ripple rate	$I_{\rm rf} = \frac{ (I_{\rm pk+} - I_{\rm pk-}) }{2 \times  I_{\rm DC} } \times 100$
Crest factor	$I_{\rm cf} = \left  \frac{I_{\rm pk}}{I} \right $
Maximum current ratio	$MCR = \left  \frac{I_{cf}}{\lambda} \right $
M: Number of samples between sync	hronization timing points; s: Sample point number

### (3) Power calculation formulas

Item (RECTIFIER)	Calculation formulas	
Active power (AC+DC, AC+DC Umn)	$P = \frac{1}{M} \sum_{s=0}^{M-1} (u_{s} \times i_{s})$	
Active power simple average value (DC)	$P_{\rm DC} = U_{\rm DC} \times I_{\rm DC}$	
Active power AC component (AC)	$P_{\rm AC} = P - P_{\rm DC}$	
Fundamental wave active power (FND)	$P_1$ from harmonic calculation formula	
Apparent power	$S = U \times I$	
(AC+DC, AC, AC+DC Umn)	Calculated values from the respective rectifiers are used for $U$ and $I$ . (For AC+DC Umn, the AC+DC value is used for current.)	
Fundamental wave apparent power (FND)	$S_1$ from harmonic calculation formula	
Reactive power (AC+DC, AC, AC+DC Umn)	$Q =_{si} \sqrt{S^2 - P^2}$	
	Calculated values from the respective rectifiers are used for $P$ and $S$ .	
Fundamental wave reactive power (FND)	$Q_1$ from harmonic calculation formula	
Power factor (AC+DC, AC, AC+DC Umn)	$\lambda =_{\rm si} \left  \begin{array}{c} P \\ S \end{array} \right $	
	Calculated values from the respective rectifiers are used for $P$ and $S$ .	
Fundamental wave power factor (FND)	$\lambda_1$ from harmonic calculation formula	
Phase angle (AC)	When $P_{AC} \ge 0$ $\varphi =_{si} \cos^{-1}  \lambda $ (0° ~ ±90°) When $P_{AC} < 0$ $\varphi =_{si}  180 - \cos^{-1}  \lambda  $ (±90° ~ ±180°) Calculated values from the respective rectifiers are used for $\lambda$ .	
Fundamental wave voltage current phase difference (FND)	$\varphi_1$ from harmonic calculation formula	

### (4) Harmonic measurement parameter calculation formulas

Item	Calculation formulas
Harmonic voltage	$U_{\rm k} = \sqrt{(U_{\rm kr})^2 + (U_{\rm ki})^2}$
Harmonic voltage content percentage	$U_{\rm HDk} = \frac{U_{\rm k}}{U_{\rm l}} \times 100$
Harmonic voltage phase angle	$\theta U_{\rm k} = \tan^{-1}(\frac{U_{\rm kr}}{-U_{\rm ki}})$
Total harmonic voltage distortion	$U_{\rm thd} = \frac{\sqrt{\sum_{k=2}^{K} (U_k)^2}}{U_1} \times 100$
Harmonic current	$I_{\rm k} = \sqrt{(I_{\rm kr})^2 + (I_{\rm ki})^2}$
Harmonic current content percentage	$I_{\rm HDk} = \frac{I_{\rm k}}{I_{\rm 1}} \times 100$
Harmonic current phase angle	$\theta I_{\rm k} = \tan^{-1}(\frac{I_{\rm kr}}{-I_{\rm ki}})$
Total harmonic current distortion	$I_{\rm thd} = \frac{\sqrt{\sum_{k=2}^{K} (I_k)^2}}{I_1} \times 100$
Harmonic active power	$P_{\rm k} = U_{\rm kr} \times I_{\rm kr} + U_{\rm ki} \times I_{\rm ki}$
Harmonic active power content percentage	$P_{\rm HDk} = \frac{P_{\rm k}}{P_{\rm l}} \times 100$
Fundamental wave voltage current phase difference	$\varphi_1 = (\theta I_1 - \theta U_1) \times (-1)$
Harmonic voltage current phase difference	$\varphi_k = (\theta I_k - \theta U_k)$
Fundamental wave apparent power	$S_1 = U_1 \times I_1$
Fundamental wave reactive power	$Q_1 = (U_{1r} \times I_{1i} - U_{1i} \times I_{1r}) \times (-1)$
Fundamental wave power factor	$\lambda_1 = {}_{\rm sic}  \cos \varphi_1 $

## Maintenance and Service Chapter 6

#### **Inspection and Repair**

For more information about error messages, see 6.2 Error Indication (p.170).

# 

Touching any of the high-voltage points inside the instrument is very dangerous. Customers are not allowed to modify, disassemble, or repair the instrument. Doing so may cause fire, electric shock, or injury.

- If damage is suspected, check the "Before having the instrument repaired" (p.168) section before contacting your authorized Hioki distributor or reseller.
- The fuse is housed in the power unit of the instrument. If the power does not turn on, the fuse may be blown. If this occurs, a replacement or repair cannot be performed by customers. Please contact your authorized Hioki distributor or reseller.

#### Calibrations

#### IMPORTANT

Periodic calibration is necessary in order to ensure that the instrument provides correct measurement results of the specified accuracy.

The calibration frequency varies depending on the status of the instrument or installation environment. We recommend that the calibration frequency is determined in accordance with the status of the instrument or installation environment and that you request that calibration be performed periodically.

#### **Replaceable Parts and Operating Lifetimes**

Properties of some parts used in the instrument may deteriorate after a long-term use.

The regular replacement of those parts is recommended to use the instrument properly for a long time.

For the replacement of the parts, please contact your authorized Hioki distributor or reseller.

The useful lives of the parts depend on the operating environment and frequency of use.

Operation cannot necessarily be guaranteed for the following recommended replacement period of each part.

Parts Name	Recommended Replacement Period	Note and Condition
Switching power supply	Approx. 6 years	After continuous use at 40°C The switching power supply will need to be replaced.

#### **Precautions during shipment**

Be sure to observe the following precautions:

- To avoid damage to the instrument, remove the accessories and optional equipment from the instrument. Moreover, use the original packing materials in which it was shipped, and be sure to pack in a double carton. Damage occurring during transportation is not covered by the warranty.
- When sending the instrument for repair, be sure to include details of the problem.

6.1 Troubleshooting

### Cleaning

To clean the instrument, wipe it gently with a soft cloth moistened with water or mild detergent.

#### IMPORTANT

Never use solvents such as benzene, alcohol, acetone, ether, ketones, thinners or gasoline, as they can deform and discolor the case.

#### **Disposing of the instrument**

Handle and dispose of the instrument in accordance with local regulations.

## 6.1 Troubleshooting

#### Before having the instrument repaired

Symptom	Check Item, or Cause	Remedy and Reference
The display does not appear when you turn the power on.	Has the power cord been disconnected from the instru- ment? Is it connected properly?	Verify that the power cord is connected properly. See: 2.3 Connecting the Power Cord (p.33)
	Has the key lock been activated?	Cancel the key lock state. See: 3.9.3 Disabling Control Keys (Key Lock) (p.109)
Keys do not work.	Is the <b>REMOTE</b> lamp lit up?	The instrument is being con- trolled by the controller. End control and cancel the remote state. See: 4.3 Canceling the Remote State (Activating the Local State) (p.137)
Display values differ from those obtained from other instruments.	The instrument's apparent power (S), reactive power (Q), power factor ( $\lambda$ ), and phase angle ( $\phi$ ) are calculated based on the measured voltage (U), current (I), and active power (P). Values displayed by the instrument may differ from values displayed by measuring instruments that use different operating principles or equations.	See: 5.5 Calculation Formulas Specifications (p.163)
The display value is zero.	Voltage values that are less than $\pm 0.5\%$ of the measurement range and current values that are less than $\pm 0.5\%$ of the measurement range or less than $\pm 9 \mu$ A will be forcibly displayed as zero. (this is known as zero-suppression).	Lower the range. If the display value remains zero after lower- ing the range, the value may have exceeded the instru- ment's effective measurement range.
	Is the rectifier suitable for the measurement target? (If the DC rectifier is used with an AC signal, the display val- ue will be zero.)	Set the rectifier properly. See: "Selecting the rectifier" (p.42)
I am unable to change the range.	Is range select off?	See: 3.2.3 Selecting the Volt- age and Current Ranges (p.43)
	Has the key lock been activated?	See: 3.9.3 Disabling Control Keys (Key Lock) (p.109)
	Is the <b>REMOTE</b> lamp lit up?	See: 4.3 Canceling the Remote State (Activating the Local State) (p.137)
	Is the RUN lamp lit up?	See: 3.3 Integration (p.61)
	Is the HOLD lamp lit up?	See: 3.9.1 Fixing Display Val- ues (Display Hold) (p.106)

#### If the HRM lamp (ERROR) lights up





Accurate harmonic measurement cannot be performed while the **HRM** lamp (ERROR) is lit up.

- The HRM lamp (ERROR) will light up when the instrument receives input outside the synchronization frequency range for harmonic measurement or if it is unable to perform harmonic measurement due to the effects of noise. At that time, the instrument will show the invalid data display [- - - - -].
- Since measurement processing will be reset when integration starts, preventing harmonic analysis from being performed properly during that interval, the HRM lamp (ERROR) will light up momentarily.

#### If the PEAK OVER U or PEAK OVER I lamp lights up





These lamps will light up if the voltage input or current input waveform peak value exceeds the figures listed below. At this time, the displayed data is not accurate.

• Voltage input waveform peak value: ±600% of the voltage range

When using the 300 V, 600 V, or 1,000 V range, ±1,500 V peak

Current input waveform peak value: ±600% of the current range

When using the 20 A range, ±100 A peak

Error display	Status	Solution
PEAK OVER U	When greater than ±1,500 V peak	Stop measurement immediately, deactivate power to measurement lines, and disconnect wires.
	When less than ±1,500 V peak	The internal circuit is not operating properly. Switch to a range for which the <b>PEAK OVER U</b> lamp does not light up. <b>See:</b> 3.2.3 Selecting the Voltage and Current Ranges (p.43)
PEAK OVER I	When greater than ±60 A peak	Stop measurement immediately, deactivate power to measurement lines, and disconnect wires.
	When less than ±60 A peak	The internal circuit is not operating properly. Switch to a range for which the <b>PEAK OVER I</b> lamp does not light up. <b>See:</b> 3.2.3 Selecting the Voltage and Current Ranges (p.43)

#### When no apparent cause can be established

Perform a system reset.

This will return all settings to their factory defaults.

See: 3.9.4 Initializing the Instrument (System Reset) (p.110)

## 6.2 Error Indication

The instrument will display an error if a malfunction is found during the self-test when the instrument is turned on or if it is unable to accept key input for some reason.

See: 3.9.4 Initializing the Instrument (System Reset) (p.110)



If the measurement lines are energized when the instrument is turned on, the instrument may be damaged or an error message may appear, so before energizing the lines, turn the instrument on and confirm that no error message is displayed.

#### Contact your authorized Hioki distributor or reseller if a repair should become necessary.

Error display	Description	Cause and Remedy
Err. 1	ROM error	
Err. 2	SDRAM error	The instrument needs to be repaired. (Circuit failure)
Err. 3	Control circuit error	
Err. 4	Buffer data error	Pressing any key will cause the instrument to switch to the mea- surement display after performing a system reset. If this error occurs frequently, the instrument will need to be repaired. The circuit used to save settings may be damaged.
Err. 11	Invalid key input (displayed for approx. 1 sec.)	This error is displayed when key and external control are mixed during integration.
Err. 12	Invalid key input (displayed for approx. 1 sec.)	This error is displayed when an invalid operation is attempted during integration. Example: Range switching This error is displayed when the user attempts to perform zero adjustment while the <b>CURRENT</b> • lamp is flashing and integra- tion is stopped.
Err. 14	Invalid key input (displayed for approx. 1 sec.)	This error is displayed when the user attempts to start integra- tion after the integration limit (integration time, integrated value) has been reached. This error is displayed when the user attempts to start integra- tion while the <b>CURRENT</b> • lamp is flashing.
Err. 15	Invalid key input (displayed for approx. 1 sec.)	This error is displayed when a data reset is performed during in- tegration.
Err. 16	Invalid key input (displayed for approx. 1 sec.)	This error is displayed when an invalid operation is performed during display hold operation.
Err. 17	Invalid key input (displayed for approx. 1 sec.)	This error is displayed when a range key that has been disabled with the range select function is pressed.
Err. 18	Zero-adjustment failure (displayed for approx. 1 sec.)	This error is displayed when input exceeds the zero-adjustment range. See: 2.5 Performing Zero-adjustment (p.35)

Error display	Description	Cause and Remedy
Err. 20	Synchronization loss	This error is displayed when no external signal is received while the instrument has been set as the slave with the external syn- chronization function. See: 3.5 Performing Synchronized Measurement with Multiple Instruments (Multiple-instrument Synchronized Measure- ment) (p.78)
o.r	Over-range	This error is displayed when the voltage or current exceeds 152% of the range (or 1,060.5 V when using the 1,000 V voltage range). See: 3.10.3 When o.r (over-range) Is Displayed (p.113) 3.2.3 Selecting the Voltage and Current Ranges (p.43)
5.E r r	Scaling error	This error is displayed when the display range has been exceeded due to the VT ratio or CT ratio setting. Change the VT or CT ratio. See: 3.2.8 Setting the VT Ratio and CT Ratio (p.58)
Е УРЕ. 1 Е УРЕ.2	External current sensor input	This error is displayed when a range key other than 1 A to 5 A is pressed while using external current sensor input. <b>See:</b> 3.8 Using a Current Sensor (p.100)
	No measurement or measured value not ready	When starting averaging, the [] display will change to the measured value display when the first average value has been calculated.
P R S S	Success initializing Bluetooth <sup>®</sup> serial conversion adapter	The Bluetooth <sup>®</sup> serial conversion adapter was successfully initialized.
FR ,L	Failure initializing the Bluetooth <sup>®</sup> serial conversion adapter	Turn on the adapter. Verify that the adapter's communication speed matches the instrument's setting.

# Appendix

## Appendix 1 Detailed Specifications of Measurement Items (Display Items)

Measurement items				Re	ectifier			
			AC+DC	AC+DC Umn	DC	AC	FND	Display range
Voltage		V	•	•	•	•	•	Up to ±152% of range. However, zero-suppression when less than ±0.5%
Current		А	•	•	•	•	•	Up to $\pm 152\%$ of range. However, zero-suppression when less than $\pm 0.5\%$ or less than $\pm 9 \ \mu$ A.
Active power		W	•	•	•	•	•	±0% to ±231.04% of range
Apparent power		VA	•	•	-	•	•	0% to 231.04% of range
Reactive power		var	•	•	-	•	•	±0% to ±231.04% of range
Power factor		PF	•	•	-	•	٠	±0.0000 to ±1.0000
Phase angle		0	-	-	-	•	•	+180.00 to -180.00
Frequency	Voltage Current	VHz AHz	-	_	-	-	-	0.1000 to 100.00 kHz
Current integration	Positive Negative	Ah+ Ah-	_	_	•	-	-	Display resolution 999999
	Total	Ah	•*	•*	•	-	-	
Active power integration	Positive Negative Total	Wh+ Wh- Wh	•	•	٠	_	_	Display resolution 999999
Integration time		TIME	-	-	-	-	-	00.00.00 to 10000.0
Waveform peak value	Voltage Current	Vpk Apk	-	-	-	-	_	Up to ±102% of peak range
Crest factor	Voltage Current	CF V CF A	-	-	-	-	-	1.0000 to 612.00
Maximum current ratio		MCR	-	-	-	-	-	1.0000 to 6.1200 M
Time average current		T.AV A	●*	●*	•	-	-	±0% to ±612% of range
Time average active power		T.AV W	•	•	•	-	-	±0% to ±3745.4% of range
Ripple rate	Voltage Current	RF V% RF A%	-	-	_	-	-	0.00% to 500.00%
Total harmonic distortion	Voltage Current	THD V% THD A%	-	_	_	_	-	0.00% to 500.00%

Measured value display (if using communications, measured value data) •: Displayed -: Not displayed

\* During auto-range integration mode operation, this data is invalid (-: None).

## Appendix 2 Detailed Specifications of Output

## **Appendix 2.1 Detailed Specifications of Level Output**

Not installed Los 0 V autout

#### PW3335-02 PW3335-04

						●: Instal	led – : Not installed Lo.: 0 V output	
Measurement items		AC+DC	AC+DC +Umn	DC	AC	FND	Rated output voltage	
Voltage	V	•	•	•	•	•		
Current	A	•	•	•	•	•	Relative to ±100% of the range	
Active power	W	•	•	•	•	•	STD.2: ±2 V DC STD.5: ±5 V DC	
Apparent power	VA	•	•	Lo.	•	•		
Reactive power	var	•	•	Lo.	•	•		
Power factor	PF	•	•	Lo.	•	•	STD.2: ±2 V DC at ±0.0000, ±0 V DC at ±1.0000 STD.5: ±5 V DC at ±0.0000, ±0 V DC at ±1.0000	
Phase angle	o	Lo.	Lo.	Lo.	•	•	STD.2: ±0 V DC at 0.00°, ±2 V DC at ±180.00° STD.5: ±0 V DC at 0.00°, ±5 V DC at ±180.00°	
Frequency	VHz AHz	-	_	_	_	_	5 V at set value Example: If set to 5 kHz, 5 V DC at 5 kHz	
Time average current	T.AV A	•*	•*	•	Lo.	Lo.	Relative to ±100% of the range STD.2: ±2 V DC	
Time average active power	T.AV W	•	•	•	Lo.	Lo.	STD.5: ±5 V DC	
Current integration	Ah+ Ah-	Lo.	Lo.	•	Lo.	Lo.	5 V when set value is reached Example: If set to 5 kAh, 5 V DC at 5 kAh	
	Ah	•*	•*	•	Lo.	Lo.		
Active power integration	Wh+ Wh- Wh	•	•	•	Lo.	Lo.	5 V when set value is reached Example: If set to 5 kWh, 5 V DC at 5 kWh	
Crest factor	CF V CF A	_	_	_	_	_	STD.2: ±2 V DC at 10.000 STD.5: ±5 V DC at 10.000	
Ripple rate	RF V% RF A%	_	-	_	_	_	STD.2: ±2 V DC at 100.00% STD.5: ±5 V DC at 100.00%	
Total harmonic distortion	THD V% THD A%	-	-	-	-	_		
Maximum current ratio	MCR	-	-	_	-	-	STD.2: ±2 V DC at 10.000 STD.5: ±5 V DC at 10.000	

\* During auto-range integration mode operation, the display will indicate Lo. (0 V output).

# Appendix 2.2 Detailed Specifications of High-speed Level Output

#### PW3335-02 PW3335-04

•: Installed -: Not installed

Measurement items		Rectifier					
		AC+DC	AC+DC +Umn	DC	AC	FND	Rated output voltage
Voltage	V	•	-	-	-	-	Relative to ±100% of the range
Current	Α	•	-	-	-	_	FASt.2: ±2 V DC
Active power	W	•	_	-	_	_	FASt.5: ±5 V DC

# Appendix 2.3 Detailed Specifications of Waveform Output

PW3335-02 PW3335-04

•: Installed –: Not installed

				Rectifier				
Measurement items		AC+DC	AC+DC +Umn	DC	AC	FND	Rated output voltage	
Instantaneous voltage	V	•	-	_	_	_	FASt 1 Vf.s. relative to ±100% of the	
Instantaneous current	А	•	_	-	_	_	range (RMS level)	
Instantaneous power	W	•	_	_	_	_	FASt 1 Vf.s. relative to ±100% of the range (Average level)	

# **Appendix 3 Example Accuracy Calculations**

#### Basic approach to accuracy

#### When the accuracy notation combines rdg. and f.s.

Accuracy specification: ±0.2% rdg. ±0.1%f.s. Measurement range: 300.00 V Measured value: 100.00 V

Since the value being measured is 100.00 V; (A) Reading error ( $\pm$ % rdg.):  $\pm$ 0.2% of 100.00 V =  $\pm$ 0.20 V (B) Full-scale error ( $\pm$ %f.s.):  $\pm$ 0.1% of 300 V =  $\pm$ 0.30 V (C) Total error (A+B):  $\pm$ 0.50 V Based on the total error (C), the error boundary values for a measured value of 100.00 V would be <u>99.50 V to 100.50 V</u>.

#### Method for calculating accuracy when using a current sensor

Power measurement error = Instrument's measurement error + 9661 Current Sensor additional error

Example calculation: If input is less than 50% of the range

#### **Measurement conditions**

Voltage range of 300 V, current range of 200 A (2 A range, CT ratio: 100), power display value of 16 kW Voltage input of 200 V, current input of 80 A, 50 Hz, sine wave

- Effective power accuracy of instrument's external current sensor input: ±0.1% rdg. ±0.1% f.s. (Representative accuracy when input is less than 50% of the range)
- 9661 measurement accuracy: ±0.3%rdg. ±0.01%f.s.

#### **Calculation method**

- Check the instrument's power range in the instruction manual. <u>Voltage range: 300 V</u>, <u>Current range: 200 A</u> (2 A range, CT ratio: 100) → 60.000 kW range
- Calculate the instrument's error. ±(16 kW × 0.1%) rdg. ±(60 kW × 0.1%)f.s. = ±0.076 kW
- Check the power range to use when calculating the 9661's accuracy addition. Since the sensor is the 9661, use the power range for the 500 A current range (5 A range, CT ratio: 100) for f.s.\*
   <u>Voltage range: 300 V</u>, <u>Current range: 500 A</u> (5 A range, CT ratio: 100) → 150 kW range
- 4. Calculate the additional power accuracy when using the 9661.  $\pm(16 \text{ kW} \times 0.3\%) \text{ rdg. } \pm(150 \text{ kW} \times 0.01\%)\text{f.s.} = \pm0.063 \text{ kW}$
- Add the instrument's error and the 9661 error. ±0.076 kW ±0.063 kW = ±0.139 kW ··· ±0.87% rdg.
- \* Since the current sensor itself has no power range, use the power meter's power range when calculating the f.s. error.

(Unit: mm)

# **Appendix 4 Rack Mounting**

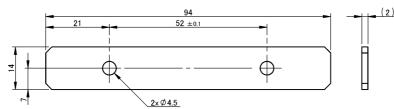
By removing the screws on the sides, this instrument can be installed in a rack mounting plate.

Observe the following precautions regarding the mounting screws to avoid instrument damage and electric shock accidents.

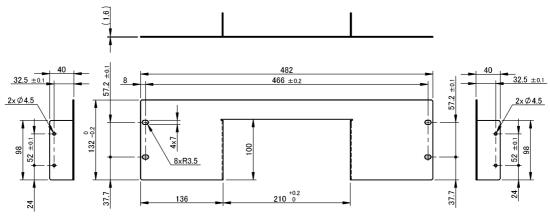
- When installing the Rack Mounting Plate, the screws must not intrude more than 6 mm into either side of the instrument.
  - When removing the Rack Mounting Plate to return the instrument to stand-alone use, replace the same screws that were installed originally. (Feet: M3  $\times$  6 mm, Sides: M4  $\times$  6 mm)

When installing into the rack, reinforce the installation with a commercially available support stand.

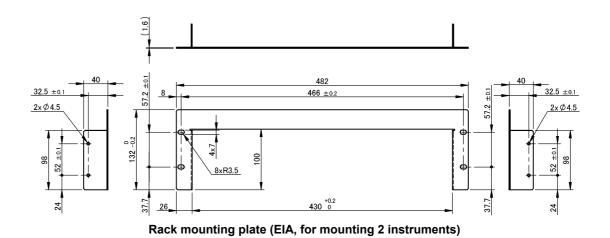
#### Rack mounting plate template diagram

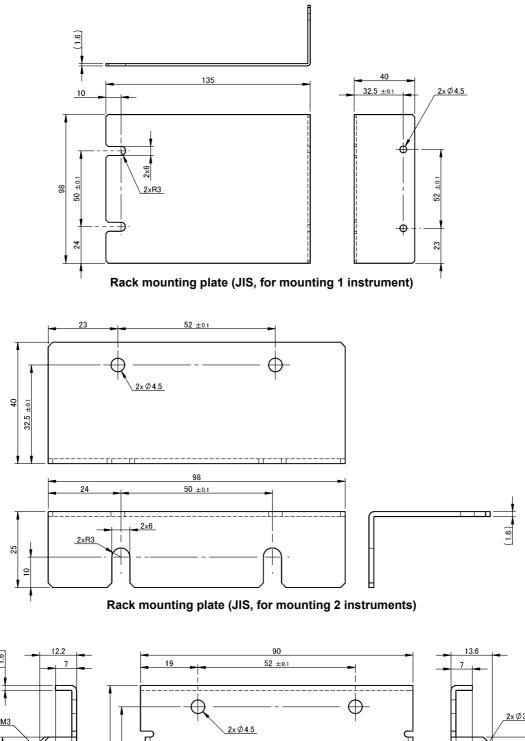


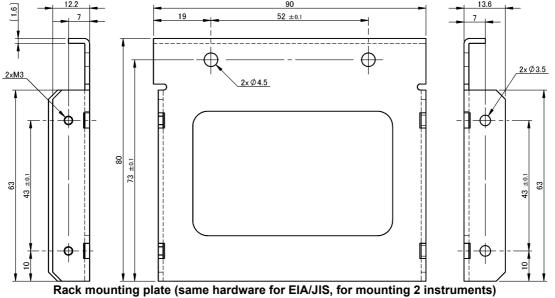
Spacer (same hardware for EIA/JIS)



Rack mounting plate (EIA, for mounting 1 instrument)

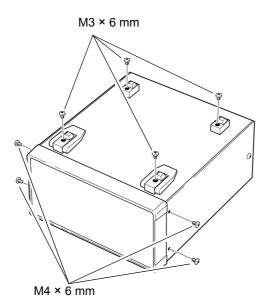






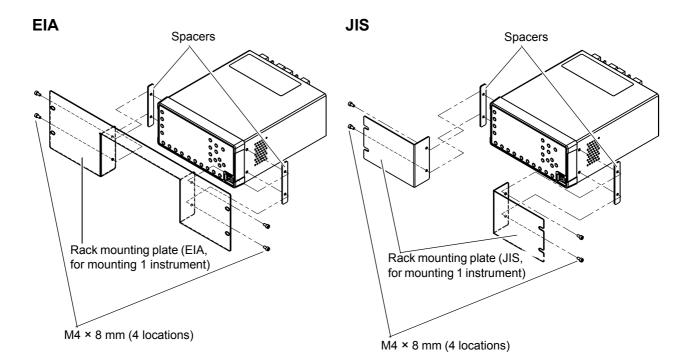
#### Installation procedure

**1** Remove the feet from the bottom of the instrument, and the screws from the sides (four near the front).



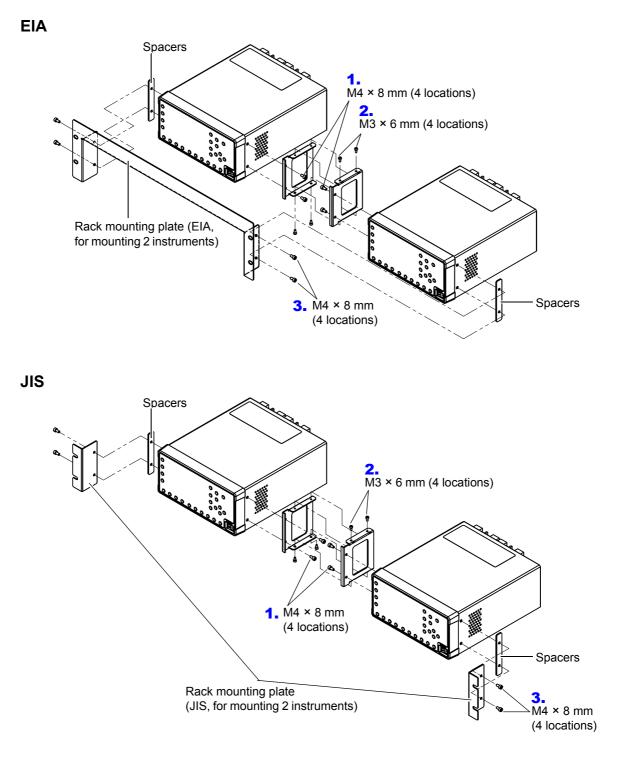
#### 2 1 instrument

Installing the spacers on both sides of the instrument, affix the rack mounting plate (for mounting 1 instrument) with the M4  $\times$  10 mm screws (4 locations).



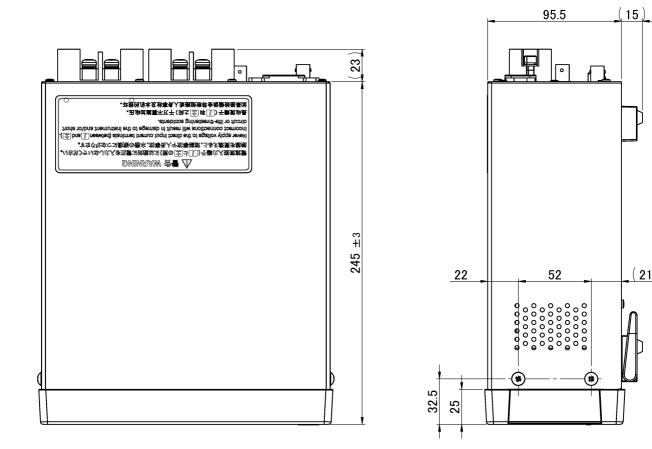
#### 2 2 instrument

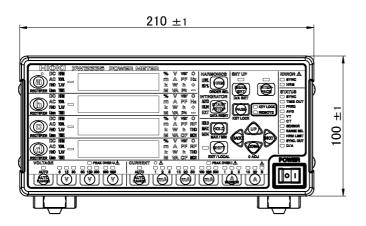
- 1. Attach rack mounting plates (same hardware for EIA/JIS, for mounting 2 instruments) to the inside sides of the two instruments that are to be connected together using M4 × 8 mm screws (4 locations).
- Connect the rack mounting plates attached in step (1) above using M3 × 6 mm screws (4 locations).
- **3.** Insert spacers on the outside sides of the two connected instruments and attach them to the rack mounting plate (for mounting 2 instruments) with M4 × 8 mm screws (4 locations).



# **Appendix 5 Dimensional Diagram**

Example: PW3335-04



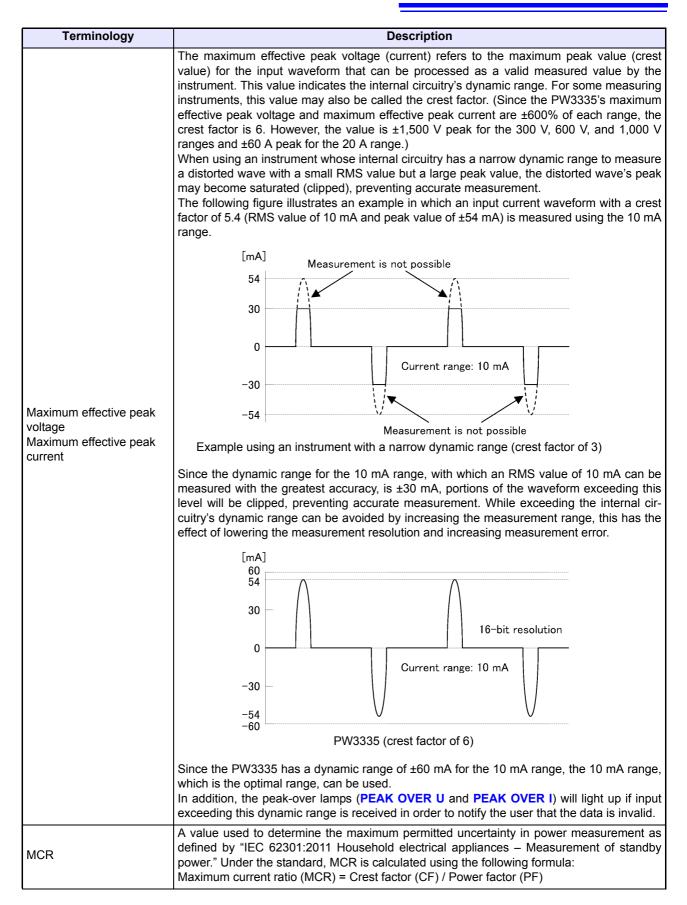


(Unit: mm)

(21.5)

# Appendix 6 Terminology

Terminology	Description
Creat factor	Crest factor, which is the ratio of the crest value (peak value) to the RMS value of the volt- age waveform or current waveform, and can be defined with the following expression. Crest factor = crest value (peak value)/RMS value
Crest factor	For a pure sine wave, the crest factor is 1.4142 ( $\sqrt{2}$ ). For pure DC current, it is 1. For measuring instruments such as power meters, the crest factor may also indicate the magnitude of the internal circuitry's dynamic range.
Effect of power factor	Error caused by the phase difference between voltage and current in the instrument's inter- nal circuitry. The effect of power factor affects active power measured values.
Harmonics HRM	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.
IEC61010	The International Electrotechnical Commission (IEC) has established IEC 61010 as a safety standard for measuring instruments. To ensure that measuring instruments can be used safely, this standard defines safety levels as a series of measurement categories (CAT II to CAT IV) based on the locations in which instruments are used. (p.4)
Instrument loss	Instrument loss, which is caused by the input resistance of power measuring instruments' voltage and current inputs, increases with the input voltage and input current as well as with certain connection methods, and this in turn causes the error component of measured values to increase.



Terminology	Description
RECTIFIER	For the PW3335, the rectifier refers to the rectification method. (p.42)
AC + DC	Displays true RMS values for DC only, AC only, or mixed DC and AC voltage and current. True RMS: The waveform including harmonic components is determined based on the RMS calculation formula.
AC + DC Umn	<ul> <li>Umn: Abbreviation for "voltage mean."</li> <li>Displays mean value rectified RMS equivalents for DC only, AC only, or mixed DC and AC voltage. Current values are displayed as RMS values.</li> <li>Mean value rectified RMS equivalents:</li> <li>The input waveform is treated as an undistorted sine wave (single frequency only). The AC signal mean is calculated, converted to an RMS value, and displayed. The measurement error increases when the waveform is distorted.</li> </ul>
FND	FND: Abbreviation for "fundamental." Extracts and displays the fundamental wave component only using harmonic measurement.
Ripple rate	The ratio of the AC component contained in a DC voltage or DC current to the DC component.
Total harmonic voltage distortion Total harmonic current distortion (THD)	THD: Abbreviation for "total harmonic distortion." There are two types of THD: 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: $\frac{\sqrt{\sum}(\text{from 2nd order})^2}{\text{fundamental wave}} \times 100[\%]$ (for the PW3335, calculation of up to the 50th order depending on the input frequency) This value can be monitored to assess waveform distortion for each item, providing a yard- stick that indicates the extent to which the total harmonic component is distorting the funda- mental waveform. THD-R: The ratio of the size of the total harmonic component to the size of RMS values, expressed as a percentage using the following equation: $\frac{\sqrt{\sum}(\text{from 2nd order})^2}{\text{RMS value}} \times 100[\%]$ (for the PW3335, calculation of up to the 50th order depending on the input frequency) THD-F is typically used. The PW3335 displays THD-F as THD. (THD-R is not available as a measurement parameter.)
Zero-cross filter	The PW3335 calculates parameters such as RMS values and active power based on one cycle of the synchronization source's input waveform (voltage U or current I). This cycle is obtained by detecting the zero-cross interval (the interval from one rising edge until the next cycle's rising edge). A filter used when it is not possible to accurately detect the zero-cross due to the effects of ringing or noise close to the input waveform's zero-cross point.
Zero-suppression	Functionality for treating values that are less than a certain threshold as zero.

# Index

# A

AC	
AC+DC	
AC+DC Umn	
Accuracy calculations	A 4
Additional integration	64
Auto-range	
Averaging	
AVG	

#### В

Backup function	34
Browser	34

# С

Cleaning	
Communications	
1:1	126
Default Gateway	
IP address	120
Subnet mask	120
Connection method selection	
Crest factor	A 10
СТ	
CT ratio	58
Current direct input	
Current ranges	43
Current sensor	

## D

Damage	167
DATA RESET	65
DC	42
Dedicated application	119
Dimensional diagram	A 9
Display hold	106
Display parameters	40, A 1
Disposing	168

## E

Effect of power factor	A 10
Error Indication	170
EXT.CONTROL	82
External control	62, 82

External CT	105
External current sensor input	. 38

## F

FND	A 12
FREQ	50
Frequency measurement range	50

# G

GP-IB	131
GP-IB address	133
GP-IB connector	132

### Н

Harmonic	.71, A 10
Harmonic analysis order	
High-speed level output	88
HOLD	106
HRM	A 10
HRM ERROR	

#### 

IEC61010	A 10
Instantaneous value	107
Instrument loss	A 10
Instrument loss calculation	30
Integrated value display format	70
Integration	61
Integration time	65

### K

KEY LOCK
----------

#### L

LAN	120
Level output	88
Local	137

## M

MAC address	124
Master	78
MAX/MIN	107
Maximum effective peak current	A 11

# Index **2**

Maximum effective peak voltage	A 11
Maximum value	107
MCR	A 11
Measurement items	A 1
Measurement workflow	20
Minimum value	107

# N

Number of averaging	 56

# 0

o.r	113
ORDER SEL	72

## Ρ

Power	3, 34
Power cord	33

# Q

Query error		131
-------------	--	-----

## R

Deals measurations	
Rack mounting	A 5
Range select function	
RECTIFIER	A 12
Rectifier	
Remote	137
Repair	167
Replaceable parts	167
Resetting integrated values	65
Ripple rate	A 12
RS-232C	127
RS-232C connector	18, 129

# S

Slave	
Solderless terminals	
Subnet mask	120
SYNC	
SYNC (ERROR)	50
Synchronization source	
Synchronized measurement	
System reset	110

## т

2
62
62
54
65
5

Total harmonic current distortion	A 12
Total harmonic voltage distortion	A 12
TYPE.1 current sensors	38
TYPE.2 current sensors	38

## U

Unit indicator flashes		11	4
------------------------	--	----	---

### V

Voltage ranges	
VT (PT)	
VT ratio	58

#### W

Waveform output	
-----------------	--

# Ζ

Zero-adjustment	
Zero-cross filter	50, A 12
Zero-suppression	23, 40, 45, 168, A 12

## Warranty Certificate

Model	Serial number	Warranty period Three (3) years from date of purchase ( / )
Customer name:		

Customer address:

#### Important

- Please retain this warranty certificate. Duplicates cannot be reissued.
- Complete the certificate with the model number, serial number, and date of purchase, along with your name and address. The personal information you provide on this form will only be used to provide repair service and information about Hioki products and services.

This document certifies that the product has been inspected and verified to conform to Hioki's standards. Please contact the place of purchase in the event of a malfunction and provide this document, in which case Hioki will repair or replace the product subject to the warranty terms described below.

#### Warranty terms

- The product is guaranteed to operate properly during the warranty period (three [3] years from the date of purchase).
   If the date of purchase is unknown, the warranty period is defined as three (3) years from the date (month and year) of manufacture (as indicated by the first four digits of the serial number in YYMM format).
- 2. If the product came with an AC adapter, the adapter is warrantied for one (1) year from the date of purchase.
- 3. The accuracy of measured values and other data generated by the product is guaranteed as described in the product specifications.
- 4. In the event that the product or AC adapter malfunctions during its respective warranty period due to a defect of workmanship or materials, Hioki will repair or replace the product or AC adapter free of charge.
- 5. The following malfunctions and issues are not covered by the warranty and as such are not subject to free repair or replacement:
  - -1. Malfunctions or damage of consumables, parts with a defined service life, etc.
  - -2. Malfunctions or damage of connectors, cables, etc.
  - -3. Malfunctions or damage caused by shipment, dropping, relocation, etc., after purchase of the product
  - -4. Malfunctions or damage caused by inappropriate handling that violates information found in the instruction manual or on precautionary labeling on the product itself
  - -5. Malfunctions or damage caused by a failure to perform maintenance or inspections as required by law or recommended in the instruction manual
  - -6. Malfunctions or damage caused by fire, storms or flooding, earthquakes, lightning, power anomalies (involving voltage, frequency, etc.), war or unrest, contamination with radiation, or other acts of God
  - -7. Damage that is limited to the product's appearance (cosmetic blemishes, deformation of enclosure shape, fading of color, etc.)
  - -8. Other malfunctions or damage for which Hioki is not responsible
- 6. The warranty will be considered invalidated in the following circumstances, in which case Hioki will be unable to perform service such as repair or calibration:
  - -1. If the product has been repaired or modified by a company, entity, or individual other than Hioki
  - -2. If the product has been embedded in another piece of equipment for use in a special application (aerospace, nuclear power, medical use, vehicle control, etc.) without Hioki's having received prior notice
- 7. If you experience a loss caused by use of the product and Hioki determines that it is responsible for the underlying issue, Hioki will provide compensation in an amount not to exceed the purchase price, with the following exceptions:
  - -1. Secondary damage arising from damage to a measured device or component that was caused by use of the product
  - -2. Damage arising from measurement results provided by the product
  - -3. Damage to a device other than the product that was sustained when connecting the device to the product (including via network connections)
- 8. Hioki reserves the right to decline to perform repair, calibration, or other service for products for which a certain amount of time has passed since their manufacture, products whose parts have been discontinued, and products that cannot be repaired due to unforeseen circumstances.

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