User's Manual

WT1800 Precision Power Analyzer Getting Started Guide

YOKOGAWA
Yokogawa Test & Measurement Corporation

IM WT1801-03EN
7th Edition

Product Registration

Thank you for purchasing YOKOGAWA products.

YOKOGAWA provides registered users with a variety of information and services.
Please allow us to serve you best by completing the product registration form accessible from our website.

http://tmi.yokogawa.com/

Thank you for purchasing the WT1800 Precision Power Analyzer. The WT1800 is an instrument capable of measuring parameters such as voltage, current, and power with high precision.
This getting started guide primarily explains the handling precautions and basic operations of the WT1800. To ensure correct use, please read this manual thoroughly before beginning operation.
Keep this manual in a safe place for quick reference in the event that a question arises.

List of Manuals

The following manuals, including this one, are provided as manuals for this instrument.
Please read all manuals.

Manual Title	Manual No.	Description
WT1800 Precision Power Analyzer Features Guide	IM WT1801-01EN	The supplied CD contains the PDF file of this manual. This manual explains all the WT1800 features other than the communication interface features.
WT1800 Precision Power Analyzer User's Manual	IM WT1801-02EN	The supplied CD contains the PDF file of this manual. The manual explains how to operate the WT1800.
WT1800 Precision Power Analyzer Getting Started Guide	IM WT1801-03EN	This manual. This guide explains the handling precautions and basic operations of the WT1800.
WT1800 Precision Power Analyzer Communication Interface User's Manual	IM WT1801-17EN	The supplied CD contains the PDF file of this manual. This manual explains the WT1800 communication interface features and how to use them.
Model WT1800 Precision Power Analyzer	IM WT1801-92Z1	Document for China

The "EN" and "Z1" in the manual numbers are the language codes.

Contact information of Yokogawa offices worldwide is provided on the following sheet.

Document No.	Description
PIM 113-01Z2	List of worldwide contacts

Notes

- The contents of this manual are subject to change without prior notice as a result of continuing improvements to the instrument's performance and functionality. The figures given in this manual may differ from those that actually appear on your screen.
- Every effort has been made in the preparation of this manual to ensure the accuracy of its contents. However, should you have any questions or find any errors, please contact your nearest YOKOGAWA dealer.
- Copying or reproducing all or any part of the contents of this manual without the permission of YOKOGAWA is strictly prohibited.
- The TCP/IP software of this product and the documents concerning it have been developed/created by YOKOGAWA based on the BSD Networking Software, Release 1 that has been licensed from the Regents of the University of California.

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Revisions

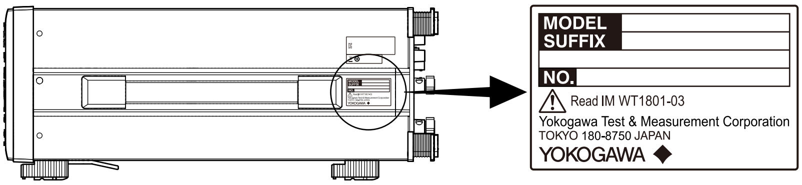
- 1st Edition: February 2011
- 2nd Edition: August 2011
- 3rd Edition: December 2011
- 4th Edition: December 2012
- 5th Edition: February 2014
- 6th Edition: December 2015
- 7th Edition: October 2017

Checking the Package Contents

Unpack the box, and check the contents before operating the instrument. If the wrong items have been delivered, if items are missing, or if there is a problem with the appearance of the items, contact your nearest YOKOGAWA dealer.

WT1800

Check that the product that you received is what you ordered by referring to the model name and suffix code given on the name plate on the left side panel.



Model	Suffix Code	Description					
WT1800 one input element model							
WT1801	-01	50A					
	-10	5A					
WT1800 two input element model							
WT1802	-02	50A	50A				
	-11	5A	50A				
	-20	5A	5A				
WT1800 three input element model							
WT1803	-03	50A	50A	50A			
	-12	5A	50A	50A			
	-21	5A	5A	50A			
	-30	5A	5A	5A			
WT1800 four input element model							
WT1804	-04	50A	50A	50A	50A		
	-13	5A	50A	50A	50A		
	-22	5A	5A	50A	50A		
	-31	5A	5A	5A	50A		
	-40	5A	5A	5A	5A		
WT1800 five input element model							
WT1805	-05	50A	50A	50A	50A	50A	
	-14	5A	50A	50A	50A	50A	
	-23	5A	5A	50A	50A	50A	
	-32	5A	5A	5A	50A	50A	
	-41	5A	5A	5A	5A	50A	
	-50	5A	5A	5A	5A	5A	
WT1800 six input element model							
WT1806	-06	50A	50A	50A	50A	50A	50A
	-15	5A	50A	50A	50A	50A	50A
	-24	5A	5A	50A	50A	50A	50A
	-33	5A	5A	5A	50A	50A	50A
	-42	5A	5A	5A	5A	50A	50A
	-51	5A	5A	5A	5A	5A	50A
	-60	5A	5A	5A	5A	5A	5A

Model	Suffix Code	Description
Power cord[1]	-D	UL/CSA standard power cord (part no.: A1006WD) [Maximum rated voltage: 125 V]
	-F	VDE standard power cord (part no.: A1009WD) [Maximum rated voltage: 250 V]
	-R	AS standard power cord (part no.: A1024WD) [Maximum rated voltage: 250 V]
	-Q	BS standard power cord (part no.: A1054WD) [Maximum rated voltage: 250 V]
	-H	GB standard power cord (part no.: A1064WD) [Maximum rated voltage: 250 V]
	-N	NBR standard power cord (Part No.: A1088WD) [Maximum rated voltage: 250 V]
Language	-HE	English menu
	-HC	Chinese/English menu[2]
	-HG	German/English menu[2]
	-HR	Russian/English menu[7]
Options	/EX1	External current sensor input (for the WT1801)
	/EX2	External current sensor input (for the WT1802)
	/EX3	External current sensor input (for the WT1803)
	/EX4	External current sensor input (for the WT1804)
	/EX5	External current sensor input (for the WT1805)
	/EX6	External current sensor input (for the WT1806)
	/B5	Built-in printer[3]
	/G5	Harmonic measurement[4]
	/G6	Simultaneous dual harmonic measurement[4]
	/DT	Delta computation
	/FQ	Add-on frequency measurement
	/V1	RGB output
	/DA	20-channel D/A output[5]
	/MTR	Motor evaluation function[6]
	/AUX	Auxiliary input[6]
	/HS	High speed data capturing[2]
	/EC	EC Package
	/US	US Package

1 Make sure that the attached power cord meets the designated standards of the country and area that you are using it in.
2 This features covers firmware versions 2.01 or later of the WT1800.
3 Includes two rolls of paper (B9316FX)
4 The /G5 and /G6 options cannot be installed on the same instrument.
5 One 36-pin connector (A1005JD) is installed in the instrument.
6 The /MTR and /AUX options cannot be installed on the same instrument.
7 This features covers firmware versions 2.11 or later of the WT1800.

For products whose suffix code contains “Z,” an exclusive manual may be included. Please read it along with the standard manual.

No. (Instrument number)

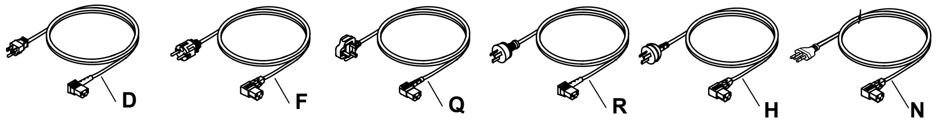
When contacting the dealer from which you purchased the instrument, please tell them the instrument number.

Accessories

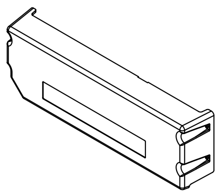
The instrument is shipped with the following accessories. Make sure that all accessories are present and undamaged.

Power cord (one of the following power cords is supplied according to the instrument's suffix codes)[4]

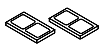
UL/CSA standard A1006WD **VDE standard A1009WD** **BS standard A1054WD** **AS standard A1024WD** **GB standard A1064WD** **NBR Standard A1088WD**



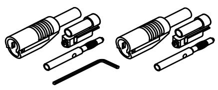
Current input protection cover B8211BX



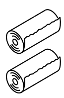
Rubber stoppers A9088ZM



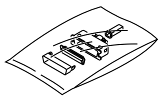
Safety terminal adapter set[1] 758931



Printer roll paper[2] B9316FX

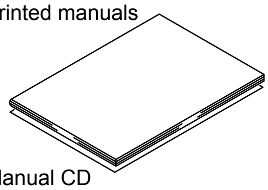


36-pin connector[3] A1005JD

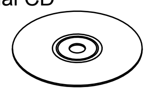


Manuals[5]

- Printed manuals



- Manual CD



1. Same number of sets as the number of installed input elements
   WT1801: One set with one hexagonal socket wrench
   WT1802: Two sets with one hexagonal socket wrench
   WT1803: Three sets with one hexagonal socket wrench
   WT1804: Four sets with one hexagonal socket wrench
   WT1805: Five sets with one hexagonal socket wrench
   WT1806: Six sets with one hexagonal socket wrench
   For instructions on how to assemble the 758931, see section 2.6.
2. Included with models that have a built-in printer (/B5)
3. Included with models that have 20-channel D/A output and remote control (/DA)
4. Make sure that the attached power cord meets the designated standards of the country and area that you are using it in.
5. Manuals

Name	Model/Part No.	Quantity	Note
Printed manuals	IM WT1801-03EN	1	Getting Started Guide (this guide)
	IM WT1801-92Z1	1	Document for China
	PIM 113-01Z2	1	List of worldwide contacts
Manual CD	B8211ZZ	1	For details, see the next page.

How to Use the CD (User's Manuals)

The CD contains PDF files of the following manuals. The CD also contains Japanese manuals.

- WT1800 Precision Power Analyzer Features Guide
  IM WT1801-01EN
- WT1800 Precision Power Analyzer User's Manual
  IM WT1801-02EN
- WT1800 Precision Power Analyzer Communication Interface User's Manual
  IM WT1801-17EN

To view the manuals above, you need Adobe Reader.

WARNING

Never play this manual CD, which contains the user's manuals, in an audio CD player.
Doing so may cause loss of hearing or speaker damage due to the large sounds that may be produced.

Optional Accessories (Sold separately)

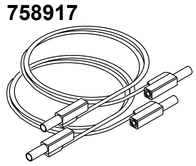
The following optional accessories are available for purchase separately. Use the accessories specified in this manual. Moreover, use the accessories of this product only with Yokogawa products that specify them as accessories.
For information about ordering accessories, contact your nearest YOKOGAWA dealer.

Name	Model/ Part No.	Min. Q'ty	Notes
Measurement lead	758917	1	Two leads in one set. Used with the 758922 or 758929 adapter (sold separately). Cable length: 0.75 m. Rated voltage: 1000 V.*
Safety terminal adapter set	758923	1	Two pieces in one set. Rated voltage 600 V.*
	758931	1	Two pieces in one set. Rated voltage 1000 V.*
Alligator clip adapter set	758922	1	Two pieces in one set. For use with measurement lead 758917. Rated voltage: 300 V.*
	758929	1	Two pieces in one set. For use with measurement lead 758917. Rated voltage: 1000 V.*
Fork terminal adapter set	758921	1	Two pieces in one set. For use with measurement lead 758917. Rated voltage: 1000 V. Rated current: 25 A.*
BNC cable	366924	1	42 V or less. Total length: 1 m.
	366925	1	42 V or less. Total length: 2 m.
External sensor cable	B9284LK	1	For connecting to the WT1800's external current sensor input connector. Cable length: 0.5 m.
Conversion adapter	758924	1	BNC-4 mm socket adapter. Rated voltage: 500 V.*

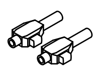
These optional accessories are sold individually.

* The actual voltage that can be used is the lowest voltage of the WT1800 and cable specifications.

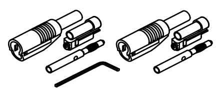
Measurement leads
758917



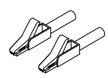
Safety terminal adapter set
758923



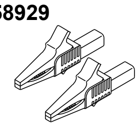
Safety terminal adapter set
758931



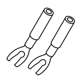
Alligator clip adapter set
758922



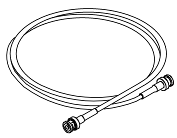
Alligator clip adapter set
758929



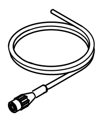
Fork terminal adapter set
758921



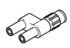
BNC cable
366924 (1 m)
366925 (2 m)



External sensor cable
B9284LK



Conversion adapter
758924



Consumables (Sold separately)

The following consumables are available for purchase separately.
For information about ordering consumables, contact your nearest YOKOGAWA dealer.

Name	Part No.	Min. Q'ty	Notes
Printer roll paper	B9316FX	10	Heat-sensitive paper. One roll is one unit. Length: 10 m.

Safety Precautions

This instrument is an IEC safety class I instrument (provided with a terminal for protective earth grounding).
The general safety precautions described herein must be observed during all phases of operation. If the instrument is used in a manner not specified in this manual, the protection provided by the instrument may be impaired. YOKOGAWA assumes no liability for the customer's failure to comply with these requirements.

The following Symbols Are Used on This Instrument.


Warning: handle with care. Refer to the user's manual or service manual. This symbol appears on dangerous locations on the instrument which require special instructions for proper handling or use. The same symbol appears in the corresponding place in the manual to identify those instructions.


Electric shock, danger


Protective earth ground or protective earth ground terminal


Ground or the functional ground terminal (do not use as the protective earth ground terminal)


Alternating current


Both direct and alternating current

On (power)


Off (power)


In-position of a bi-stable push control


Out-position of a bi-stable push control

Failure to comply with the precautions below could lead to injury or death or damage to the instrument.

WARNING

Use the Instrument Only for Its Intended Purpose
This instrument is a power measurement instrument that can measure parameters such as voltage, current, and power. Do not use this instrument for anything other than as a power measurement instrument.

Check the Physical Appearance
Do not use the instrument if there is a problem with its physical appearance.

Use the Correct Power Supply
Before connecting the power cord, ensure that the source voltage matches the rated supply voltage of the instrument and that it is within the maximum rated voltage of the provided power cord.

Use the Correct Power Cord and Plug
To prevent the possibility of electric shock or fire, be sure to use the power cord supplied by YOKOGAWA. The main power plug must be plugged into an outlet with a protective earth terminal. Do not invalidate this protection by using an extension cord without protective earth grounding. Also, do not use the power cord that came with the instrument on any other device.

Connect the Protective Ground Terminal
Make sure to connect the protective earth to prevent electric shock before turning on the power. The power cord that comes with the instrument is a three-prong type power cord. Connect the power cord to a properly grounded three-prong outlet.

Do Not Impair the Protective Grounding
Never cut off the internal or external protective earth wire or disconnect the wiring of the protective earth terminal. Doing so may result in electric shock or damage to the instrument.

Do Not Operate with Defective Protective Grounding or Fuse
Do not operate the instrument if the protective earth or fuse might be defective. Check the grounding and the fuse before operating the instrument.

Do Not Operate in an Explosive Atmosphere
Do not operate the instrument in the presence of flammable gasses or vapors. Doing so is extremely dangerous.

Fuse
To have the instrument's fuse replaced, contact your nearest YOKOGAWA dealer.

Do Not Remove the Covers or Disassemble or Alter the Instrument
Only qualified YOKOGAWA personnel may remove the covers and disassemble or alter the instrument. The inside of the instrument is dangerous because parts of it have high voltages.

Ground the Instrument before Making External Connections
Securely connect the protective grounding before connecting to the item under measurement or to an external control unit. Before touching a circuit, turn off its power and check that it has no voltage.

Measurement Category

The measurement category of the instrument is II. Do not use it for measurement category III or IV measurements.

Measurement category Other (O) applies to measurement of circuits that are not directly connected to a main power supply.
This category applies to measurement of secondary electric circuits in equipment across a transformer.
Measurement category II applies to measurement of circuits, such as household electric appliances and portable electric tools, that are connected to low-voltage installations.
Measurement category III applies to measurement of facility circuits, such as distribution boards and circuit breakers.
Measurement category IV applies to measurement of power source circuits, such as entrance cables to buildings and cable systems, for low-voltage installations.

Install or Use the Instrument in Appropriate Locations

- This instrument is designed to be used indoors. Do not install or use it outdoors.
- Install the instrument so that you can immediately remove the power cord if an abnormal or dangerous condition occurs.

Connect Cables Correctly

This instrument can measure large voltages and currents directly. If you use a voltage transformer or a current transformer together with this power meter, you can measure even larger voltages or currents. When you are measuring a large voltage or current, the power capacity of the item under measurement becomes large. If you do not connect the cables correctly, an overvoltage or overcurrent may be generated in the circuit under measurement. This may lead to not only damage to the instrument and the item under measurement, but electric shock and fire as well. Be careful when you connect the cables, and be sure to check the following points.

Before you begin measuring (before you turn the item under measurement on), check that:

- Cables have been connected to the terminals of this instrument correctly.
  Check that there are no voltage measurement cables that have been connected to the current input terminals.
  Check that there are no current measurement cables that have been connected to the voltage input terminals.
  If you are measuring multiphase power, check that there are no mistakes in the phase wiring.
- Cables have been connected to the power supply and the item under measurement correctly.
  Check that there are no short circuits between terminals or between connected cables.
- The cables are connected firmly to the current input terminals.
- There are no problems with the current input terminals and the crimping terminals, such as the presence of foreign substances.

During measurement (never touch the terminals and the connected cables when the item under measurement is on), check that:

- There no problems with the input terminals and the crimping terminals, such as the presence of foreign substances.
- The input terminals are not abnormally hot.
- The cables are connected firmly to the input terminals.
  The terminal connections may become loose over time. If this happens, heat may be generated due to changes in contact resistance. If you are going to take measurements using the same setup for a long time, periodically check that the cables are firmly connected to the terminals. (Be sure to turn both the power meter and the item under measurement off before you check the connections.)

After measuring (immediately after you turn the item under measurement off):

After you measure a large voltage or current, power may remain for some time in the item under measurement even after you turn it off. This remaining power may lead to electric shock, so do not touch the input terminals immediately after you turn the item under measurement off. The amount of time that power remains in the item under measurement varies depending on the item.

Accessories

Use the accessories specified in this manual. Moreover, use the accessories of this product only with Yokogawa products that specify them as accessories.
Do not use faulty accessories.

CAUTION

Operating Environment Limitations

This product is a Class A (for industrial environments) product. Operation of this product in a residential area may cause radio interference in which case the user will be required to correct the interference.

Sales in Each Country or Region

Waste Electrical and Electronic Equipment

Waste Electrical and Electronic Equipment (WEEE), Directive
(This directive is valid only in the EU.)
This product complies with the WEEE directive marking requirement. This marking indicates that you must not discard this electrical/electronic product in domestic household waste.

Product Category
With reference to the equipment types in the WEEE directive, this product is classified as a "Monitoring and control instruments" product.

When disposing of products in the EU, contact your local Yokogawa Europe B.V. office.
Do not dispose in domestic household waste.

EU Battery Directive

EU Battery Directive
(This directive is valid only in the EU.)
Batteries are included in this product. This marking indicates they shall be sorted out and collected as ordained in the EU battery directive.

Battery type: Lithium battery

You cannot replace batteries by yourself. When you need to replace batteries, contact your local Yokogawa Europe B.V. office.

Authorized Representative in the EEA

Yokogawa Europe B.V. is the authorized representative of Yokogawa Test & Measurement Corporation for this product in the EEA. To contact Yokogawa Europe B.V., see the separate list of worldwide contacts, PIM 113-01Z2.

Symbols and Notation Used in This Manual

Unit

k: Denotes 1000. Example: 100 kHz
K: Denotes 1024. Example: 720 KB (file size)

Displayed Characters

Bold characters in procedural explanations are used to indicate panel keys and soft keys that are used in the procedure and menu items that appear on the screen.

Notes and Cautions

The notes and cautions in this manual are categorized using the following symbols.

Improper handling or use can lead to injury to the user or damage to the instrument. This symbol appears on the instrument to indicate that the user must refer to the user’s manual for special instructions. The same symbol appears in the corresponding place in the user’s manual to identify those instructions. In the manual, the symbol is used in conjunction with the word “WARNING” or “CAUTION.”

WARNING Calls attention to actions or conditions that could cause serious or fatal injury to the user, and precautions that can be taken to prevent such occurrences.

CAUTION Calls attention to actions or conditions that could cause light injury to the user or damage to the instrument or user’s data, and precautions that can be taken to prevent such occurrences.

Note Calls attention to information that is important for proper operation of the instrument.

Workflow

The figure below is provided to familiarize the first-time user with the workflow of WT1800 operation. For a description of an item, see the relevant section or chapter. In addition to the sections and chapters that are referenced in the figure below, this manual also contains safety precautions for handling and wiring the instrument. Be sure to observe the precautions.

Installation and Circuit Wiring

	Getting Started Guide
Install the WT1800.	Section 2.2
Connect the power supply, and turn the power on.	Sections 2.3 and 2.4
Select the measurement method.	Section 2.8
Wire the circuit under measurement.	Sections 2.9 to 2.11

Read the precautions in sections 2.5 and 2.7 thoroughly before connecting the wires. Also, if necessary, assemble the input terminal adapter that connects to the voltage input terminal (see section 2.6) before connecting the wires.

Common Operations

	Getting Started Guide
Perform key operations.	Sections 3.1 to 3.4
Synchronize the clock.	Section 3.5
Initialize settings.	Section 3.6
Display help.	Section 3.7

Set the Measurement Conditions

	User's Manual
Basic measurement conditions	Chapter 1
Harmonic measurement conditions (option)	Chapter 2
Motor evaluation conditions (option)	Chapter 3
Auxiliary input conditions (option)	Chapter 4

Display Measured/Computed Results

	User's Manual
Measured power value and computations	Chapters 6 and 7
Integrated power (watt hour)	Chapter 8
Voltage/current waveforms	Chapter 9
Trends	Chapter 10
Harmonic measurements (option), bar graphs, vectors	Chapters 11 and 12
Cursor measurement	Chapter 14

Acquire Data

	User's Manual
Store data to the internal RAM disk.	Chapter 15
Save data to a USB memory device.	Chapters 16 and 17
Print data (option).	Chapter 18
Transmit data using D/A output (option).	Section 20.6
Transmit data through the USB, GP-IB, or Ethernet interface.	Chapter 19 and the communication interface user's manual

Contents

Chapter 6 Specifications

Appendix

1.1 Front Panel, Rear Panel, and Top Panel

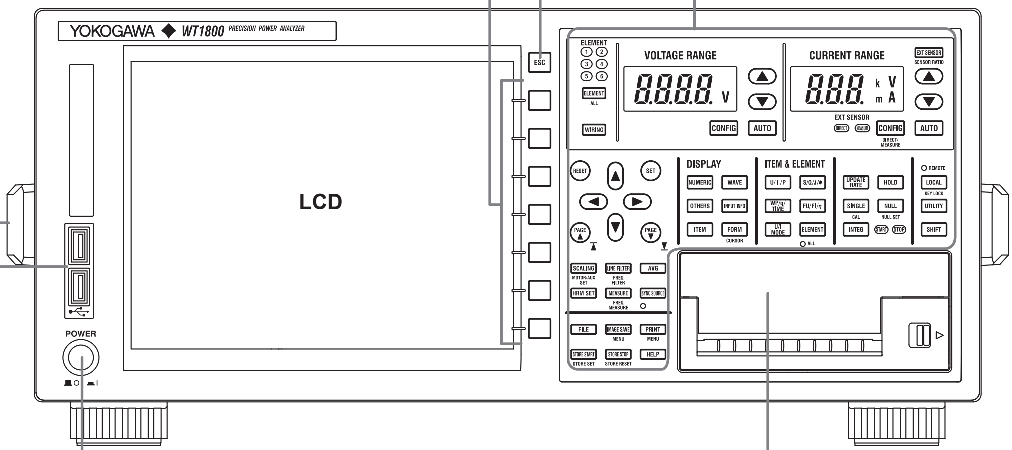
Front Panel

Soft keys
Use to select items on the soft key menus that appear during configuration.

ESC key
Use to clear soft key menus and pop-up menus.

Handle

Setup and execution keys
Explanation → section 1.2



Power switch

Built-in printer (option)
Use to print screen images and numeric data.

USB ports for peripherals
Use to connect a USB keyboard, mouse, or memory device.
Usage explanation → section 3.3 and the user's manual

Rear Panel

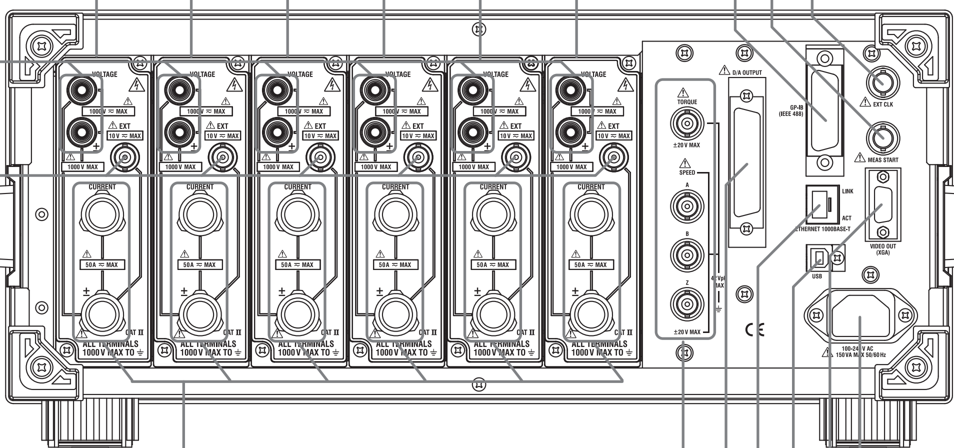
GP-IB connector
Use to communicate with the WT1800 through the GP-IB interface.
Explanation of the communication feature → communication interface user's manual

External start signal I/O connector ⚠
- Use to perform master and slave synchronized measurement.→ section 4.4
- RReceives the external sync signal during high speed data capturing. → section 4.4

Voltage input terminals ⚠
For connecting voltage measurement cables.
→ sections 2.8 to 2.11

External clock input connector ⚠
- Receives the synchronization source (signal), which determines the measurement period. → section 4.3
- Receives the external PLL source (signal) for harmonic measurement. → section 4.3

Input element 1
Input element 2
Input element 3
Input element 4
Input element 5
Input element 6



Current input terminals ⚠
For connecting current measurement cables. → sections 2.8, 2.9, and 2.11

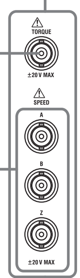
Power inlet ⚠
Power connection → section 2.3

External current sensor input connector ⚠
For connecting cables from an external current sensor.
→ section 2.10

RGB (XGA) output connector (option) ⚠
Transmits image signals. → section 4.5

Model with the motor evaluation function (option)

Torque signal input connector (option) ⚠
Receives signals from a torque meter during motor evaluation.
→ section 4.1



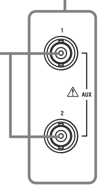
USB port for PCs
Use to connect the WT1800 to a PC that has a USB port.
Usage explanation → communication interface user's manual

Revolution signal input connectors (option) ⚠
Receive signals from a revolution sensor during motor evaluation. → section 4.1

Ethernet port
Use to connect the WT1800 to a LAN.
Usage explanation → Features guide and communication interface user's manual

Model with the auxiliary input option

Auxiliary input connectors (option) ⚠
Receive signals from sensors. → section 4.2

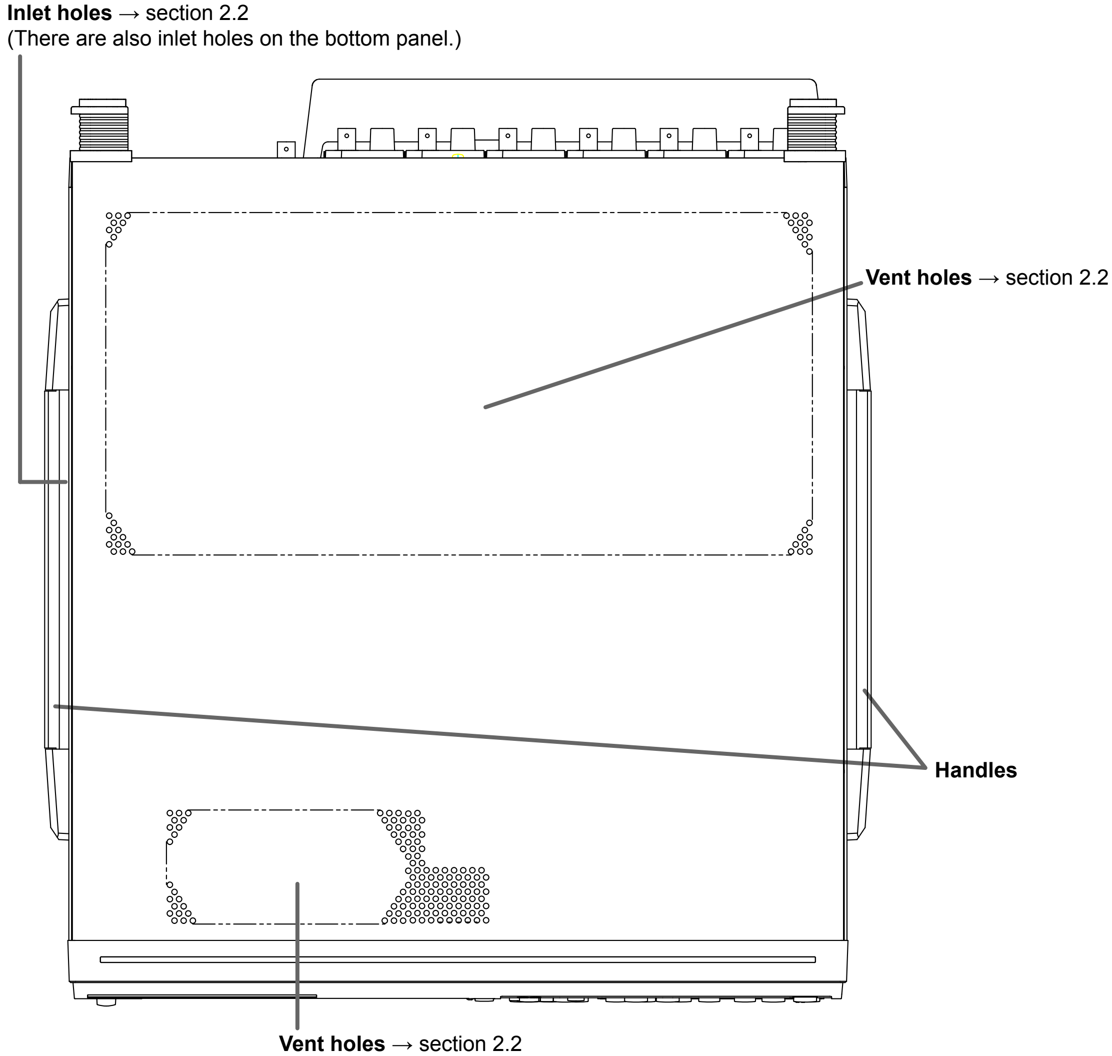


D/A output and remote control connector (option) ⚠

D/A output
Transmits DC voltage (an analog signal) that corresponds to the numeric data.
→ section 4.6

Remote control
Receives control signals for holding values; performing single measurements; starting, stopping, and resetting integration; and printing. → section 4.6

Top Panel


Inlet holes → section 2.2
(There are also inlet holes on the bottom panel.)
Vent holes → section 2.2
Handles
Vent holes → section 2.2

1.2 Keys

Measurement Conditions

WIRING Key

Press this key to display the menu for selecting the wiring system, setting the efficiency equation, selecting the independent input element configuration, and setting the delta computation (option).

ELEMENT Key

- Press this key to select the input element that you want to select the measurement range for. The selected input element changes each time that you press ELEMENT.
- When you select the wiring system, input elements that are assigned to the same wiring unit are selected at the same time.

SHIFT+ELEMENT (ALL) Key Combination

Press this key combination to collectively set the voltage range, current range, or external current sensor range (option) of all the input elements that satisfy the following conditions.

- The input elements are the same type (5 A or 50 A input elements).
- The valid measurement range settings are the same.

Press ELEMENT again to configure settings for individual elements.

▲ and ▼ Keys

Use these keys to select the voltage range, current range, or external current sensor range (option). The ranges selected with these keys are valid when the AUTO key described below is not illuminated (when the fixed range feature is being used).

AUTO Key

Press AUTO to activate the auto range feature. When this feature is active, the AUTO key illuminates. The auto range feature automatically sets the voltage, current, and external current sensor ranges depending on the amplitude of the received electrical signal. Press AUTO again to activate the fixed range feature. The AUTO key turns off.

EXT SENSOR Key

Press EXT SENSOR to illuminate the EXT SENSOR key. While the WT1800 is in this state, press the current range's ▲ and ▼ keys to select the external current sensor range that is used when the WT1800 measures the output from the current sensor. Press EXT SENSOR again to turn off the EXT SENSOR key and enable the selecting of the current range for direct input.

SHIFT+EXT SENSOR (SENSOR RATIO) Key Combination

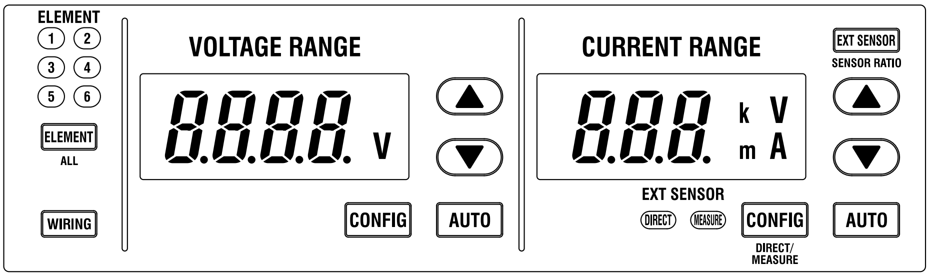
Press this key combination to display a menu for setting the external current sensor conversion ratio for each input element. These conversion ratios are used to convert current sensor output to current.

CONFIG Key

Press this key to display a menu for setting the valid measurement ranges for the voltage range, current range, or external current sensor range (option). You can also set the measurement range to switch to when a peak over-range occurs.

SHIFT+CONFIG (DIRECT/MEASURE) Key Combination

Press this key combination to display a menu for setting the display format of the external current sensor range.



SCALING Key

Press this key to display a menu for setting the VT and CT ratios or the power coefficient for each input element. These ratios and the coefficient are used to convert the VT/CT output or the power derived from measuring the VT and CT outputs to the real voltage, current, and power of the item under measurement.

LINE FILTER Key

Press this key to display a menu for setting the filters to apply to the circuit under measurement for each input element.

SHIFT+LINE FILTER (FREQ FILTER) Key Combination

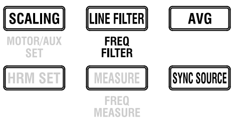
Press this key combination to display a menu for setting the filters to apply to the circuit under frequency measurement for each input element.

AVG Key

Press this key to display a menu for configuring the measured value averaging feature.

SYNC SOURCE Key

Press this key to display a menu for setting the synchronization source for each wiring unit. The synchronization source defines the period (measurement period) over which sampled data, which is used to produce numeric data (measured values such as voltage, current, and power), is acquired.



UPDATE RATE Key

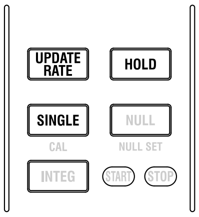
Press this key to display a menu for selecting the period (data update interval) at which sampled data, which is used to produce numeric data (measured values such as voltage, current, and power), is acquired.

HOLD Key

Press HOLD to illuminate the HOLD key, stop data measurement and display operations per data update interval, and hold the numeric data display. Press HOLD again to turn the HOLD key off and enable the updating of the numeric data display.

SINGLE Key

While the numeric data is held, press SINGLE to measure data only once at the set data update interval and then hold the numeric data.



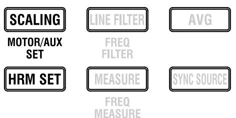
Harmonic Measurement (Option), Motor Evaluation (Option), and Auxiliary Input (Option)

HRM SET Key

- Press this key on models with the harmonic measurement option to display a menu for setting the PLL source, the measured harmonic orders, and the distortion factor equation.
- Press this key on models with the simultaneous dual harmonic measurement option to display a menu for configuring the input element groups and setting the PLL source, the measured harmonic orders, and the distortion factor equation for each group.

SHIFT+SCALING (MOTOR/AUX SET) Key Combination

- Press this key combination on models with the motor evaluation function (option) to display a menu for configuring the motor evaluation function.
- Press this key combination on models with the auxiliary input option to display a menu for configuring the auxiliary input feature.



Displaying the Measured Results

NUMERIC Key

Press this key to display numeric data.

- When you are displaying numeric data, you can press ITEM, which is described later in this section, to display a menu for changing the displayed items.
- When you are displaying numeric data, you can press FORM, which is described later in this section, to display a menu for changing the display format.

WAVE Key

Press this key to display waveforms.

- When you are displaying waveforms, you can press ITEM, which is described later in this section, to display a menu for selecting and zooming in on the displayed waveforms.
- When you are displaying waveforms, you can press FORM, which is described later in this section, to display a menu for configuring settings such as the time axis of the displayed waveforms, the triggers for displaying waveforms on the screen, the number of divisions of the waveform screen, and the mapping of waveforms to parts of the divided screen.

OTHERS Key

Press this key to display a menu for selecting the trend, bar graph,[1] vector,[1] split displays and high speed data capturing.[2]

1 On models with the harmonic measurement option or simultaneous dual harmonic measurement option

2 On models with the high speed data capturing option

INPUT INFO Key

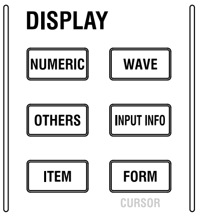
Press this key to display the list of conditions for measuring voltage or current signals, such as the wiring system, wiring unit, measurement range, input filter, scaling, and synchronization source, for each input element. A list of the measurement range and valid measurement range settings are also displayed.

ITEM Key

Press this key to display a menu for setting the displayed items in the display that has been selected using NUMERIC, WAVE, or OTHERS.

FORM Key

Press this key to display a menu for selecting the display format for the display that has been selected using NUMERIC, WAVE, or OTHERS.



U/I/P Key, S/Q/λ/Φ Key, WP/q/TIME Key, and FU/FI/η Key

Each time you press U/I/P, the measurement function of the selected display item switches between measurement functions in the following order: U, I, P, the measurement function that was selected before you pressed U/I/P, and then back to U. The numeric data for the selected measurement function is displayed.

- The above behavior takes place when numeric data is being displayed but a menu is not being displayed.
- Only the measurement function changes.
- When you press S/Q/λ/Φ, WP/q/TIME, or FU/FI/η, the measurement function changes in the same manner as was explained above for the U/I/P key.

U/I MODE Key

Each time you press U/I MODE, the measurement function U or I of the selected display item switches between modes in the following order: rms, mean, dc, rmean, ac, and then back to rms. The numeric data for the selected measurement function is displayed. The above behavior takes place when numeric data is being displayed but a menu is not being displayed.

ELEMENT Key

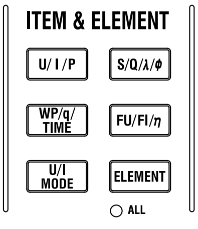
On WT1800s that have six input elements installed, each time you press ELEMENT, the input element or wiring unit of the selected display item switches between input elements and wiring units in the following order: 1, 2, 3, 4, 5, 6, ΣA, ΣB, ΣC, and then back to 1. The numeric data for the selected input element or wiring unit is displayed.

- The above behavior takes place when numeric data is being displayed but a menu is not being displayed.
- Only the input element or wiring unit changes.
- The displayed input elements and wiring units vary depending on the number of input elements that are installed in the WT1800 and the selected wiring system.

SHIFT+ELEMENT (ALL) Key Combination

On WT1800s that have six input elements installed, pressing SHIFT+ELEMENT (ALL) illuminates the ALL indicator. With the WT1800 in this state, each time you press ELEMENT, the input elements or wiring units of the displayed page switch between input elements and wiring units in the following order: 1, 2, 3, 4, 5, 6, ΣA, ΣB, ΣC, and then back to 1. The numeric data for the selected input element or wiring unit is displayed. Press SHIFT+ELEMENT (ALL) again to turn the ALL indicator off and disable the feature for changing all the input elements or wiring units on the page.

- The above behavior takes place when numeric data is being displayed but a menu is not being displayed.
- Only the input elements or wiring units change.
- The displayed input elements and wiring units vary depending on the number of input elements that are installed in the WT1800 and the selected wiring system.



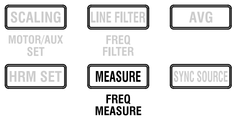
Computation

MEASURE Key

Press this key to display a menu for configuring settings for user-defined functions, MAX hold, user-defined events, apparent and reactive power equations, corrected power equations, for selecting the phase difference display format and the sampling frequency, and for configuring settings for master and slave synchronized measurement.

SHIFT+MEASURE (FREQ MEASURE) Key Combination

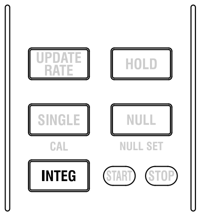
Press this key combination to display a menu for setting the item under frequency measurement. However, on models with the add-on frequency measurement option, the frequencies of the voltages or currents of all elements can be measured, so this menu is not displayed.



Integrated Power (Watt hour)

INTEG Key

Press this key to display a menu for turning independent integration on and off; starting, stopping, and resetting integration; and setting the integration mode, the integration timer, the scheduled integration, the integration auto calibration, the watt-hour integration methods for each polarity, the current mode for current integration, and the rated time of integrated D/A output (option).

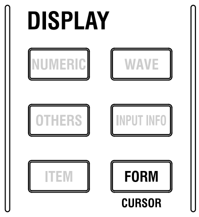


Cursor Measurement

SHIFT+FORM (CURSOR) Key Combination

Press this key combination when you are displaying waveforms, trends, or bar graphs* to display a menu for measuring values such as waveform and graph values using cursors.

* On models with the harmonic measurement option or simultaneous dual harmonic measurement option



Storing Data, Saving and Loading Data, Printing on the Built-In Printer (Option)

STORE START Key

Press this key to start the storage operation.

STORE STOP Key

Press this key to stop the storage operation.

SHIFT+STORE STOP (STORE RESET) Key Combination

Press this key combination to reset the storage operation.

SHIFT+STORE START (STORE SET) Key Operation

Press this key combination to display a menu for setting storage control, stored items, and save conditions.

FILE Key

Press this key to display a menu for performing operations such as saving and loading setup parameters, saving measured data, deleting and copying folders (directories) and files, renaming folders and files, and making folders.

IMAGE SAVE Key

Press this key to save the screen image data.

SHIFT+IMAGE SAVE (MENU) Key Combination

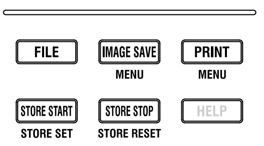
Press this key combination to display a menu for setting screen image data save options such as the file name, data format, color mode, and comments.

PRINT Key

Press this key to print the screen image or the list of numeric data.

SHIFT+PRINT MENU Key Combination

Press this key combination to display a menu for performing print-related tasks such as setting the print format, the comment, and auto-printing, and feeding paper.



Other Functions

SHIFT+SINGLE (CAL) Key Combination

Press this key combination to execute zero-level compensation. When zero level compensation is executed, the WT1800 creates a zero input condition in its internal circuitry and sets the zero level to the level at that point.

NULL Key

Press NULL to enable the NULL feature. The NULL indicator illuminates. Press NULL again to disable the NULL feature. The NULL indicator turns off.

SHIFT+NULL (NULL SET) Key Combination

Press this key combination to display a menu for setting the NULL feature.

UTILITY Key

Press this key to display a menu for displaying system information (input element information, installed options, and firmware version); initializing settings; configuring communication settings, system settings, network settings, D/A output settings; and performing self-tests.

LOCAL Key

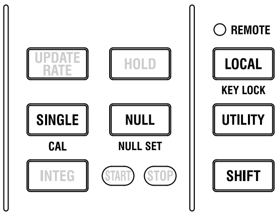
Press this key to switch from remote mode (in which the REMOTE indicator is illuminated) to local mode (in which front panel key operations are valid). This key is disabled when the WT1800 is in local lockout mode.

SHIFT+LOCAL (KEY LOCK) Key Combination

Press this key combination to lock the keys on the front panel. The LOCAL (KEY LOCK) key illuminates. Press the key combination again to unlock the keys.

SHIFT Key

Press this key once to illuminate it and access the features that are written in purple below each key. Press the key again to disable the shifted state.



RESET Key

Press this key to reset the entered value to its default value.

SET Key

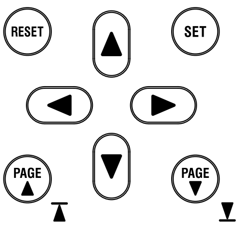
Press this key to display menus that you select using the cursor keys and to confirm items and values in the selected window. When the menu is turned off on the numeric data display, press this key to open a menu for changing displayed items.

Cursor Keys (▲▼◀▶)

Press the ▶◀ keys to move the cursor between numeric digits. Press the ▲▼ keys to increment or decrement the value of a digit. You can also use the ▲▼ keys to select setup items.

PAGE▼ and PAGE▲ Keys

When measured items span over multiple pages on the numeric data display, press these keys to switch between pages. Press SHIFT+PAGE▲ to move to the first page and SHIFT+PAGE▼ to move to the last page.

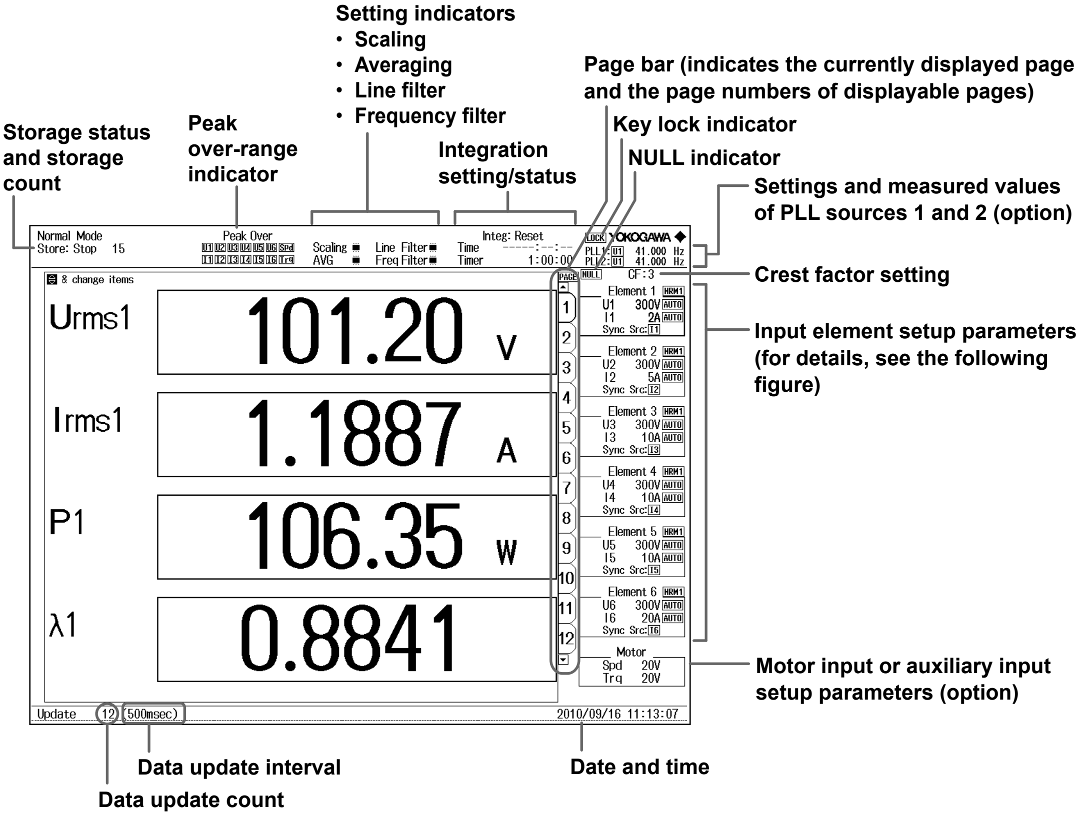


HELP Key

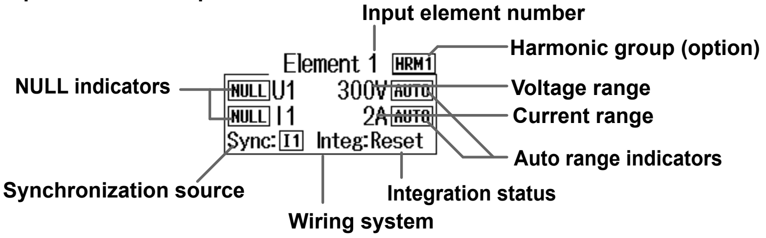
Press this key to display and hide the help window, which explains various features.

1.3 Screen Display

Display Example When Measuring Power (Numeric display)



Input Element Setup Parameters



Non-Numeric Displays

--OL-- **Overload**
Displayed if the measured value exceeds 140% of the measurement range.

--OF-- **Overflow**
Displayed if the measured or computed result cannot be displayed using the specified decimal place or unit.

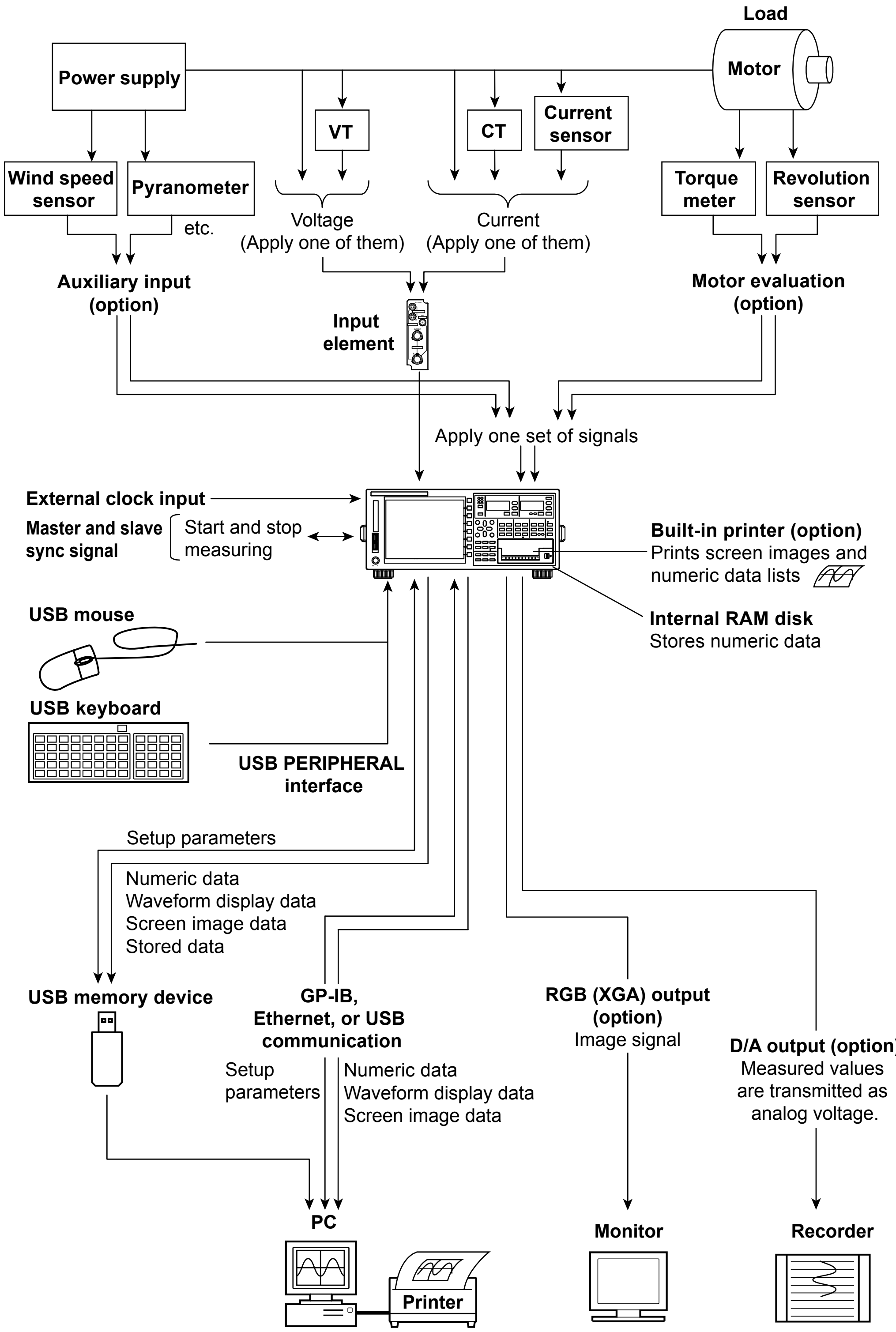
------- **No data**
Displayed if a measurement function is not selected or if there is no numeric data.

Error **Error**
Displayed in cases such as when a measured value is outside of its determined range.

Note

The WT1800 LCD may have a few defective pixels. For details, see section 6.2, "Display."

1.4 System Configuration



2.1 Handling Precautions

Safety Precautions

If you are using this instrument for the first time, make sure to read “Safety Precautions” on pages ix to xi.

Do Not Remove the Case

Do not remove the case from the instrument. Some parts of the instrument use high voltages and are extremely dangerous. For internal inspection and adjustment, contact your nearest YOKOGAWA dealer.

Unplug If Abnormal Behavior Occurs

If you notice smoke or unusual odors coming from the instrument, immediately turn off the power and unplug the power cord. Also, turn off the power to any circuits under measurement that are connected to the input terminals. Then, contact your nearest YOKOGAWA dealer.

Do Not Damage the Power Cord

Nothing should be placed on top of the power cord. The power cord should also be kept away from any heat sources. When unplugging the power cord from the outlet, never pull by the cord itself. Be sure to hold and pull by the plug. If the power cord is damaged, purchase a replacement with the same part number as the one indicated on page v.

General Handling Precautions

Do Not Place Objects on Top of the Instrument

Never stack the instrument or place other instruments or any objects containing water on top of it. Doing so may cause the instrument to malfunction.

Keep Electrically Charged Objects Away from the Instrument

Keep electrically charged objects away from the input terminals. They may damage the internal circuitry.

Do Not Damage the LCD

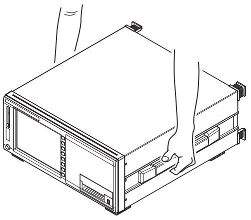
Because it is very easy to damage the LCD, do not allow any sharp objects near it. Also, the LCD should not be exposed to vibration or mechanical shock.

During Extended Periods of Non-Use

Turn off the power to the circuit under measurement and the instrument and remove the power cord from the outlet.

When Carrying the Instrument

First, turn off the circuit under measurement and remove the measurement cables. Then, turn off the instrument and remove the power cord and any attached cables. As indicated in the following figure, use both hands to firmly hold the handles when carrying the instrument. In addition, if storage media is inserted in the instrument, be sure to remove the storage media before you move the instrument.



WARNING

- Do not install the instrument outdoors or in locations subject to rain or water.
- Install the instrument so that you can immediately remove the power cord if an abnormal or dangerous condition occurs.

When Cleaning the Instrument

When cleaning the case or the operation panel, turn off the circuit under measurement and the instrument and remove the instrument's power cord from the outlet. Then, wipe the instrument lightly with a clean dry cloth. Do not use chemicals such as benzene or thinner. Doing so may cause discoloring and deformation.

2.2 Installing the Instrument

WARNING

- This instrument is designed to be used indoors. Do not install or use it outdoors.
- Install the instrument so that you can immediately remove the power cord if an abnormal or dangerous condition occurs.

CAUTION

If you block the inlet or outlet holes on this instrument, this instrument will become hot and may break down.

Installation Conditions

Install the instrument in an indoors environment that meets the following conditions.

Flat and Level Location

Install the instrument on a stable surface that is level in all directions. If you install the instrument on an unstable or tilted surface, the quality of recordings made by its printer and the accuracy of its measurements may be impeded.

Well-Ventilated Location

Inlet and vent holes are located on the top and bottom of the instrument. To prevent internal overheating, allow at least 20 mm of space around the inlet and vent holes.

When connecting measurement wires and other various cables and when opening and closing the cover of the built-in printer, allow extra space for operation.

Ambient Temperature and Humidity

Ambient temperature:	5°C to 40°C
Ambient humidity:	20% RH to 80% RH (when the printer is not being used)
	35% RH to 80% RH (when the printer is being used)
	In either case, there must be no condensation.

Do Not Install the Instrument in the Following Kinds of Places

- Outdoors
- In direct sunlight, or near sources of heat
- Where the instrument is exposed to water or other liquids
- In an environment with excessive amounts of soot, steam, dust, or corrosive gases
- Near strong magnetic fields
- Near high voltage equipment or power lines
- In a place that is subject to large levels of mechanical vibration
- On an unstable surface

Note

- For the most accurate measurements, use the instrument in the following kind of environment.
  Ambient temperature: 23°C ± 5°C Ambient humidity: 30% RH to 75% RH (no condensation)
  When using the instrument in a place where the ambient temperature is 5°C to 18°C or 28°C to 40°C, add the temperature coefficient to the accuracy as specified in chapter 6.
- When installing the instrument in a place where the ambient humidity is 30% or less, take measures to prevent static electricity such as using an anti-static mat.
- Condensation may form when the instrument is moved from a low temperature/humidity environment to a high temperature/humidity environment, or when there is a sudden change in temperature. In these kinds of circumstances, wait for at least an hour before using the instrument, to acclimate it to the surrounding temperature.

Storage Location

- Ambient temperature: -25 to 60°C (no condensation)
- Ambient humidity: 20 to 80% RH (no condensation)

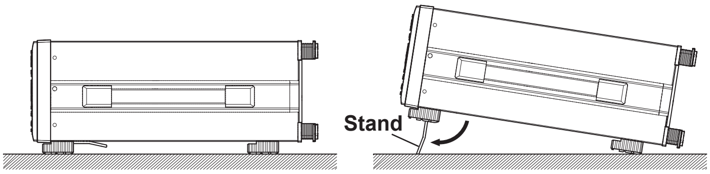
When storing the instrument, avoid the following places.
- Where the level of mechanical vibration is high
- In direct sunlight
- Where there are corrosive or explosive gasses
- Where an excessive amount of soot, dust, salt, or iron is present
- Near a strong source of heat or moisture
- Where water, oil, or chemicals may splash onto the instrument

We recommend that the instrument be stored in an environment where the temperature is between 5°C and 40°C.

Installation Position

Desktop

Place the instrument on a flat, level surface as shown in the figure below.



Rubber Stoppers

If the instrument is installed so that it is flat as shown in the above figure, rubber stoppers can be attached to the feet to prevent the instrument from sliding. Two sets of rubber stoppers (four stoppers) are included in the package.

WARNING

- When you put away the stand, be careful not to get your hand caught between the stand and the instrument.
- Handling the stand without firmly supporting the instrument can be dangerous. Please take the following precautions.
  - Only handle the stand when the instrument is on a stable surface.
  - Do not handle the stand when the instrument is tilted.
- Do not place the instrument in any position other than those shown in the above figures.

CAUTION

Do not apply excessive force or shock to the stand. Doing so may break the stand support.

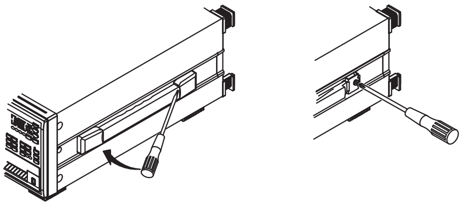
Rack Mounting

To mount the instrument on a rack, use a rack mount kit (sold separately).

Name	Model	Notes
Rack mount kit	751535-E4	For EIA
Rack mount kit	751535-J4	For JIS

A summary of the procedure for mounting the instrument on a rack is given below. For detailed instructions, see the manual that is included with the rack mount kit.

1. Remove the handles from both sides of the instrument.



2. Remove the four feet from the bottom of the instrument.
3. Remove the two plastic rivets and the four seals covering the rack mount attachment holes on each side of the instrument near the front.
4. Place seals over the feet and handle attachment holes.
5. Attach the rack mount kit to the instrument.
6. Mount the instrument on a rack.

Note

- When mounting the instrument on a rack, allow at least 20 mm of space around the inlet and vent holes to prevent internal heating.
- Make sure to provide adequate support from the bottom of the instrument. The support should not block the inlet and vent holes.

2.3 Connecting the Power Supply

Before Connecting the Power Supply

To prevent electric shock and damage to the instrument, follow the warnings below.

WARNING

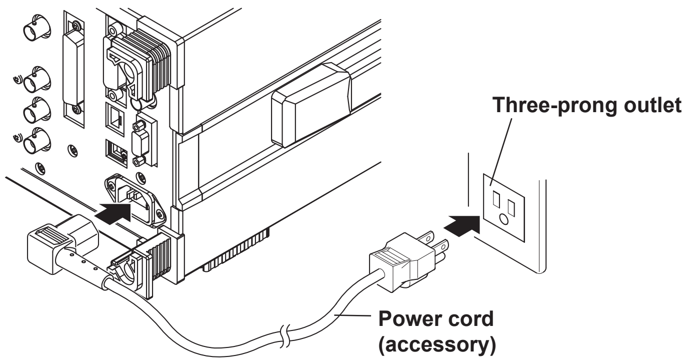
- Make sure that the power supply voltage matches the instrument’s rated supply voltage and that it does not exceed the maximum voltage range specified for the power cord.
- Confirm that the instrument’s power switch is off before you connect the power cord.
- To prevent fire and electric shock, only use a power cord supplied by YOKOGAWA.
- To avoid electric shock, be sure to ground the instrument. Connect the power cord to a three-prong power outlet with a protective earth terminal.
- Do not use an ungrounded extension cord. Doing so renders the protective features of the instrument ineffective.
- Use an outlet that complies with the power cord provided and securely connect the protective grounding. If such an outlet is unavailable and protective grounding cannot be furnished, do not use the instrument.

Connecting the Power Cord

1. Confirm that the instrument’s power switch is off.
2. Connect the instrument’s power cord to the power inlet on the rear panel.
3. Connect the other end of the cord to an outlet that meets the conditions below. Use a three-prong power outlet with a protective earth terminal.

Item	Specifications
Rated supply voltage	100 VAC to 120 VAC, 200 VAC to 240 VAC
Permitted supply voltage range	90 VAC to 132 VAC, 180 VAC to 264 VAC
Rated supply frequency	50/60 Hz
Permitted supply frequency range	48 Hz to 63 Hz
Maximum power consumption (when the printer is being used)	150 VA

* The instrument can use a 100 V or a 200 V power supply. The maximum voltage rating differs according to the type of power cord. Before you use the instrument, check that the voltage supplied to it is less than or equal to the maximum rated voltage of the power cord provided with it (see page v for the maximum voltage rating).



2.4 Turning the Power Switch On and Off

Before Turning On the Power, Check That:

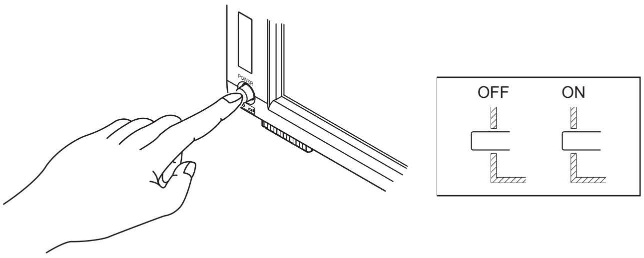
- The instrument is installed properly. → section 2.2, "Installing the Instrument"
- The power cord is connected properly. → section 2.3, "Connecting the Power Supply"

Power Switch Location

The power switch is located in the lower left of the front panel.

Turning the Power Switch On and Off

The power switch is a push button. Press the button once to turn the instrument on and press it again to turn the instrument off.



Operations Performed When the Power Is Turned On

When the power is turned on, a self-test starts automatically. When the self-test completes successfully, the screen that was displayed immediately before the power was turned off appears. Before using the instrument, check that the self-test completes successfully.

When the Power-on Operation Does Not Finish Normally

Turn off the power switch, and check the following items.

- Check that the power cord is securely connected.
- Check that the correct voltage is coming to the power outlet. → Page 2-6
- Initialize the settings to their factory defaults by turning on the power switch while holding down the RESET key.

If the instrument still does not work properly, contact your nearest YOKOGAWA dealer for repairs.

Note

- After turning the power off, wait at least 10 seconds before you turn it on again.
- If the instrument does not operate as described above when the power is turned on, turn the power off, and then check that:
  - The power cord is securely connected.
  - The correct voltage is coming to the power outlet. → see section 2.3, "Connecting the Power Supply"
  - After checking the above, try turning on the power while holding down RESET to initialize the settings (reset them to their factory defaults). For details about initializing the settings, see section 3.6, "Initializing Settings."
- If the instrument still does not work properly, contact your nearest YOKOGAWA dealer for repairs.
- It may take a few seconds for the startup screen to appear.

To Make Accurate Measurements

- After turning on the power, wait at least 30 minutes to allow the instrument to warm up.
- After the instrument warms up, execute zero-level compensation. → see the user's manual

Operations Performed When the Power Is Turned Off

After the power is turned off, the instrument stores the setup parameters in its memory before shutting down. The same is true when the power cord is disconnected from the outlet. The next time the power is turned on, the instrument powers up using the stored setup parameters.

Note

The instrument stores the settings using an internal lithium battery. When the lithium battery voltage falls below a specified value, you will no longer be able to store setup parameters, and a message (error 901) will appear on the screen when you turn on the power. If this message appears frequently, you need to replace the battery soon. Do not try to replace the battery yourself. Contact your nearest YOKOGAWA dealer to have the battery replaced.

2.5 Precautions When Wiring the Circuit under Measurement

To prevent electric shock and damage to the instrument, follow the warnings below.

WARNING

- Ground the instrument before connecting measurement cables. The power cord that comes with the instrument is a three-prong cord. Insert the power cord into a grounded three-prong outlet.
- Turn the circuit under measurement off before connecting and disconnecting cables to it. Connecting or removing measurement cables while the power is on is dangerous.
- Do not wire a current circuit to the voltage input terminal or a voltage circuit to the current input terminal.
- Strip the insulation covers of measurement cables so that when they are wired to the input terminals, the conductive parts (bare wires) do not protrude from the terminals. Also, make sure to fasten the input terminal screws securely so that cables do not come loose.
- When connecting measurement cables to the voltage input terminals, only connect measurement cables that have safety terminals that cover their conductive parts. Using a terminal with bare conductive parts (such as a banana plug) can be dangerous if the terminal comes loose.
- When connecting cables to the external current sensor input terminals, only connect cables that have safety terminals that cover their conductive parts. Using a connector with bare conductive parts can be dangerous if the terminal comes loose.
- When the voltage of the circuit under measurement is being applied to the current input terminals, do not touch the external current sensor input terminals. Doing so is dangerous because the terminals are electrically connected inside the instrument.
- When connecting a measurement cable from an external current sensor to an external current sensor input connector, remove the cables connected to the current input terminals. Also, when the voltage of the circuit under measurement is being applied to the external current sensor input terminals, do not touch the current input terminals. Doing so is dangerous because the terminals are electrically connected inside the instrument.
- When using an external voltage transformer (VT) or current transformer (CT), make sure that it has enough dielectric strength for the voltage (U) being measured (2U + 1000 V recommended). Also, make sure that the secondary side of the CT does not become an open circuit while the power is being applied. If this happens, high voltage will appear at the secondary side of the CT, making it extremely dangerous.
- When using an external current sensor, make sure to use a sensor that comes in a case. The conductive parts and the case should be insulated, and the sensor should have enough dielectric strength for the voltage of the circuit under measurement. Using a bare sensor is dangerous, because there is a high probability that you might accidentally touch it.
- When using a shunt-type current sensor as an external current sensor, turn off the circuit under measurement before you connect the sensor. Connecting or removing the sensor while the power is on is dangerous.
- When using a clamp-type current sensor as an external current sensor, make sure that you understand the voltage of the circuit under measurement and the specifications and handling of the clamp-type sensor, and then confirm that there are no dangers, such as shock hazards.
- For safety reasons, when using the instrument after mounting it on a rack, furnish a switch for turning off the circuit under measurement from the front side of the rack.
- For safety reasons, after you connect the measurement cables, use the included screws to attach the current input protection cover (screw tightening torque: 0.6 N•m). Make sure that the conductive parts do not protrude from the protection cover.

- To make the protective features effective, before applying the voltage or current from the circuit under measurement, check that:
  - The power cord provided with the instrument is being used to connect to the power supply and that the instrument is grounded.
  - The instrument is turned on.
  - The current input protection cover provided with the instrument is attached.
- When the instrument is turned on, do not apply a signal that exceeds the following values to the voltage or current input terminals. When the instrument is turned off, turn the circuit under measurement off. For information about other input terminals, see the specifications in chapter 6.

Instantaneous maximum allowable input (within 20 ms)

Voltage input

Peak value of 4 kV or rms value of 2 kV, whichever is less.

Current input

Direct input

5 A input elements
Peak value of 30 A or rms value of 15 A, whichever is less.
50 A input elements
Peak value of 450 A or rms value of 300 A, whichever is less.

External current sensor input

Peak value less than or equal to 10 times the range.

Instantaneous maximum allowable input (1 s or less)

Voltage input

Peak value of 3 kV or rms value of 1.5 kV, whichever is less.

Current input

Direct input

5 A input elements
Peak value of 10 A or rms value of 7 A, whichever is less.
50 A input elements
Peak value of 150 A or rms value of 55 A, whichever is less.

External current sensor input

Peak value less than or equal to 10 times the range.

Continuous maximum allowable input

Voltage input

Peak value of 2 kV or rms value of 1.1 kV, whichever is less.

Current input

Direct input

5 A input elements
Peak value of 10 A or rms value of 7 A, whichever is less.
50 A input elements
Peak value of 150 A or rms value of 55 A, whichever is less.

External current sensor input

Peak value less than or equal to 5 times the range.

CAUTION

- Use measurement cables with dielectric strengths and current capacities that are appropriate for the voltage or current being measured.
  Example: When making measurements on a current of 20 A, use copper wires that have a conductive cross-sectional area of 4 mm^2 or greater.
- The act of connecting measuring cables may cause radio interference, in which case users will be required to correct the interference.

Note

- If you are measuring large currents or voltages or currents that contain high frequency components, take special care in dealing with mutual interference and noise when you wire the cables.
- Keep measurement cables as short as possible to minimize the loss between the circuit under measurement and the instrument.
- The thick lines on the wiring diagrams shown in sections 2.9 to 2.11 are the parts where the current flows. Use wires that are suitable for the current levels.
- To make accurate measurements of the voltage of the circuit under measurement, connect the measurement cable that is connected to the voltage input terminal to the circuit as closely as possible.
- To make accurate measurements, separate the measurement cables as far away from the ground wires and the instrument’s case as possible to minimize static capacitance to the ground.
- To measure the apparent power and power factor more accurately on an unbalanced three-phase circuit, we recommend that you use a three-voltage, three-current method with a three-phase, three-wire system (3P3W; 3V3A).

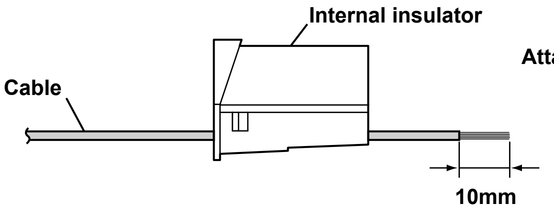
2.6 Assembling the Adapters for the Voltage Input Terminals

Assembling the 758931 Safety Terminal Adapter

When connecting a measurement cable to a WT1800 voltage input terminal, use the included 758931 Safety Terminal Adapter or the 758923 Safety Terminal Adapter (sold separately). When using the 758931 Safety Terminal Adapter, assemble it according to the following procedure.

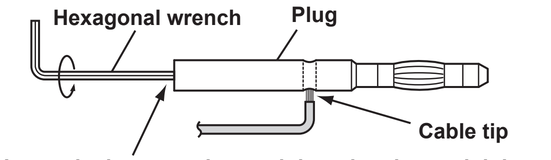
Assembling the Safety Terminal Adapter

1. Remove approximately 10 mm of the covering from the end of the cable and pass the cable through the internal insulator.

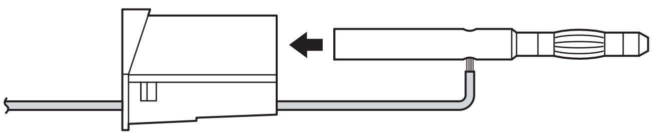


Attachable cable
Covering: max. diameter 3.9 mm
Core wire: max. diameter 1.8 mm

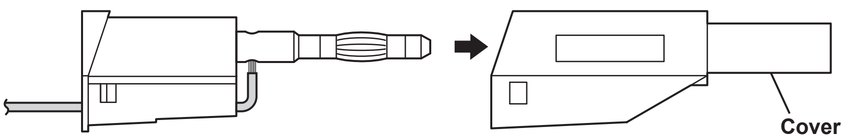
2. Insert the tip of the cable into the plug. Fasten the cable in place using the hexagonal wrench.



3. Insert the plug into the internal insulator.



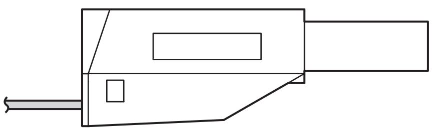
4. Attach the external cover. Make sure that the cover does not come off.



Note

Once you attach the cover, it is difficult to disassemble the safety terminal adapter. Use care when attaching the cover.

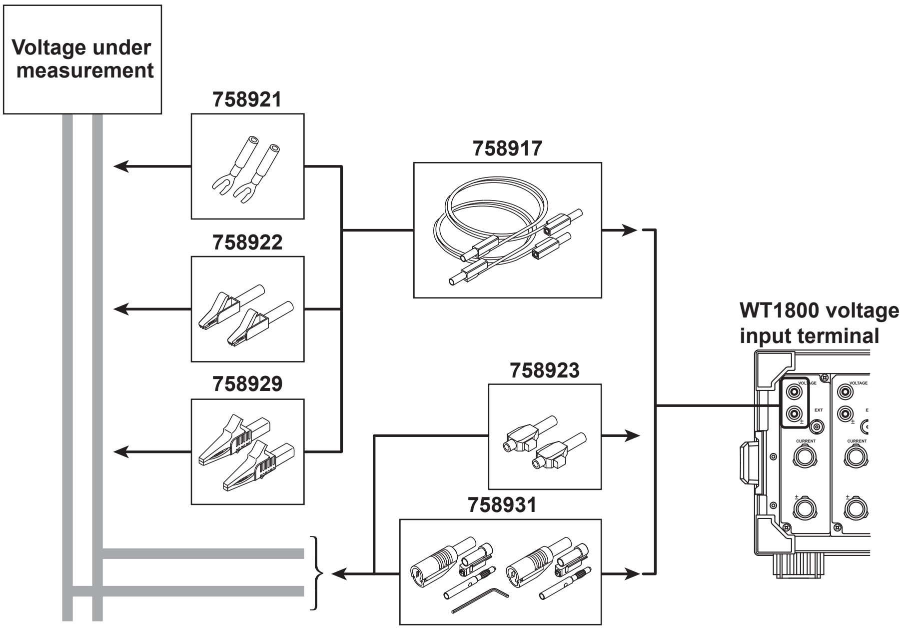
Below is an illustration of the adapter after it has been assembled.



Explanation

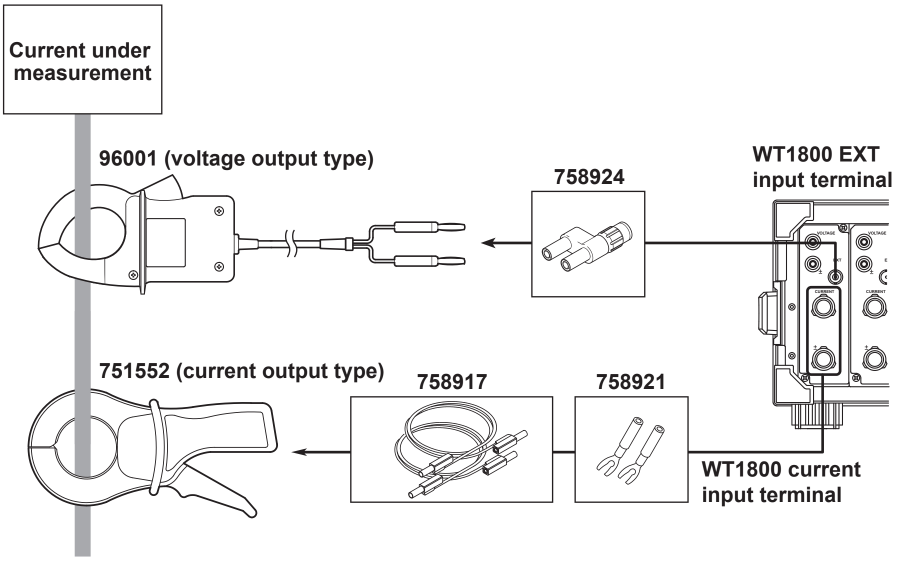
Wire the adapters that come with the WT1800 or the adapters and various sensors that are sold separately as shown below:

Wiring When Measuring Voltage



Use the clamp-on probes (sold separately) as shown below.

Wiring When Measuring Current



Connecting a clamp-on probe

*** The current input terminal and EXT input terminal cannot be wired (used) simultaneously.**

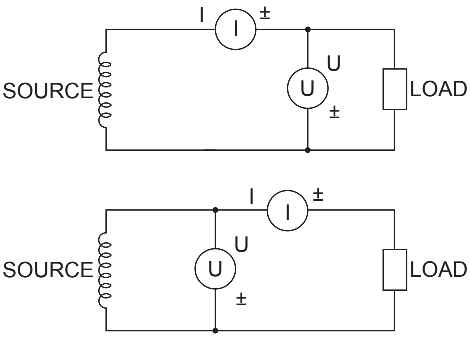
2.7 Wiring for Accurate Measurements

When you are wiring a single-phase device, there are the four patterns of terminal wiring positions shown in the following figures for wiring the voltage input and current input terminals. Depending on the terminal wiring positions, the effects of stray capacitance and the effects of the measured voltage and current amplitudes may become large. To make accurate measurements, refer to the items below when wiring the voltage input and current input terminals.

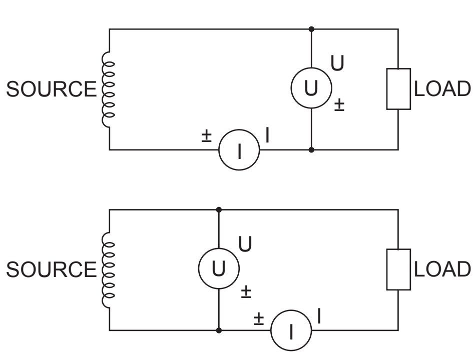
Effects of Stray Capacitance

When measuring a single-phase device, the effects of stray capacitance on measurement accuracy can be minimized by connecting the instrument's current input terminal to the side that is closest to the earth potential of the power supply (SOURCE).

- **Easily affected**

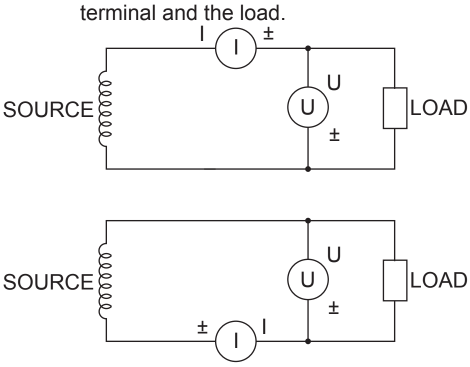


- **Not easily affected**

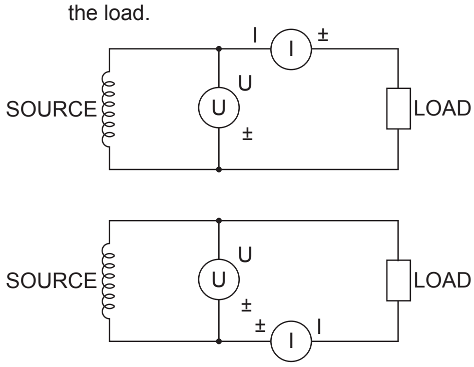


Effects of the Measured Voltage and Current Amplitudes

- **When the measured current is relatively large**
  Connect the voltage measurement terminal between the current measurement terminal and the load.



- **When the measured current is relatively small**
  Connect the current measurement terminal between the voltage measurement terminal and the load.



Explanation

For details on the effects of stray capacitance and the effects of the measured voltage and current amplitudes, see appendix 3, "How to Make Accurate Measurements."

2.8 Guide for Selecting the Method Used to Measure the Power

Select the measurement method from the table below according to the amplitude of the measured voltage or current. For details about a wiring method, see its corresponding section (indicated in the table).

Voltage Measurement Methods

		When the Voltage Is 1000 V or Less	When the Voltage Exceeds 1000 V
Voltage wiring	Direct input	→ Section 2.9	Direct input is not possible.
	VT (voltage transformer)	→ Section 2.11	

Current Measurement Methods

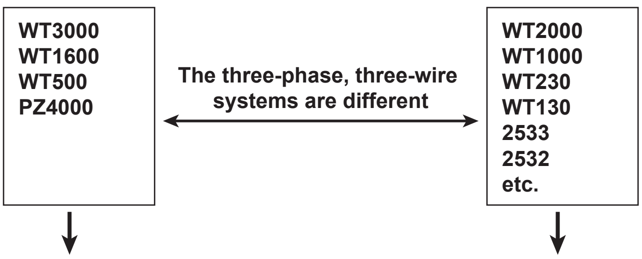
		When the Voltage Is 1000 V or Less		When the Voltage Exceeds 1000 V
Input element	50 A	When the Current Is 50 A or Less	When the Current Exceeds 50 A	
	5 A	When the Current Is 5 A or Less	When the Current Exceeds 5 A	
Current wiring	Direct input	→ Section 2.9*	Direct input is not possible.	
	Shunt-type current sensor	→ Section 2.10**		Shunt-type current sensors cannot be used.
	Clamp-type current sensor (voltage output type)	→ Section 2.10		
	Clamp-type current sensor (current output type)	→ Section 2.11		
	CT (current transformer)	→ Section 2.11		

* With /EX1 to /EX6 option
Voltage: 1000 V or less (maximum allowable voltage that can be measured)
600 V or less (rating voltage of EN61010-2-030)
Do not touch the inside of the external current sensor input BNC connector.
Without /EX1 to /EX6 option
Voltage: 1000 V or less

** The voltage is less than or equal to 600 V.

Notes when Replacing Other Power Meters with the WT1800

In three-phase, three-wire systems (3P3W) and three-phase, three-wire systems that use a three-voltage, three-current method (3P3W; 3V3A), the wiring system of the WT1800 may be different from that of another product (another digital power meter) depending on whether the reference voltage used to measure the line voltage (see appendix 2 for details) is based on single-phase or three-phase power. To make accurate measurements, see the referenced sections in the selection guide above and check the wiring method of the corresponding three-phase, three-wire system.



You can change from another digital power meter to the WT1800 without making changes to the three-phase, three-wire systems.

When you change from another digital power meter to the WT1800, you have to make changes to the three-phase, three-wire systems.

For example, if you replace the WT1000 (used in a three-phase, three-wire system) with the WT1800 and leave the wiring unchanged, the measured power of each element will be different between the WT1000 and the WT1800. Refer to this manual and re-wire the system correctly.

2.9 Wiring the Circuit under Measurement for Direct Input

This section explains how to wire the measurement cable directly from the circuit under measurement to the voltage or current input terminal.
To prevent electric shock and damage to the instrument, follow the warnings given in section 2.5, “Precautions When Wiring the Circuit under Measurement.”

Connecting to the Input Terminal

Voltage Input Terminal

The terminals are safety banana jacks (female) that are 4 mm in diameter.
Only insert a safety terminal whose conductive parts are not exposed into a voltage input terminal.
If you are using the included 758931 Safety Terminal Adapter, see section 2.6.

Current Input Terminal

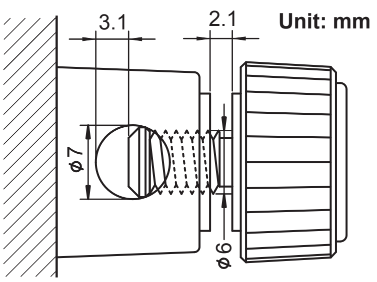
The terminal is a binding post, and the screws are M6. Either wind the wire around the screw or pass the crimping terminal through the screw axis, and then tighten firmly with the terminal knob.

WARNING

- When the voltage of the circuit under measurement is being applied to the current input terminals, do not touch the external current sensor input terminals. Doing so is dangerous because the terminals are electrically connected inside the instrument.
- When connecting a measurement cable from an external current sensor to an external current sensor input terminal, remove the cables connected to the current input terminals. Also, when the voltage of the circuit under measurement is being applied to the external current sensor input terminals, do not touch the current input terminals. Doing so is dangerous because the terminals are electrically connected inside the instrument.

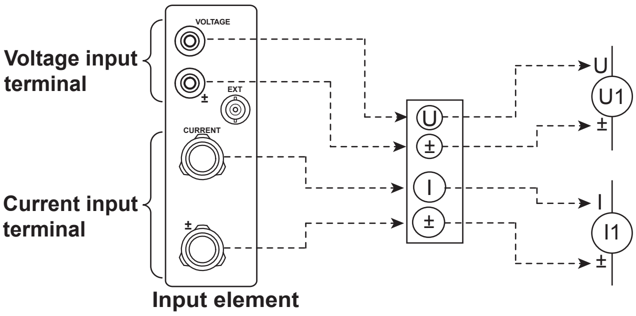
CAUTION

- Confirm that no foreign materials are caught between the current input terminal and the crimping terminal.
- Periodically confirm that the current input terminal is not loose and that there are no foreign materials caught between the current input terminal and the crimping terminal.



Connecting to this instrument

In the following figures, the WT1800's input elements, voltage input terminals, and current input terminals are simplified as shown in the following figure.



The voltage input terminal and current input terminal of input element 1 are labeled as U1 and I1, respectively.

The wiring examples shown below are examples of the following wiring systems in which the specified input elements have been wired. To wire other input elements, substitute the numbers in the figures with the appropriate element numbers.

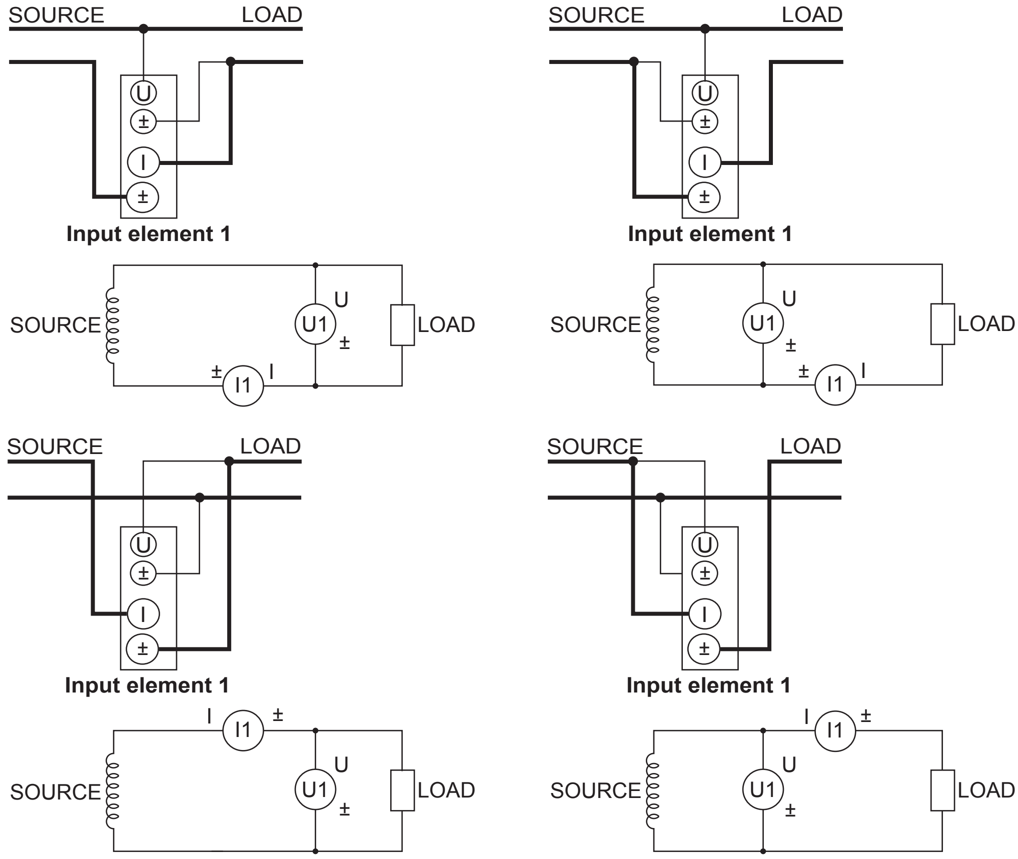
- Single-phase, two-wire systems (1P2W): Input element 1
- Single-phase, three-wire system (1P3W) and three-phase, three-wire system (3P3W): Input elements 1 and 2
- Three-phase, three wire system that uses a three-voltage, three-current method (3P3W; 3V3A) and three-phase, four-wire system (3P4W): Input elements 1 to 3

CAUTION

The thick lines on the wiring diagrams are the parts where the current flows. Use wires that are suitable for the current levels.

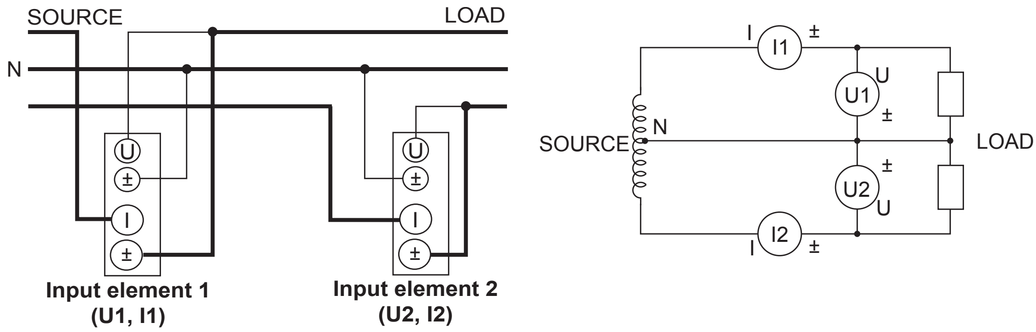
Wiring Examples of Single-Phase, Two-Wire Systems (1P2W)

If six input elements are available, six single-phase, two-wire systems can be wired. For information about deciding which of the wiring systems shown below you should select, see section 2.7.



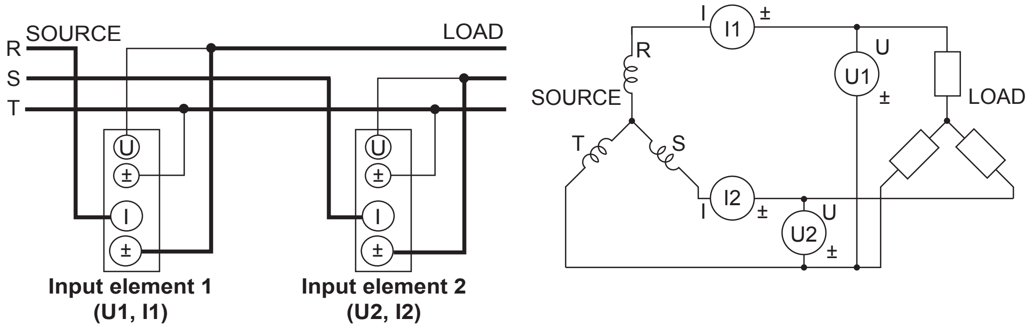
Wiring Example of a Single-Phase, Three-Wire System (1P3W)

If six input elements are available, three single-phase, three-wire systems can be wired.



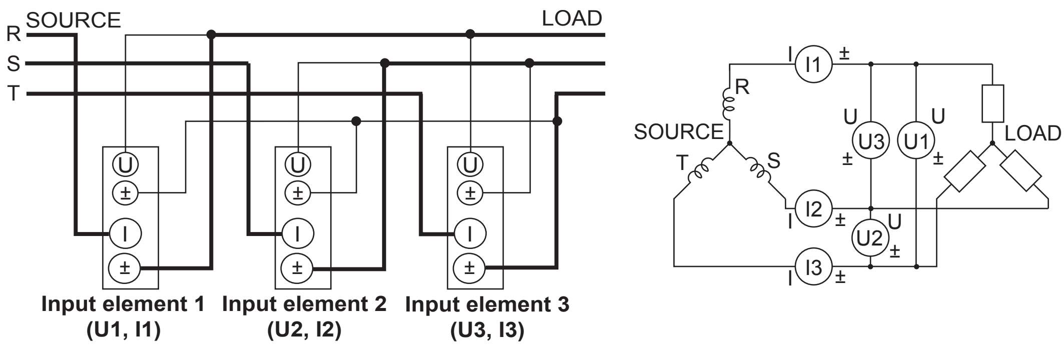
Wiring Example of a Three-Phase, Three-Wire System (3P3W)

If six input elements are available, three three-phase, three-wire systems can be wired.



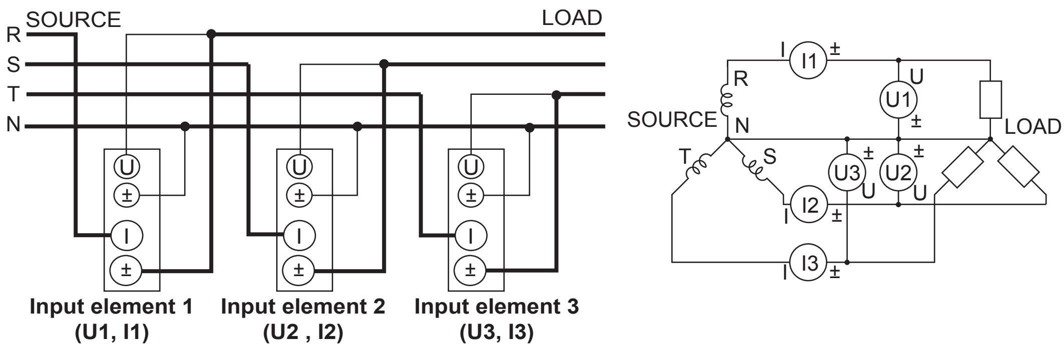
Wiring Example of a Three-Phase, Three-Wire System That Uses a Three-Voltage, Three-Current Method (3P3W; 3V3A)

If six input elements are available, two three-phase, three-wire systems that use a three-voltage, three-current method can be wired.



Wiring Example of a Three-Phase, Four-Wire System (3P4W)

If six input elements are available, two three-phase, four-wire systems can be wired.



Note

For details about the relationship between the wiring system and how measured and computed values are determined, see appendix 1, “Symbols and Determination of Measurement Functions.”

2.10 Wiring the Circuit under Measurement When Using Current Sensors

To prevent electric shock and damage to the instrument, follow the warnings given in section 2.5, “Precautions When Wiring the Circuit under Measurement.”

If the maximum current of the circuit under measurement exceeds the maximum range of the input elements, you can measure the current of the circuit under measurement by connecting an external current sensor to the external current sensor input connector.

- 5 A input elements
  When the maximum current exceeds 5 Arms
- 50 A input elements
  When the maximum current exceeds 50 Arms

Current Sensor Output Type

- If you are using a shunt-type current sensor or a clamp-type current sensor that outputs voltage as the external current sensor, see the wiring examples in this section.
- If you are using a clamp-type current sensor that outputs current, see section 2.11.

Connecting to the Input Terminal

External Current Sensor Input Terminal

- The terminal is an isolated BNC.
- Connect an external current sensor cable with a BNC connector (B9284LK, sold separately) to an external current sensor input connector.

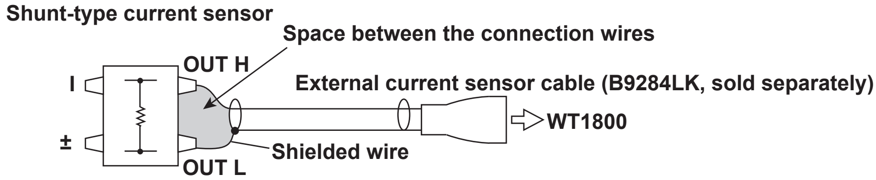
WARNING

When connecting a measurement cable from an external current sensor to an external current sensor input terminal, remove the cables connected to the current input terminals. Because the external current sensor input terminal and the current input terminal are connected internally, connecting both terminals simultaneously not only results in measurement errors but may also cause damage to the instrument. Also, when the voltage of the circuit under measurement is being applied to the external current sensor input terminals, do not touch the current input terminals. Doing so is dangerous because the terminals are electrically connected inside the instrument.

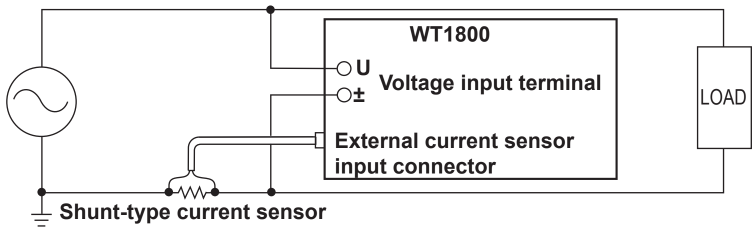
Note

- The thick lines on the wiring diagrams are the parts where the current flows. Use wires that are suitable for the current levels.
- To measure the apparent power and power factor more accurately on an unbalanced three-phase circuit, we recommend that you use a three-phase, three-wire system that uses a three-voltage, three-current method (3P3W; 3V3A).
- Note that the frequency and phase characteristics of the current sensor affect the measured data.
- Make sure that you have the polarities correct when you make connections. If the polarity is reversed, the polarity of the measurement current will be reversed, and you will not be able to make correct measurements. Be especially careful when connecting clamp-type current sensors to the circuit under measurement, because it is easy to reverse the connection.
- To minimize error when using shunt-type current sensors, follow the guidelines below when connecting the external current sensor cable.

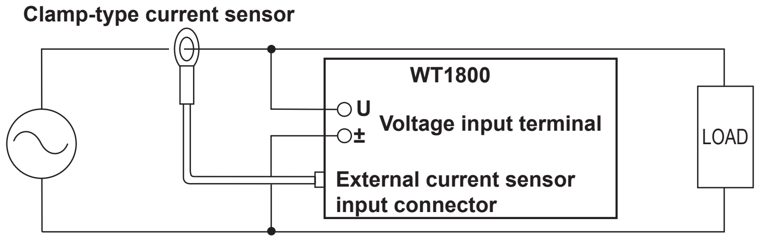
- Connect the shielded wire of the external current sensor cable to the L side of the shunt output terminal (OUT).
- Minimize the area of the space between the wires connecting the current sensor to the external current sensor cable. This reduces the effects of the lines of magnetic force (which are caused by the measurement current) and the external noise that enter the space.



- Connect the shunt-type current sensor to the power earth ground as shown in the figure below. If you have to connect the sensor to the non-earth side, use a wire that is thicker than AWG18 (with a conductive cross-sectional area of approximately 1 mm^2) between the sensor and the instrument to reduce the effects of common mode voltage. Take safety and error reduction into consideration when constructing external current sensor cables.

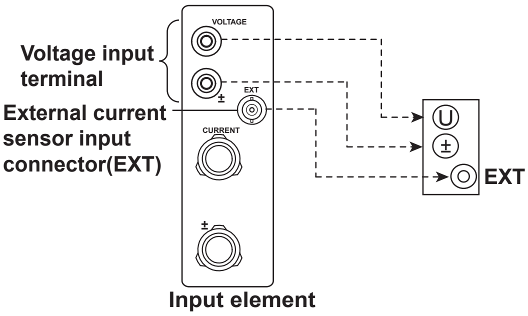


- When the circuit under measurement is not grounded and the signal is high in frequency or large in power, the effects of the inductance of the shunt-type current sensor cable become large. In this case, use an isolation sensor (CT, DC-CT, or clamp) to perform measurements.

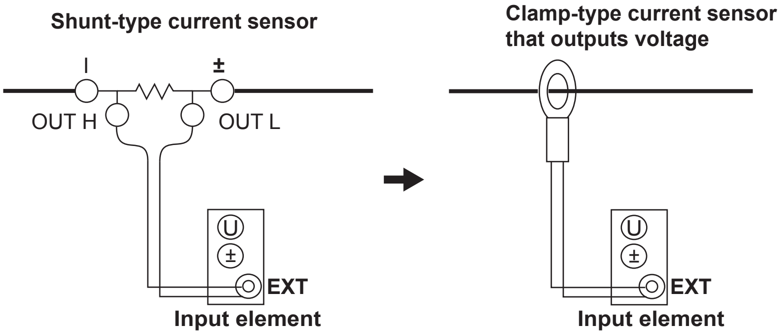


Connecting to this instrument

In the figures on the following pages, the WT1800's input elements, voltage input terminals, and external current sensor input connectors are simplified as shown in the following figure.



The following wiring examples are for connecting shunt-type current sensors. When connecting a clamp-type current sensor that outputs voltage, substitute shunt-type current sensors with clamp-type current sensors.



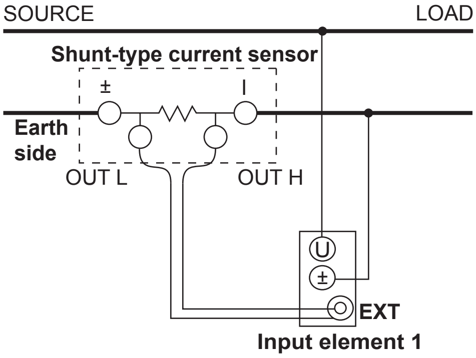
The wiring examples shown below are examples of the following wiring systems in which the specified input elements have been wired. To wire other input elements, substitute the numbers in the figures with the appropriate element numbers.

- Single-phase, two-wire system (1P2W): Input element 1
- Single-phase, three-wire system (1P3W) and three-phase, three-wire system (3P3W): Input elements 1 and 2
- Three-phase, three wire system that uses a three-voltage, three-current method (3P3W; 3V3A) and three-phase, four-wire system (3P4W): Input elements 1 to 3

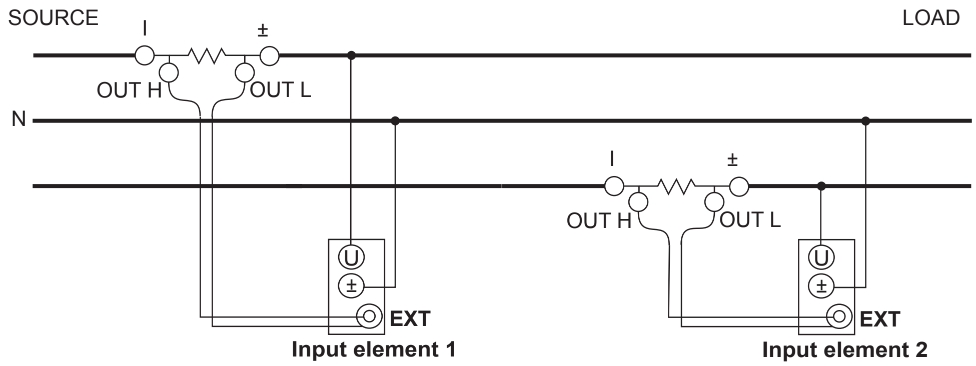
CAUTION

The thick lines on the wiring diagrams are the parts where the current flows. Use wires that are suitable for the current levels.

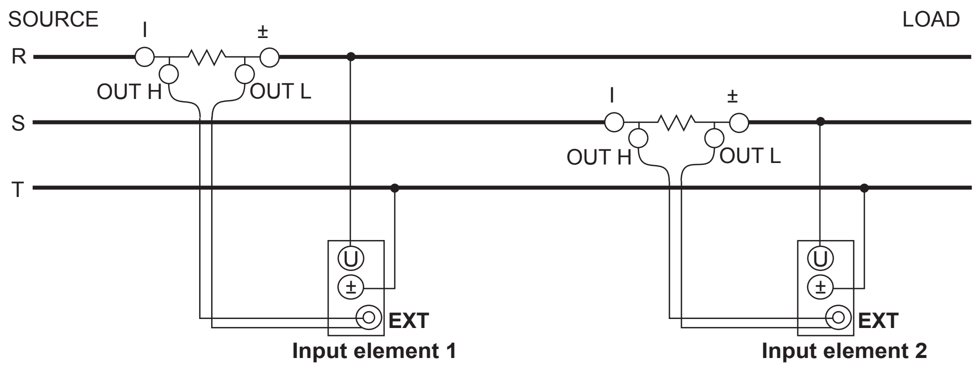
Wiring Example of a Single-Phase, Two-Wire System (1P2W) with a Shunt-Type Current Sensor



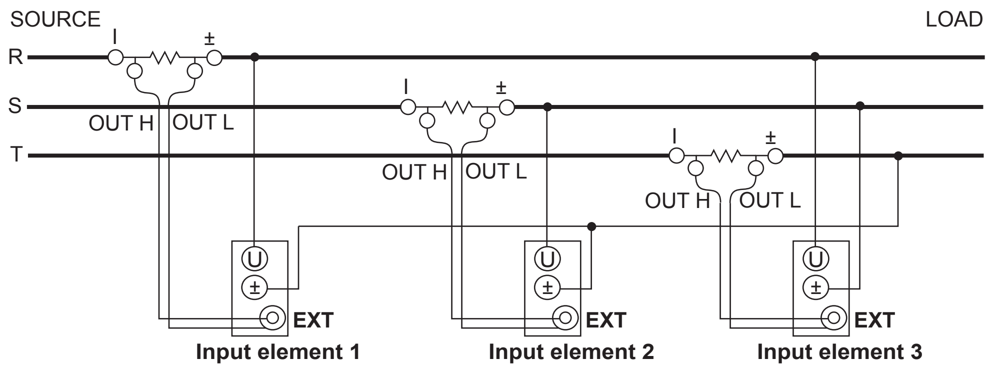
Wiring Example of a Single-Phase, Three-Wire System (1P3W) with Shunt-Type Current Sensors



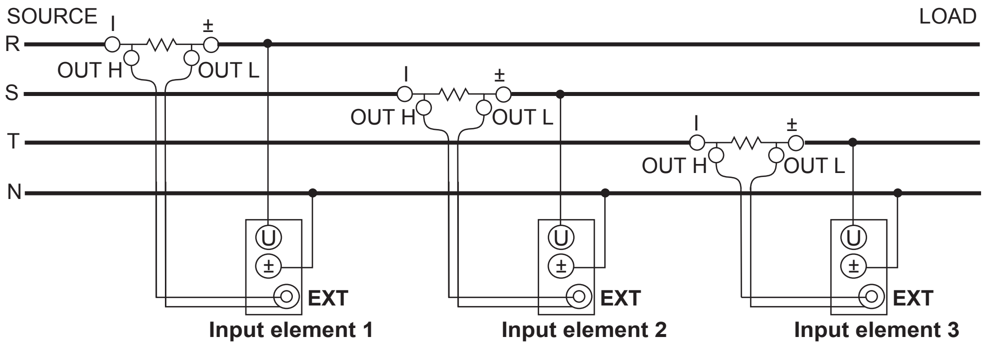
Wiring Example of a Three-Phase, Three-Wire System (3P3W) with Shunt-Type Current Sensors



Wiring Example of a Three-Phase, Three-Wire System That Uses a Three-Voltage, Three-Current Method (3P3W; 3V3A) with Shunt-Type Current Sensors



Wiring Example of a Three-Phase, Four-Wire System (3P4W) with Shunt-Type Current Sensors



Note

For details about the relationship between the wiring system and how measured and computed values are determined, see appendix 1, "Symbols and Determination of Measurement Functions."

2.11 Wiring the Circuit under Measurement When Using Voltage and Current Transformers

This section explains how to wire measurement cables from external voltage transformers (VT) or current transformers (CT) to the voltage or current input terminals of input elements. Also refer to this section when wiring clamp-type current sensors that output current.
To prevent electric shock and damage to the instrument, follow the warnings given in section 2.5, “Precautions When Wiring the Circuit under Measurement.”
When the maximum voltage of the circuit under measurement exceeds 1000 Vrms, you can perform measurements by connecting an external VT to the voltage input terminal.
If the maximum current of the circuit under measurement exceeds the maximum range of the input elements, you can measure the current of the circuit under measurement by connecting an external CT, or a clamp-type sensor that outputs current, to the current input terminal.

- 5 A input elements
  When the maximum current exceeds 5 Arms
- 50 A input elements
  When the maximum current exceeds 50 Arms

Connecting to the Input Terminal

Voltage Input Terminal

The terminals are safety banana jacks (female) that are 4 mm in diameter.
Only insert a safety terminal whose conductive parts are not exposed into a voltage input terminal.
If you are using the included 758931 Safety Terminal Adapter, see section 2.6.

Current Input Terminal

- The screws used on the terminal (binding post) are M6 screws. Wind the wire around the screw, use the Fork Terminal Adapter (758921; sold separately), or pass the crimping terminal through the screw axis, and then tighten firmly with the terminal knob.
- For the dimensions of the terminal parts, see section 2.9.
- For the precautions to follow when you connect the current input terminal and the crimping terminal and after you connect these terminals, see section 2.9.

WARNING

- When the voltage of the circuit under measurement is being applied to the current input terminals, do not touch the external current sensor input terminals. Doing so is dangerous because the terminals are electrically connected inside the instrument.
- When connecting a measurement cable from an external current sensor to an external current sensor input terminal, remove the cables connected to the current input terminals. Also, when the voltage of the circuit under measurement is being applied to the external current sensor input terminals, do not touch the current input terminals. Doing so is dangerous because the terminals are electrically connected inside the instrument.

General VT and CT Handling Precautions

- Do not short the secondary side of a VT. Doing so may damage it.
- Do not short the secondary side of a CT. Doing so may damage it.

Also, follow the VT or CT handling precautions in the manual that comes with the VT or CT that you are using.

Note

- The thick lines on the wiring diagrams are the parts where the current flows. Use wires that are suitable for the current levels.
- Make sure that you have the polarities correct when you make connections. If the polarity is reversed, the polarity of the measurement current will be reversed, and you will not be able to make correct measurements. Be especially careful when connecting clamp-type current sensors to the circuit under measurement, because it is easy to reverse the connection.
- Note that the frequency and phase characteristics of the VT or CT affect the measured data.
- For safety reasons, the common terminals (+/−) of the secondary side of the VT and CT are grounded in the wiring diagrams in this section. However, the necessity of grounding and the grounding location (ground near the VT or CT or ground near the power meter) vary depending on the item under measurement.
- To measure the apparent power and power factor more accurately on an unbalanced three-phase circuit, we recommend that you use a three-phase, three-wire system that uses a three-voltage, three-current method (3P3W; 3V3A).

Connecting to this instrument

The following wiring examples are for connecting a CT. When connecting a clamp-type current sensor that outputs current, substitute the CT with the clamp-type current sensor.

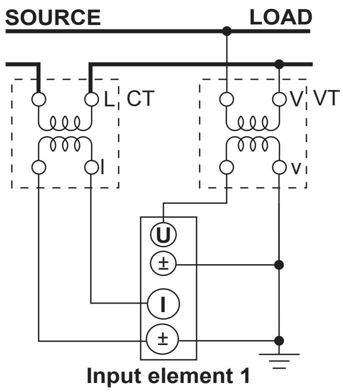
The wiring examples shown below are examples of the following wiring systems in which the specified input elements have been wired. To wire other input elements, substitute the numbers in the figures with the appropriate element numbers.

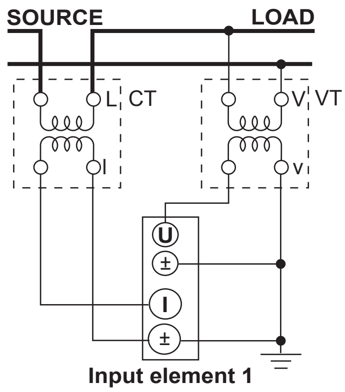
- Single-phase, two-wire systems (1P2W): Input element 1
- Single-phase, three-wire system (1P3W) and three-phase, three-wire system (3P3W): Input elements 1 and 2
- Three-phase, three wire system that uses a three-voltage, three-current method (3P3W; 3V3A) and three-phase, four-wire system (3P4W): Input elements 1 to 3

CAUTION

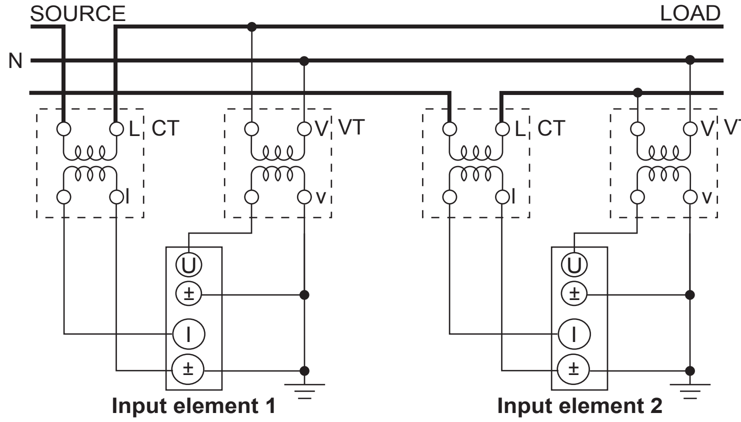
The thick lines on the wiring diagrams are the parts where the current flows. Use wires that are suitable for the current levels.

Wiring Example of Single-Phase, Two-Wire Systems (1P2W) with a VT and CT

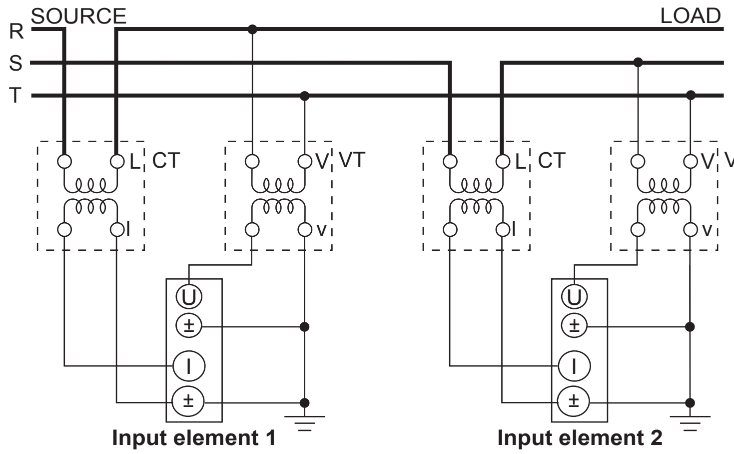




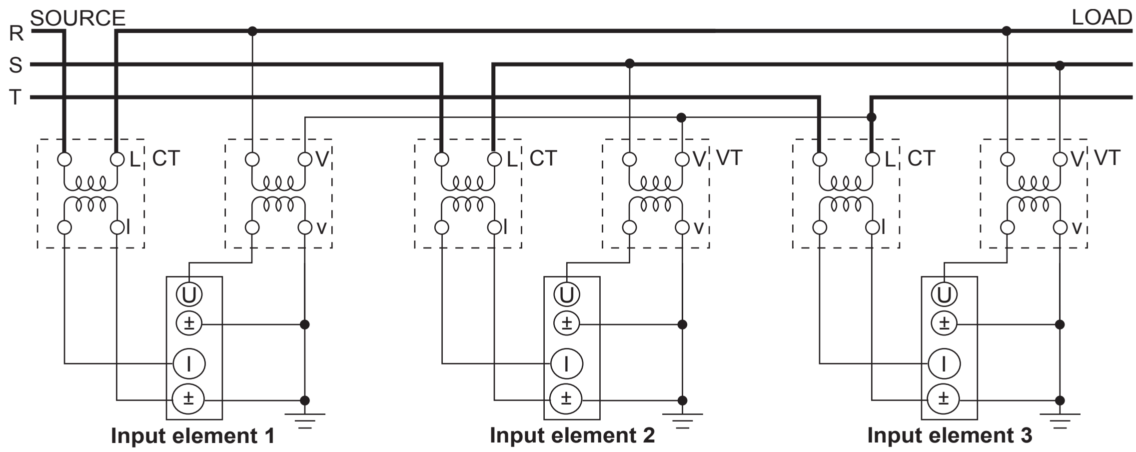
Wiring Example of a Single-Phase, Three-Wire System (1P3W) with VTs and CTs



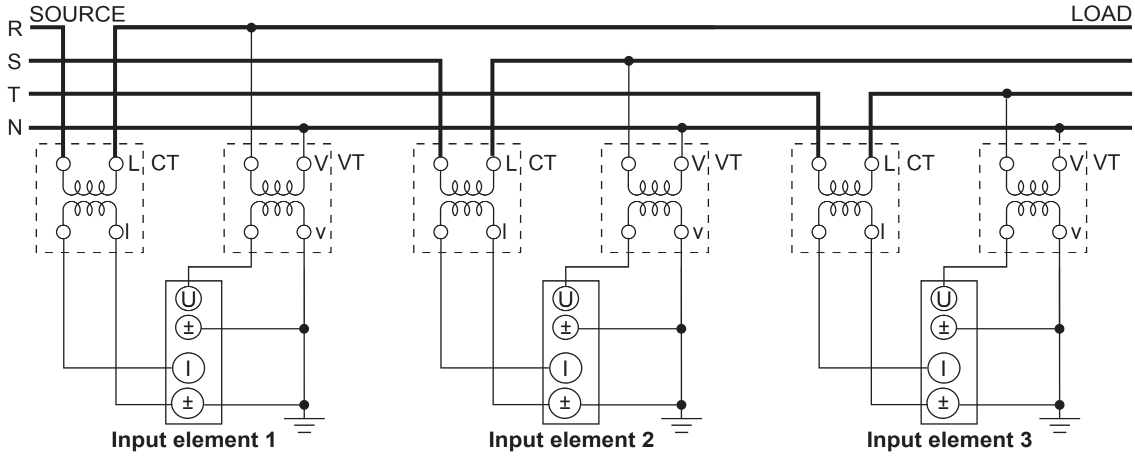
Wiring Example of a Three-Phase, Three-Wire System (3P3W) with VTs and CTs



Wiring Example of a Three-Phase, Three-Wire System That Uses a Three-Voltage, Three-Current Method (3P3W; 3V3A) with VTs and CTs



Wiring Example of a Three-Phase, Four-Wire System (3P4W) with VTs and CTs



Note

For details about the relationship between the wiring system and how measured and computed values are determined, see appendix 1, "Symbols and Determination of Measurement Functions."

2.12 Loading Roll Paper into the Built-In Printer (Option)

This section explains how to load roll paper into the optional built-in printer.

Printer Roll Paper

Only use roll paper specifically made for use with the WT1800. When you first use the printer, use the included roll paper. When you need a new supply of roll paper, contact your nearest YOKOGAWA dealer.

Part Number:	B9316FX
Specifications:	Heat sensitive paper, 10 m
Minimum Quantity:	10 rolls

Handling Roll Paper

The roll paper is made of heat sensitive paper that changes color thermochemically. Please read the following information carefully.

Storage Precautions

When in use, the heat-sensitive paper changes color gradually at temperatures of approximately 70° C or higher. The paper can be affected by heat, humidity, light, and chemicals, whether something has been recorded on it or not. As such, please follow the guidelines listed below.

- Store the paper in a cool, dry, and dark place.
- Use the paper as quickly as possible after you break its protective seal.
- If you attach a plastic film that contains plasticizing material, such as vinyl chloride film or cellophane tape, to the paper for a long time, the recorded sections will fade due to the effect of the plasticizing material. Use a holder made of polypropylene to store the roll paper.
- When pasting the record paper to another material, do not use paste that contains organic solvents such as alcohol or ether. Doing so will change the paper’s color.
- We recommend that you make copies of the recordings if you intend to store them for a long period of time. Because of the nature of heat-sensitive paper, the recorded sections may fade.

Handling Precautions

- Use genuine, YOKOGAWA-supplied roll paper.
- If you touch the roll paper with sweaty hands, there is a chance that you will leave fingerprints on the paper, thereby blurring the recorded sections.
- If you rub something against the surface of the roll paper, the paper may change color due to frictional heat.
- If the roll paper comes into contact with products such as chemicals or oil, there is a chance that the paper will change color or that the recorded sections will disappear.

Loading the Roll Paper

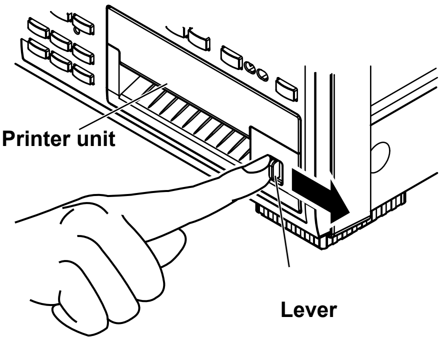
WARNING

A roll paper cutter is present inside the printer unit cover. Be careful of the cutter so as to avoid injuring your fingers or hands.

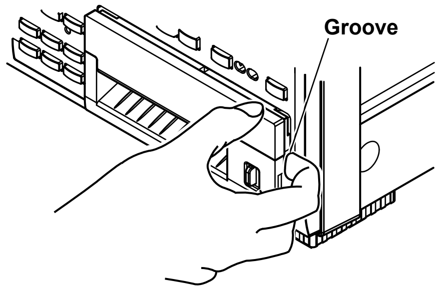
- Do not insert your fingers into the opening on the printer unit (the roll paper ejection hole).
- When you have opened the printer unit cover to place roll paper in the holder, avoid touching the cutter with your fingers and hands.

Do not touch the print head and print motor with your fingers and hands. Doing so when these parts are extremely hot may lead to burns.

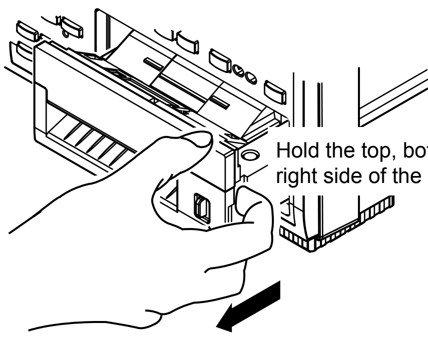
1. Slide the lever to the right to make the printer unit protrude from the WT1800.



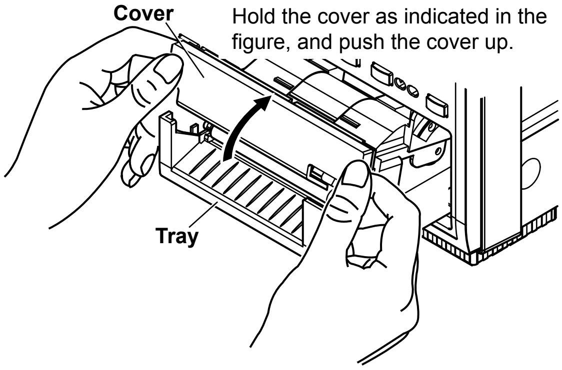
2. Insert your finger into the groove on the right side of the printer unit.



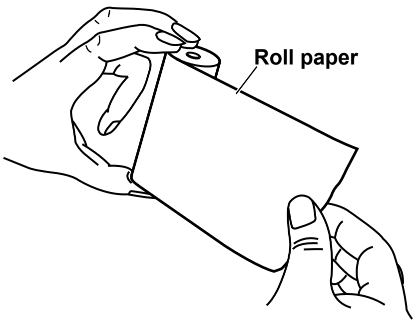
3. Hold the top, bottom, and right side of the printer unit, and then pull it toward you until it stops (pull the unit approximately 5 cm).

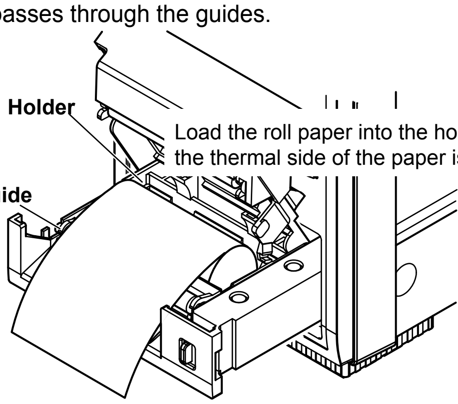


4. Hold the left and right sides of the printer unit's tray with your hands, and push the right and left sides of the front of the cover with your thumbs to raise it.

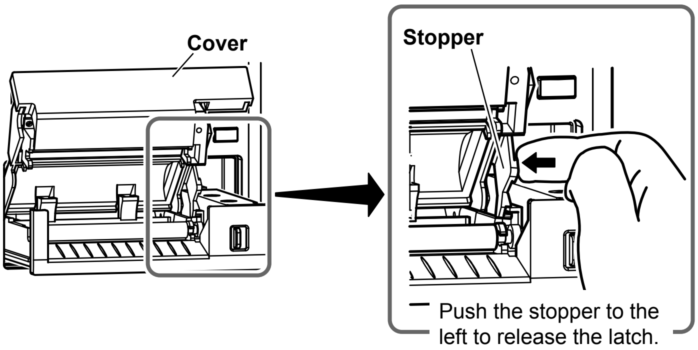


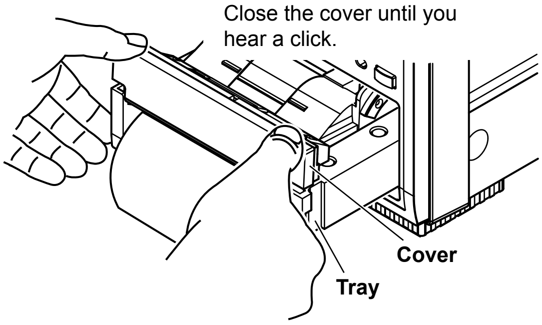
5. Pull approximately 10 cm of the roll paper out, and load the roll paper in the holder so that the thermal side of the paper is facing up. Load the paper so that it passes through the guides.



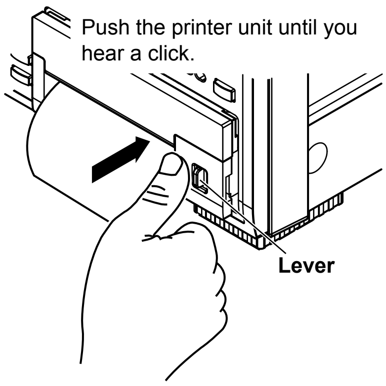


6. Lower the cover while you push the stopper to the left to release the latch. Hold the tray from underneath with both hands, and close the cover until you hear a click.

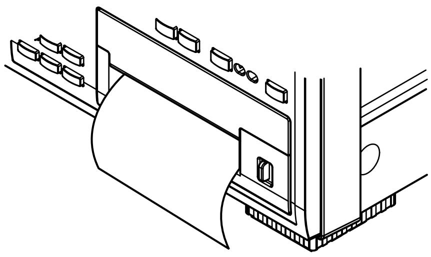




7. Push the printer unit (push the area to the left of the lever on the front panel) back into the WT1800 until you hear a click.



This completes the procedure for loading the roll paper.



Feeding Paper

Press **SHIFT+PRINT** (MENU) to display the following menu.

Feeds paper
Each time that you press this soft key, the WT1800 feeds approximately 3 cm of the roll paper.

Cutting Roll Paper

After you load roll paper and close the cover or after you print measured data, to cut the roll paper, pull the paper up against the top of the cover.

Note

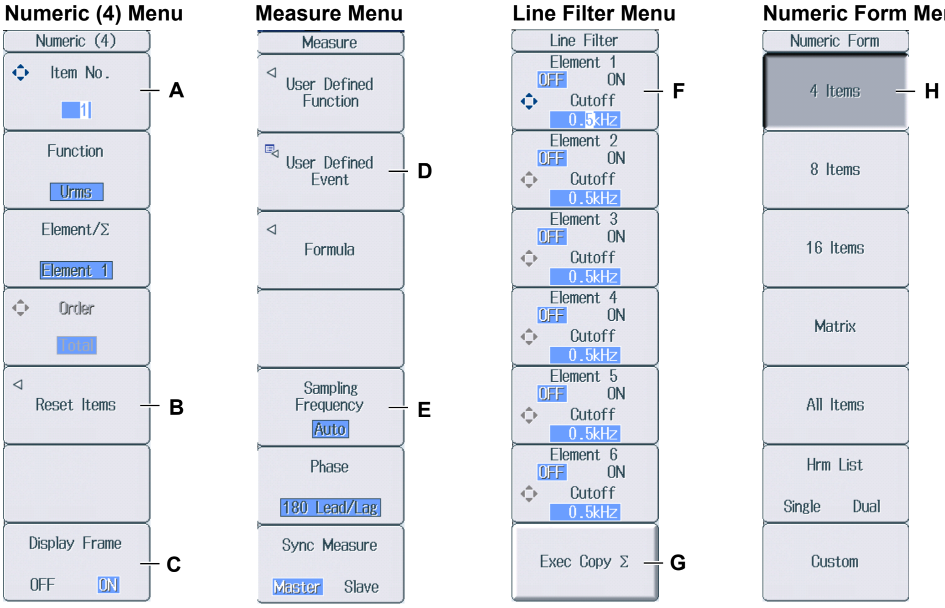
- If you open the printer cover immediately after you cut the roll paper, repeat steps 5 to 7 on pages 2-26 and 2-27.
- After you load roll paper and close the cover, check whether the paper feeds correctly. If the roll paper does not feed straight, repeat steps 1 to 7 on pages 2-26 and 2-27.
- If you load the roll paper backwards, the paper may not feed properly or data may not be printed. This is because the print head doesn't come into contact with the thermal side of the paper. Load the roll paper into the holder in the proper orientation.

3.1 Key Operation and Functions

Key Operation

How to Use Setup Menus That Appear When Keys Are Pressed

The operation after you press a key varies depending on the key that you press.



A: Press the soft key to use the cursor keys to configure this setting. Use the cursor keys to set the value or select an item.

B: A related setup menu appears when you press the soft key.

C: The selected setting switches each time you press the soft key.

D: A dialog box or the keyboard appears when you press the soft key.
Use the cursor keys and the SET key to configure the settings.

E: Press the soft key to display a selection menu.
Press the soft key that corresponds to the appropriate setting.

F: Press the soft key to use the cursor keys to configure this setting. After you configure the setting, the status of the selected setting switches each time you press the soft key.

G: Press the soft key to execute the specified feature.

H: Press the soft key to apply the value assigned to the key.

How to Display the Setup Menus That Are Written in Purple below the Keys

In the explanations in this manual, “SHIFT+key name (written in purple)” is used to indicate the following operation.

1. Press **SHIFT**. The SHIFT key illuminates to indicate that the keys are shifted.
   Now you can select the setup menus written in purple below the keys.
2. Press the key that you want to display the setup menu of.

ESC Key Operation

If you press **ESC** when a setup menu or available options are displayed, the screen returns to the menu level above the current one. If you press **ESC** when the highest level menu is displayed, the setup menu disappears.

RESET Key Operation

If you press **RESET** when you are using the cursor keys to set a value or select an item, the setting is reset to its default value (depending on the operating state of the WT1800, the setting may not be reset).

SET Key Operation

The operation varies as indicated below depending on what you are setting.

- For a soft key menu that has two values that you use the cursor keys to adjust
  Press **SET** to switch the value that the cursor keys adjust.
- For a menu that has the cursor keys + SET mark (✥+SET) displayed on it
  Press **SET** to confirm the selected item.

Cursor Keys Operations

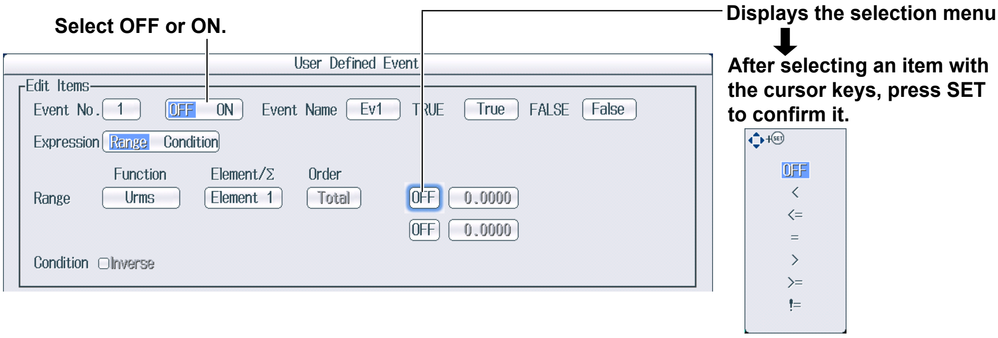
The operation varies as indicated below depending on what you are setting.

- When setting a value
  Up and down **cursor** keys:
  Increases and decreases the value
  Left and right **cursor** keys:
  Changes which digit to set
- When selecting the item to set
  Up and down **cursor** keys:
  Moves the cursor between settings

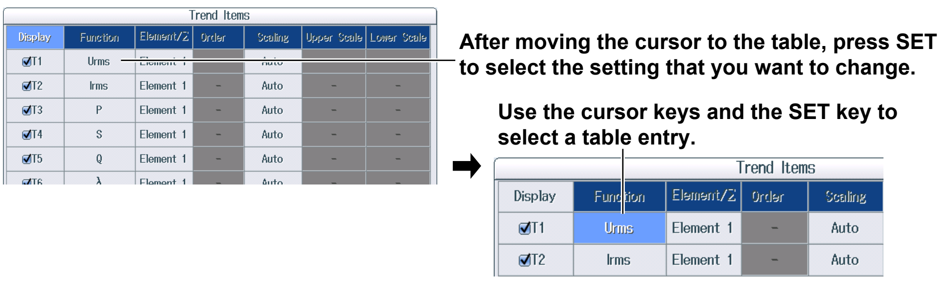
How to Enter Values in Setup Dialog Boxes

1. Use the keys to display the appropriate setup dialog box.
2. Use the **cursor** keys to move the cursor to the item that you want to set.
3. Press **SET**. The operation varies as indicated below depending on what you are setting.
   - A selection menu appears.
   - A check box is selected or cleared.
   - An item is selected.
   - A table of settings is selected.

Displaying a Selection Menu and Selecting an Item



Setting Items in a Table



How to Clear Setup Dialog Boxes

Press **ESC** to clear the setup dialog box from the screen.

3.2 Entering Values and Strings

Entering Values

Using the Cursor Keys to Enter Values

Select the appropriate item using the soft keys, and change the value using the cursor keys and the SET key. This manual sometimes describes this operation simply as “using the cursor keys.”

Note

Some items that you can set using the cursor keys are reset to their default values when you press the RESET key.

Entering Character Strings

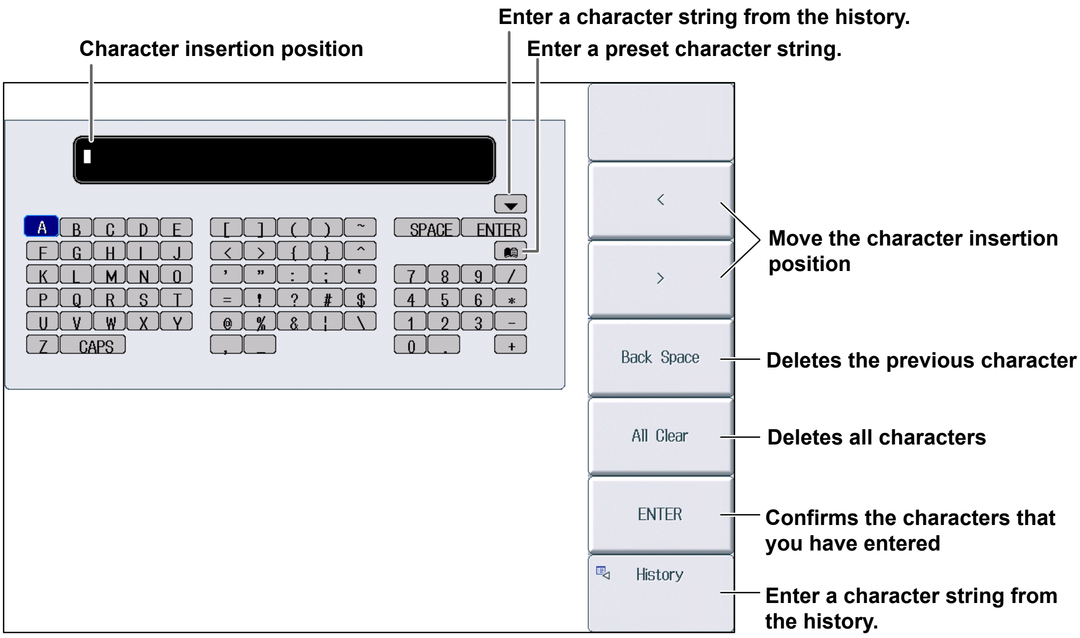
Use the keyboard that appears on the screen to enter character strings such as file names and comments. Use the cursor keys and the SET key to operate the keyboard and enter a character string.

How to Operate the Keyboard

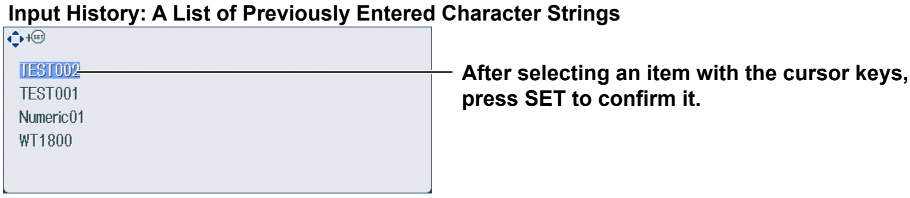
1. After bringing up the keyboard, use the **cursor** keys to move the cursor to the character that you want to enter.
2. Press **SET** to enter the character.
   - If a character string has already been entered, use the arrow soft keys (**<** and **>**) to move the cursor to the position you want to insert characters into.
   - To switch between uppercase and lowercase letters, move the cursor to **CAPS** on the keyboard, and then press **SET**.
   - To delete the previous character, press the **Back Space** soft key.
   - To delete all the characters, press the **All Clear** soft key.
3. Repeat steps 1 and 2 to enter all the characters in the string.
   - Select [▼] on the keyboard or press the **History** soft key to display a list of character strings that you have entered previously. Use the cursor keys to select a character string, and press **SET** to enter the selected character string.
   - Select [preset] on the keyboard to display a list of preset character strings. The following operands and equations, which are used with user-defined functions, are included as preset character strings.

ABS(	PPK(	HVF(	RMS(
SQR(	MPK(	HCF(	MN(
SQRT(	CF	KFACT(	RMN(
LOG(	TI(	EAU(	DC(
LOG10(	THD(	EAI(	AC(
EXP(	THF(	PLLFRQ(	PC(
NEG(	TIF(		

   Use the **cursor** keys to select a character string, and press **SET** to enter the selected character string.
4. Press the **ENTER** soft key, or move the cursor to ENTER on the keyboard, and press **SET** to confirm the character string and clear the keyboard.



Input History: A List of Previously Entered Character Strings



Note

- @ cannot be entered consecutively.
- File names are not case-sensitive. Comments are case-sensitive. The following file names cannot be used due to MS-DOS limitations:
  AUX, CON, PRN, NUL, CLOCK, COM1 to COM9, and LPT1 to LPT9
- For details on file name limitations, see the features guide, IM WT1801-01EN.

3.3 Using USB Keyboards and Mouse Devices

Connecting a USB Keyboard

You can connect a USB keyboard and use it to enter file names, comments, and other items.

Usable Keyboards

You can use the following keyboards that conform to USB Human Interface Devices (HID) Class Ver. 1.1.

- When the USB keyboard language is English: 104-key keyboards
- When the USB keyboard language is Japanese: 109-key keyboards

Note

- Do not connect incompatible keyboards.
- The operation of USB keyboards that have USB hubs or mouse connectors is not guaranteed.
- For USB keyboards that have been tested for compatibility, contact your nearest YOKOGAWA dealer.

USB Ports for Peripherals

Connect a USB keyboard to one of the USB ports for peripherals on the front panel of the WT1800.

Connection Procedure

Connect a USB keyboard directly to the WT1800 using a USB cable. You can connect or remove the USB cable regardless of whether the WT1800 is on or off (hot-plugging is supported). Connect the type A connector of the USB cable to the WT1800, and connect the type B connector to the keyboard. When the power is turned on, the keyboard is detected and enabled approximately 6 seconds after it is connected.

Note

- Only connect compatible USB keyboards, mouse devices, or memory devices to the USB ports for peripherals.
- Do not connect multiple keyboards. You can connect one keyboard and one mouse to the WT1800.
- Do not connect and disconnect multiple USB devices repetitively. Wait for at least 10 seconds after you connect or remove one USB device before you connect or remove another USB device.
- Do not remove USB cables during the time from when the WT1800 is turned on until key operation becomes available (approximately 20 seconds).

Setting the USB Keyboard Language

UTILITY System Config Menu

Press **UTILITY** and then the **System Config** soft key to display the following menu.

Entering File Names, Comments, and Other Items

When a keyboard is displayed on the screen, you can enter file names, comments, and other items using the USB keyboard.

Entering Values from a USB Keyboard

You can use the USB keyboard to enter values for settings in which the ◆ mark is displayed on the menu.

- ↑ key or “8” on the numeric keypad:
  The value increases.
- ↓ key or “2” on the numeric keypad:
  The value decreases.
- → key or “6” on the numeric keypad:
  The digit cursor moves to the next digit on the right.
- ← key or “4” on the numeric keypad:
  The digit cursor moves to the next digit on the left.

Using a USB Mouse

You can connect a USB mouse and use it to perform the same operations that you can perform with the WT1800 keys. Also, by clicking a menu item, you can perform the same operation that you can perform by pressing the menu item’s soft key or selecting the menu item and pressing the SET key.

Usable USB Mouse Devices

You can use mouse devices (with wheels) that are compliant with USB HID Class Version 1.1.

Note

- For USB mouse devices that have been tested for compatibility, contact your nearest YOKOGAWA dealer.
- Some settings cannot be configured by a mouse without a wheel.

USB Ports for Peripherals

Connect a USB mouse to one of the USB ports for peripherals on the front panel of the WT1800.

Connection Procedure

To connect a USB mouse to the WT1800, use one of the USB ports for peripherals. You can connect or disconnect a USB mouse at any time regardless of whether the WT1800 is on or off (hot-plugging is supported). When the power is on, the mouse is detected approximately 6 seconds after it is connected, and the mouse pointer ( ) appears.

Note

- Only connect compatible USB keyboards, mouse devices, or memory devices to the USB ports for peripherals.
- Even though there are two USB ports for peripherals, do not connect two mouse devices to the WT1800.

Operating the WT1800 Using a USB Mouse

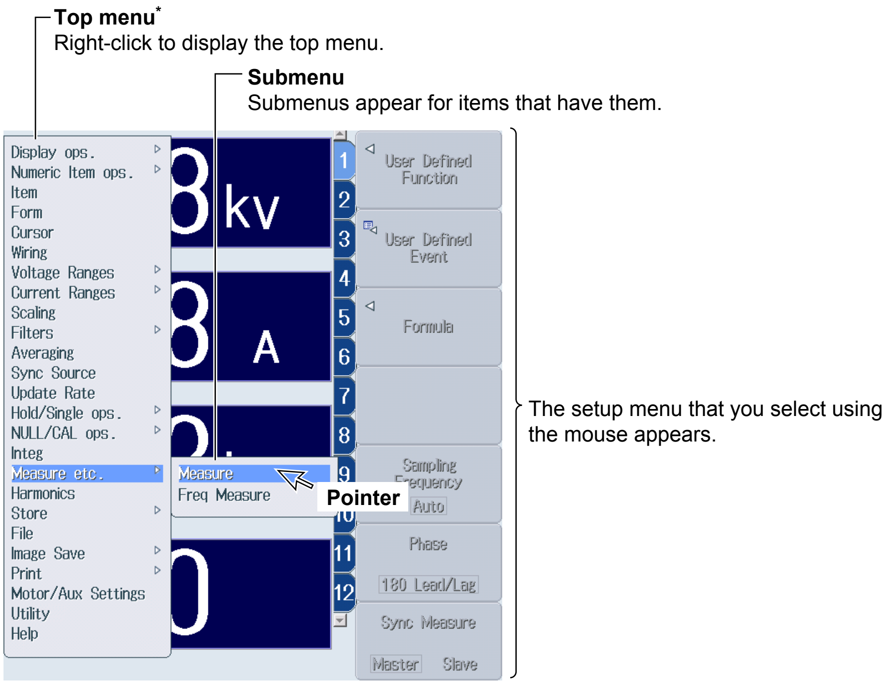
- **Operations That Correspond to the Front Panel Keys (Top menu)**

Displaying the Top Menu

Right-click on the display. A menu of the WT1800 front panel keys (the top menu) appears.

Selecting an Item from the Top Menu

Click the item that you want to select. A setup menu that corresponds to the item that you selected appears on the right side of the display. The top menu disappears.
To display an item's submenu, click the item. To select an item on a submenu, click it, just as you would to select an item on the top menu.



* "Ops." is short for "operations."

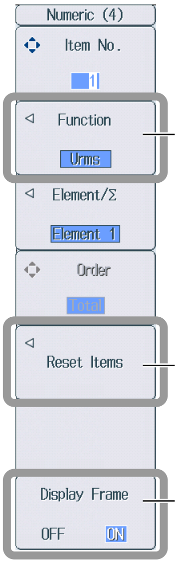
Note

- The following keys are not displayed on the top menu:
  ESC, RESET, and SET

- **Setup Menu Operations (Same as soft key operations)**

Selecting a Setup Menu Item

Click the setup menu item that you want to select.
If a selection menu appears after you select an item, click the selection menu item that you want to choose.
If an item has available options such as ON and OFF, click the item to change its setting.
For menu items that are usually selected using the cursor keys and the SET key, clicking on the item that you want to select will confirm your selection and close the dialog box.



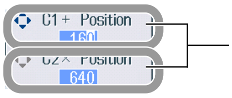
Clearing the Menu

To clear the menu, click outside of it.

- **Specifying Values**

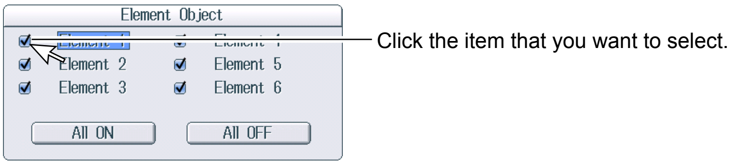
The following description explains how to specify values for menu items that have a ◆ icon next to them.

- When a menu item has two ◆ icons, click the top or bottom half of the menu item to select the corresponding setting.
- To decrease a value, rotate the mouse wheel back.
- To increase a value, rotate the mouse wheel forward.
- To increase a value, move the pointer above the value so that the pointer becomes a ︽, and then click above the value.
- To decrease a value, move the pointer below the value so that the pointer becomes a ︾, and then click below the value.
- To move the digit cursor between digits, point to the left or right of the value you want to set so that the pointer becomes a ◀ or a ▶, and then click this area. The digit cursor will move one digit to the left or right each time you click.



- **Selecting Check Boxes in Dialog Boxes**

  Click the item that you want to select. A check mark appears next to the item that you selected. To clear an item's check box, click it again.

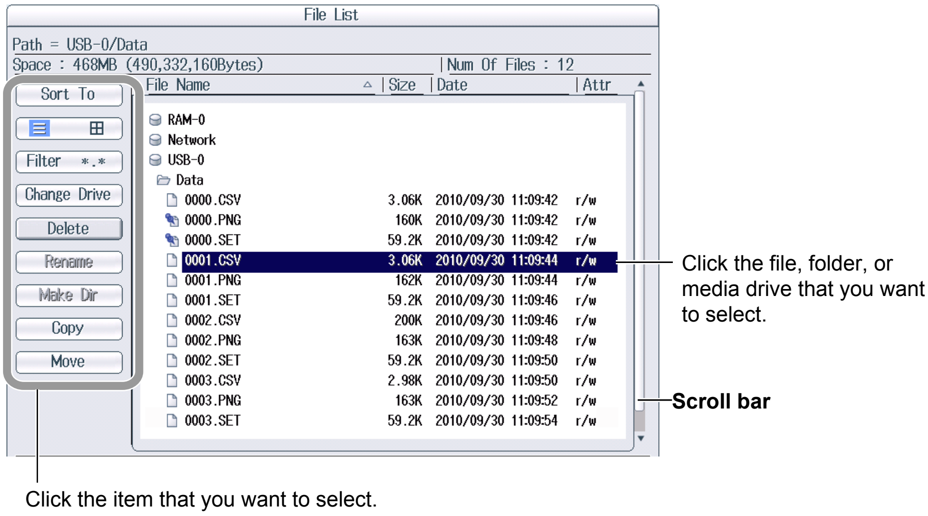


Note

To close a dialog box, click outside of it.

- **Selecting a File, Folder, or Media Drive from the File List Window**

  Click on a file, folder, or media drive to select it.
  Rotate the mouse wheel to scroll through the file list.
  To cancel your selection, click outside of the File List window. The File List window will close when you cancel your selection.

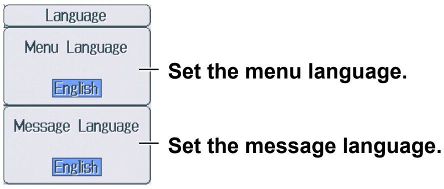


3.4 Setting the Menu and Message Languages

This section explains how to set the language that is used to display the menus and messages on the screen. The factory default setting is ENG (English).

UTILITY System Config Menu

Press **UTILITY**, the **System Config** soft key, and then the **Language** soft key to display the following menu.



Setting the Menu Language (Menu Language)

You can choose to display menus using one of the following languages.

- English
- Japanese
- Chinese[1]
- German[1]
- Russian[2]

Setting the Message Language (Message Language)

Error messages appear when errors occur. You can choose to display these messages and the help (see section 3.7) using one of the following languages. The error codes that accompany error messages are the same for all languages. For more information about error messages, see section 5.2.

- English
- Japanese
- Chinese[1]
- German[1]
- Russian[2]

1 This features covers firmware versions 2.01 or later of the WT1800.
2 This features covers firmware versions 2.21 or later of the WT1800.

Note

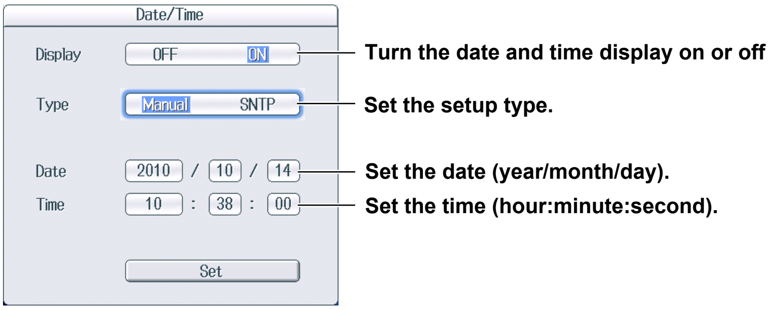
- Even if you set the menu or message language to a language other than English, some terms will be displayed in English.
- You can specify different menu and message languages. However, you cannot set Japanese and Chinese to the menu language and the message language at the same time. For example, if you specify Japanese as the menu language and Chinese as the message language, the menu language will also be set to Chinese.

3.5 Synchronizing the Clock

This section explains how to set the WT1800 clock, which is used to generate timestamps for measured data and files. When the WT1800 is shipped from the factory, it has a set date and time. You must synchronize the clock before you start measurements.

UTILITY System Config Menu

Press **UTILITY**, the **System Config** soft key, and then the **Date/Time** soft key to display the following screen.



Setting the Setup Type (Type)

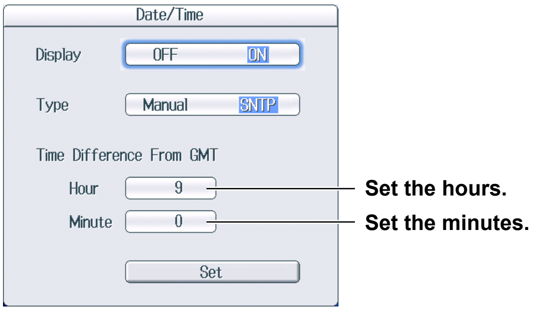
- If you select Manual, set the Date and Time values, and then select Set.
- If you select SNTP, the WT1800 uses an SNTP server to set its date and time. This setting is valid when Ethernet communications have been established. For information on SNTP, see the user’s manual. If you select SNTP, set the time difference from Greenwich Mean Time (the Time Diff. GMT values), and then select Set.

Setting the Time Difference from Greenwich Mean Time (Time Difference From GMT)

This setting is valid when the method for setting the date and time is set to SNTP.
Set the time difference between the region where you are using the WT1800 and Greenwich Mean Time to a value within the following range.

−12 hours 00 minutes to 13 hours 00 minutes

For example, Japan standard time is ahead of GMT by 9 hours. In this case, set Hour to 9 and Minute to 00.



Checking the Standard Time

Using one of the methods below, check the standard time of the region where you are using the instrument.

- Check the Date, Time, Language, and Regional Options on your PC.
- Check the standard time at the following URL:http://www.worldtimeserver.com/

Note

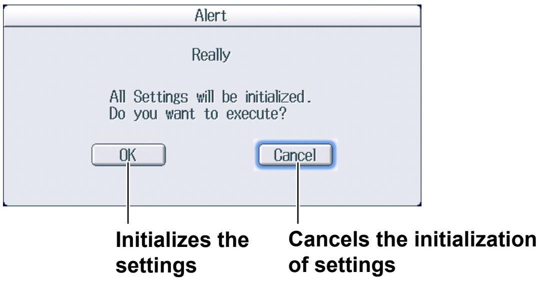
- The WT1800 does not support Daylight Savings Time. To set the Daylight Savings Time, reset the time difference from Greenwich Mean Time.
- Date and time settings are backed up using an internal lithium battery. They are retained even if the power is turned off.
- The WT1800 has leap-year information.
- The Time Difference From GMT setting is shared with the same setting found in the SNTP settings in the Ethernet communication (Network) settings. If you change this setting in the date and time settings, the Time Difference From GMT in the Ethernet communication (Network) settings also changes.

3.6 Initializing Settings

This section explains how to reset the WT1800 settings to their factory default values. This feature is useful when you want to cancel all of the settings that you have entered or when you want to redo measurement from scratch. For information about the initial settings, see appendix 8, “List of Initial Settings and Numeric Data Display Order.”

UTILITY System Config Menu

Press **UTILITY**, the **System Config** soft key, and then the **Initialize Settings** soft key to display the following screen.



Settings That Cannot Be Reset to Their Factory Default Values

- Date and time settings
- Communication settings
- Menu and message language settings

To Reset All Settings to Their Factory Default Values

While holding down RESET, turn the WT1800 on. All settings except the date and time settings (display on/off setting will be reset) and the setup data stored on the internal RAM disk will be reset to their factory default values.

Note

Only initialize the WT1800 if you are sure that it is okay for all of the settings to be returned to their initial values. You cannot undo an initialization. We recommend that you save the setup parameters before you initialize the WT1800.

3.7 Displaying Help

Displaying Help

Press HELP to display the help screen.
The table of contents and index appear in the left frame, and text appears in the right frame.

Switching between Frames

To switch to the frame that you want to control, use the left and right cursor keys.

Moving Cursors and Scrolling

- To scroll through the screen or to move the cursor in the table of contents or index, use the up and down cursor keys.
- Press PAGE ▲ or PAGE ▼ to scroll through the screen by approximately half a page in the specified direction.
- Press SHIFT+PAGE ▲ (⏫) to display the first entry.
- Press SHIFT+PAGE ▼ (⏬) to display the last entry.

Moving to the Link Destination

To move to a description that relates to blue text or to move from the table of contents or index to the corresponding description, move the cursor to the appropriate blue text or item, and press SET.

Displaying Panel Key Descriptions

With help displayed, press a panel key to display an explanation of it.

Returning to the Previous Screen

To return to the previous screen, press RESET.

Hiding Help

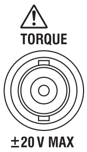
Press HELP or ESC to hide the help screen.

4.1 Motor Torque Signal and Revolution Signal Input (TORQUE/SPEED; option)

CAUTION

Only apply signals that meet the following specifications. Signals that do not meet the specifications, such as those with excessive voltage, may damage the WT1800.

Torque Signal Input Connector (TORQUE)



Apply a torque meter output signal—a DC voltage (analog) signal or pulse signal that is proportional to the motor's torque—that meets the following specifications.

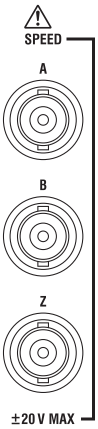
DC Voltage (Analog input)

Item	Specifications
Connector type	Isolated BNC connector
Input range	1 V, 2 V, 5 V, 10 V, 20 V
Effective input range	0% to ±110% of the measurement range
Input resistance	Approx. 1 MΩ
Maximum allowable input	±22 V
Continuous maximum common-mode voltage	±42 Vpeak or less

Pulse Input

Item	Specifications
Connector type	Isolated BNC connector
Frequency range	2 Hz to 1 MHz
Amplitude input range	±12 Vpeak
Detection level	H level: approx. 2 V or more; L level: approx. 0.8 V or less
Pulse width	500 ns or more
Input resistance	Approx. 1 MΩ
Continuous maximum common-mode voltage	±42 Vpeak or less

Revolution Signal Input Connector (SPEED)



Apply a revolution sensor output signal—a DC voltage (analog) signal or pulse signal that is proportional to the motor's rotating speed—that meets the following specifications.

DC Voltage (Analog input)

Item	Specifications
Connector type	Isolated BNC connector
Input range	1 V, 2 V, 5 V, 10 V, 20 V
Effective input range	0% to ±110% of the measurement range
Input resistance	Approx. 1 MΩ
Maximum allowable input	±22 V
Continuous maximum common-mode voltage	±42 Vpeak or less

Pulse Input

Item	Specifications
Connector type	Isolated BNC connector
Frequency range	2 Hz to 1 MHz
Amplitude input range	±12 Vpeak
Detection level	H level: approx. 2 V or more; L level: approx. 0.8 V or less
Pulse width	500 ns or more
Input resistance	Approx. 1 MΩ
Continuous maximum common-mode voltage	±42 Vpeak or less

Terminal Used for Analog Input

Apply analog input to terminal A.

Terminal Used for Pulse Input

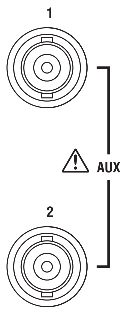
- If you do not need to detect the revolution direction of a revolution signal (SPEED), apply pulse input to terminal A.
- If you need to detect the revolution direction, apply phase A and phase B of a rotary encoder to terminals A and B, respectively.
- If you need to measure the electrical angle, apply phase Z of a rotary encoder to terminal Z.

4.2 Auxiliary Input (AUX1/AUX2; option)

CAUTION

Only apply signals that meet the following specifications. Signals that do not meet the specifications, such as those with excessive voltage, may damage the WT1800.

Auxiliary Input Connectors (AUX1/AUX2)



Apply a sensor output DC voltage signal (an analog signal) that meets the following specifications.

DC Voltage (Analog input)

Item	Specifications
Connector type	Isolated BNC connector
Input range	50 mV, 100 mV, 200 mV, 500 mV, 1 V, 2 V, 5 V, 10 V, 20 V
Effective input range	0% to ±110% of the measurement range
Input resistance	Approx. 1 MΩ
Maximum allowable input	±22 V
Continuous maximum common-mode voltage	±42 Vpeak or less

4.3 External Clock Input (EXT CLK IN)

CAUTION

Only apply signals that meet the following specifications. Signals that do not meet the specifications, such as those with excessive voltage, may damage the WT1800.

External Clock Signal Input Connector

Apply a clock signal that meets the following specifications to the external clock input connector (EXT CLK) on the rear panel.

Common

Item	Specifications
Connector type	BNC connector
Input level	TTL (0 V to 5 V)

To Apply a Synchronization Source That Determines the Measurement Period

Item	Specifications
Frequency range	Same as the measurement ranges listed under “Frequency Measurement” in section 6.5, “Features”
Input waveform	50% duty ratio rectangular wave

To Apply a PLL Source during Harmonic Measurement

Item	Specifications
Frequency range	0.5 Hz to 2.6 kHz
Input waveform	50% duty ratio rectangular wave

To Apply a Trigger Source for Displaying Waveforms

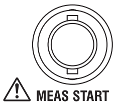
Item	Specifications
Minimum pulse width	1 μs
Trigger delay	Within (1 μs + 3 sample intervals)

4.4 External Start Signal I/O (MEAS START)

CAUTION

- If you have set the WT1800 as the master unit, do not apply an external voltage to the external start signal I/O connector (MEAS. START). Doing so may damage the WT1800.
- If you have set the WT1800 as a slave unit or set External Sync to ON in high speed data capturing mode, only apply signals to the external start signal I/O connector that meet the following specifications. Signals that do not meet the specifications, such as those with excessive voltage, may damage the WT1800.

External Start Signal I/O Connector



To Apply a Master/Slave Synchronization Signal during Normal Measurement

Connect the external start signal I/O connectors on the rear panels of the master and slave instruments using a BNC cable (sold separately).

Item	Specifications	Notes
Connector type	BNC connector	Same for both master and slave
I/O level	TTL (0 to 5 V)	Same for both master and slave
Output logic	Negative logic, falling edge	Applies to the master
Output hold time	Low level, 500 ns or more	Applies to the master
Input logic	Negative logic, falling edge	Applies to slaves
Minimum pulse width	Low level, 500 ns or more	Applies to slaves
Measurement start delay	Within 15 sample intervals	Applies to the master
	Within 1 μs + 15 sample intervals	Applies to slaves

Note

The measurement of the master and slave units cannot be synchronized under the following conditions:

- When the data update interval differs between the master and slave.
- In real-time integration mode or real-time storage mode.

Follow the procedure below to hold values during synchronized measurement.

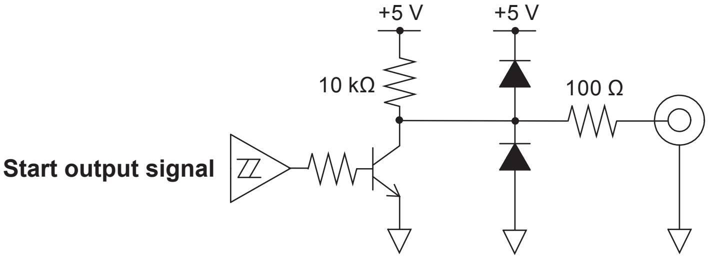
- To hold values: Hold the values on the master first.
- To stop holding values: Stop holding values on the slaves first.

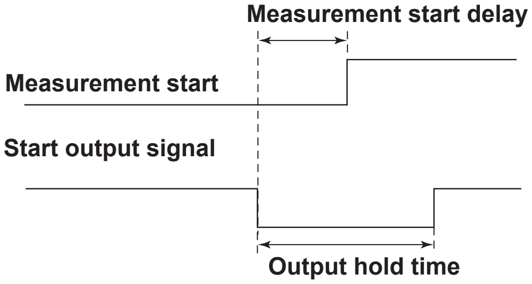
To Apply a External Synchronization Signal during High Speed Data Capturing

Apply a external synchronization signal that meets the following specifications to the external start signal I/O connector (MEAS START) on the rear panel.

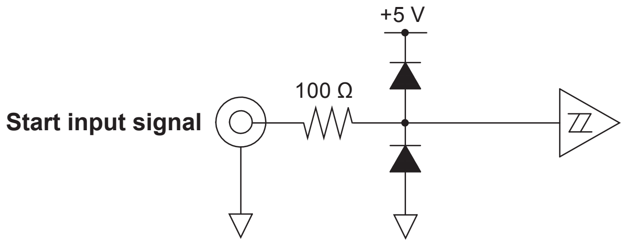
Item	Specifications
Connector type	BNC connector
Input level	TTL (0 to 5 V)
Input logic	Negative logic, falling edge
Minimum pulse width	Low level, 500 ns or more
Measurement start delay	Within 1 μs + 15 sample intervals

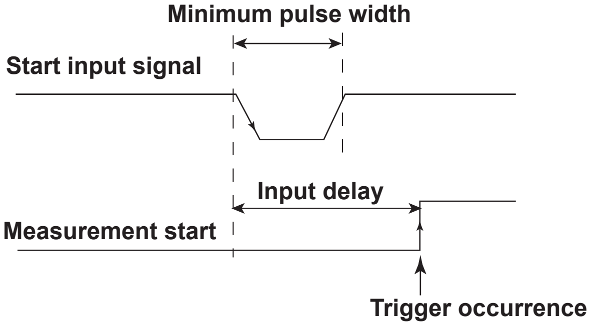
External Start Signal Output Circuit and Timing Chart





External Start Signal Input Circuit and Timing Chart



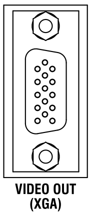


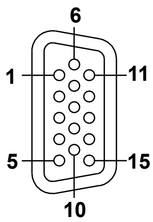
4.5 RGB Output (RGB OUT (XGA); option)

CAUTION

- Only connect the WT1800 to a monitor after turning both the WT1800 and the monitor off.
- Do not short the VIDEO OUT terminal or apply an external voltage to it. Doing so may damage the WT1800.

RGB Output Terminal





D-Sub 15-pin receptacle

You can use RGB output to display the WT1800 screen on a monitor. Any multisync monitor that supports XGA can be connected.

Item	Specifications
Connector type	D-sub 15-pin
Output format	Analog RGB output
Output resolution	XGA output, 1024 × 768 dots, approx. 60 Hz Vsync

Pin No.	Signal	Specifications
1	Red	0.7 V_{P-P}
2	Green	0.7 V_{P-P}
3	Blue	0.7 V_{P-P}
4	—	
5	—	
6	GND	
7	GND	
8	GND	
9	—	
10	GND	
11	—	
12	—	
13	Horizontal sync signal	Approx. 36.4 kHz, TTL positive logic
14	Vertical sync signal	Approx. 60 Hz, TTL positive logic
15	—	

Connecting to a Monitor

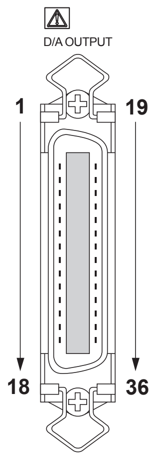
1. Turn off the WT1800 and the monitor.
2. Connect the WT1800 and the monitor using an analog RGB cable.
3. Turn on the WT1800 and the monitor.

4.6 D/A Output and Remote Control (D/A OUTPUT; option)

If you select the /DA option, 20-channel D/A output and remote control features are installed in the WT1800.

Connector Pinout

The connector's pinout is explained in the table below.



Pin No.	Signal	Pin No.	Signal
1	D/A CH1	19	D/A CH2
2	D/A CH3	20	D/A CH4
3	D/A CH5	21	D/A CH6
4	D/A CH7	22	D/A CH8
5	D/A CH9	23	D/A CH10
6	D/A CH11	24	D/A CH12
7	D/A CH13	25	D/A CH14
8	D/A CH15	26	D/A CH16
9	D/A CH17	27	D/A CH18
10	D/A CH19	28	D/A CH20
11	D/A COM	29	D/A COM
12	D/A COM	30	D/A COM
13	D/A COM	31	D/A COM
14	EXT PRINT	32	EXT RESET
15	EXT STOP	33	EXT START
16	EXT SINGLE	34	EXT HOLD
17	INTEG BUSY	35	EXT COM
18	EXT COM	36	EXT COM

Note

The D/A COM and EXT COM signals are connected internally.

D/A Output (D/A OUTPUT)

You can generate numeric data as a ±5 V FS DC voltage signals from the rear panel D/A output connector. You can set up to 20 items (channels).

CAUTION

- Do not short or apply an external voltage to the D/A output terminal. Doing so may damage the WT1800.
- When connecting the D/A output to another device, do not connect the wrong signal pin. Doing so may damage the WT1800 or the connected device.

Item	Specifications
D/A conversion resolution	16 bits
Output voltage	Each rated value ±5 V FS (maximum of approx. ±7.5 V)
Update interval	Same as the WT1800 data update interval (if the waveform display is enabled and the trigger mode is set to Auto or Normal, the data update interval depends on the trigger operation)
Number of outputs	20 channels The output items can be set for each channel.
Continuous maximum common-mode voltage	±42 Vpeak or less
Relationship between output items and D/A output voltage	See the features guide.

Remote Control

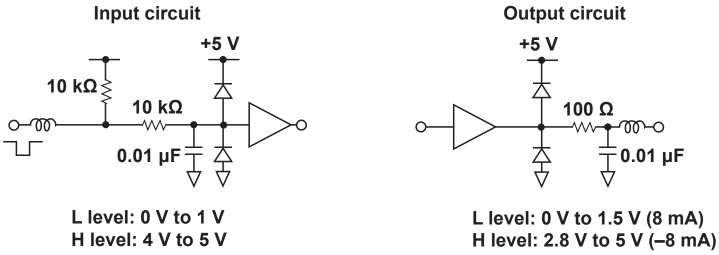
Through external control, you can hold values; perform single measurements; start, stop, and reset integration; and print.

CAUTION

Only apply voltages that are within the range of 0 V to 5 V to the remote control input pins. Do not short or apply external voltages to the output pins. Doing so may damage the WT1800.

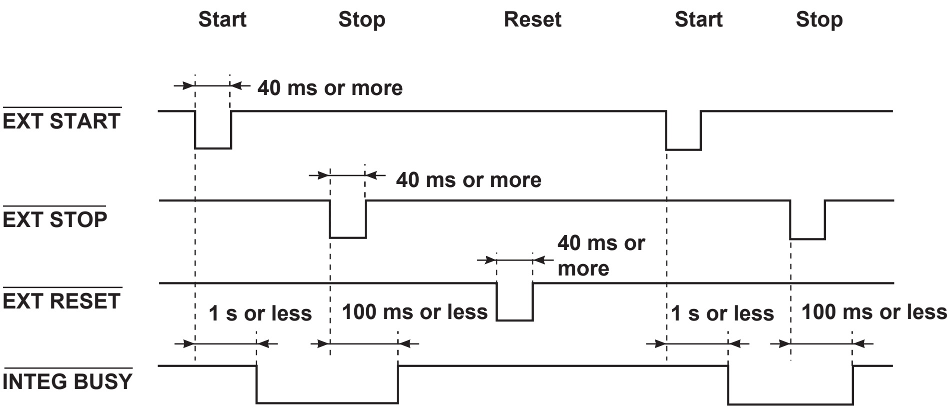
Item	Specifications
Input signal	EXT START, EXT STOP, EXT RESET, EXT HOLD,EXT SINGLE, EXT PRINT
Output signal	INTEG BUSY
Input level	0 V to 5 V

Remote Control I/O Circuit



Controlling Integration Remotely

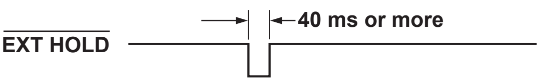
Apply signals according to the following timing chart.



The INTEG BUSY output signal is set to low level during integration.
Use this signal when you are observing integration.

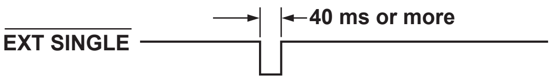
Holding the Updating of Displayed Data (The same functionality as pressing HOLD)

Apply an EXT HOLD signal as shown in the following figure.



Updating Held Display Data (The same functionality as pressing SINGLE)

While the display is being held, you can update it by applying an EXT SINGLE signal.

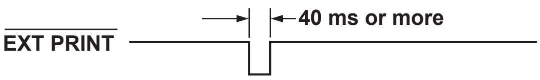


Note

If the width of the low pulse of the EXT SINGLE signal does not meet the conditions shown in the above figure, the signal may not be detected by the WT1800.

Printing on the Built-In Printer (Option; the same functionality as pressing PRINT)

Apply an EXT PRINT signal as shown in the following figure.



5.1 Troubleshooting

Dealing with Problems

- If a message appears on the screen, see the appendix in the user's manual, IM WT1801-02EN.
- If servicing is necessary, or if the instrument does not operate properly even after you have attempted to deal with the problem according to the instructions in this section, contact your nearest YOKOGAWA dealer.

Problems and Solutions		Reference Section
Nothing appears on the screen when you turn on the power.		
	Securely connect the power cord to the instrument and to the power outlet.	2.3
	Set the supply voltage to within the permitted range.	2.3
	Check the screen settings.	20.4[1]
	The built-in power supply fuse may have blown. Servicing is required.	5.2
The displayed data is not correct.		
	Confirm that the ambient temperature and humidity are within their specified ranges.	2.2
	Confirm that noise is not affecting the measurement.	2.1, 2.5
	Check the measurement cable wiring.	2.8-2.11
	Check the wiring system.	2.8-2.11, 1.1[1]
	Confirm that the line filter is off.	1.13[1]
	Check the measurement period settings.	1.12[1]
	Check the FAQ at the following URL. http://tmi.yokogawa.com/	—
	Turn the power off and then on again.	2.4
Keys do not work.		
	Check the REMOTE indicator. If the REMOTE indicator is illuminated, press LOCAL to turn it off.	—
	Confirm that keys are not locked.	20.10[1]
	Perform a key test. If the test fails, servicing is necessary.	20.7[1]
Triggering does not work.		
	Check the trigger conditions.	9.1[1]
	Confirm that the trigger source is being applied.	9.1[1]
Unable to make harmonic measurements.		
	Check the PLL source settings.	2.1[1]
	Confirm that the input signal that you have selected as the PLL source meets the specifications.	2.1[1]
Cannot print to the built-in printer.		
	The printer head may be damaged or worn out. Servicing is required.	—
Unable to recognize a storage medium.		
	Check the storage medium format. If necessary, format the storage medium.	—
	The storage medium may be damaged.	—
Unable to save data to the selected storage medium.		
	If necessary, format the storage medium.	—
	Check the free space on the storage medium. Remove files or use a different storage medium as necessary.	—
Unable to configure or control the instrument through the communication interface.		
	Confirm that the GP-IB address and the IP address settings meet the specifications.	—[2]
	Confirm that the interface meets the electrical and mechanical specifications.	—[2]

1 See the user's manual, IM WT1801-02EN.
2 See the communication interface user's manual, IM WT1801-17EN.

5.2 Power Supply Fuse

Because the power supply fuse used by this instrument is inside the case, you cannot replace it yourself. If you believe that the power supply fuse inside the case has blown, contact your nearest YOKOGAWA dealer.

5.3 Recommended Replacement Parts

Contact your nearest YOKOGAWA dealer to have parts replaced.

Part Name	Recommended Replacement Interval
Built-in printer	Under normal conditions of use, the period it takes to use 200 rolls of printer paper (part number: B9316FX)
Cooling fan	3 years
Backup battery (lithium)	3 years

6.1 Input

Item	Specifications
Input terminal type	Voltage Plug-in terminal (safety terminal) Current • Direct input: large binding post • External current sensor input: isolated BNC connector
Input format	Voltage Floating input through resistive voltage divider Current Floating input through shunt
Measurement range	Voltage Crest factor 3: 1.5 V, 3 V, 6 V, 10 V, 15 V, 30 V, 60 V, 100 V, 150 V, 300 V, 600 V, 1000 V Crest factor 6: 0.75 V, 1.5 V, 3 V, 5 V, 7.5 V, 15 V, 30 V, 50 V, 75 V, 150 V, 300 V, 500 V Current • Direct input 50 A input elements Crest factor 3: 1 A, 2 A, 5 A, 10 A, 20 A, 50 A Crest factor 6: 500 mA, 1 A, 2.5 A, 5 A, 10 A, 25 A 5 A input elements Crest factor 3: 10 mA, 20 mA, 50 mA, 100 mA, 200 mA, 500 mA, 1 A, 2 A, 5 A Crest factor 6: 5 mA, 10 mA, 25 mA, 50 mA, 100 mA, 250 mA, 500 mA, 1 A, 2.5 A • External current sensor input Crest factor 3: 50 mV, 100 mV, 200 mV, 500 mV, 1 V, 2 V, 5 V, 10 V Crest factor 6: 25 mV, 50 mV, 100 mV, 250 mV, 500 mV, 1 V, 2.5 V, 5 V
Input impedance	Voltage Input resistance: Approx. 2 MΩ; input capacitance: Approx. 10 pF Current • Direct input 50 A input element: approx. 2 mΩ + approx. 0.07 μH 5 A input element: approx. 100 mΩ + approx. 0.07 μH • External current sensor input: approx. 1 MΩ
Instantaneous maximum allowable input (within 20 ms)	Voltage Peak value of 4 kV or rms value of 2 kV, whichever is less. Current • Direct input (50 A input element): peak value of 450 A or rms value of 300 A, whichever is less • Direct input (5 A input element): peak value of 30 A or rms value of 15 A, whichever is less • External current sensor input: peak value less than or equal to 10 times the range
Instantaneous maximum allowable input (within 1 s)	Voltage Peak value of 3 kV or rms value of 1.5 kV, whichever is less Current • Direct input (50 A input element): peak value of 150 A or rms value of 55 A, whichever is less • Direct input (5 A input element): peak value of 10 A or rms value of 7 A, whichever is less • External current sensor input: peak value less than or equal to 10 times the range
Continuous maximum allowable input	Voltage Peak value of 2 kV or rms value of 1.1 kV, whichever is less If the frequency of the input voltage exceeds 100 kHz, (1200 − f) Vrms or less f is the frequency of the input voltage in units of kHz. Current • Direct input (50 A input element): peak value of 150 A or rms value of 55 A, whichever is less • Direct input (5 A input element): peak value of 10 A or rms value of 7 A, whichever is less • External current sensor input: peak value less than or equal to 5 times the range
Continuous maximum common-mode voltage (50/60 Hz)	Voltage input terminals: 1000 Vrms Current input terminals with /EX1 to /EX6 option*: 1000 Vrms (maximum allowable voltage that can be measured) 600 Vrms (rating voltage of EN61010-2-030) without /EX1 to /EX6 option: 1000 Vrms External current sensor input connector: 600 Vrms

Item	Specifications
Influence of common-mode voltage	When 1000 Vrms is applied between the input terminal and case with the voltage input terminals shorted, the current input terminals open, and the external current sensor input terminals shorted. • 50/60 Hz: ±0.01% of range or less. • Reference value for up to 100 kHz: ±{(maximum rated range)/(rated range) × 0.001 × f% of range} or less For external current sensor input, add maximum rated range/rated range × {0.0125 × log(f × 1000) − 0.021}% of range to the value above. 0.01% or greater. The unit of f is kHz. The maximum rated range in the equation is 1000 V, 50 A, 5 A, or 10 V.
Line filter	Select from off, 100 Hz to 100 kHz (in steps of 100 Hz), 300 kHz, and 1 MHz.
Frequency filter	Select from off, 100 Hz, and 1 kHz.
A/D converter	Converts voltage and current inputs simultaneously Resolution: 16 bits Conversion rate (sampling interval): approx. 500 ns. For the values when displaying harmonics, see the sections on harmonic measurement.
Range switching	The range can be set for each input element.
Auto range feature	Range increase • When Urms or Irms exceeds 110% of the measurement range. • When the peak value of the input signal exceeds approximately 330% (approximately 660% when the crest factor is set to 6) of the range. Range decrease The range is decreased when all the following conditions are met. • The measured Urms or Irms value is less than or equal to 30% of the range. • The measured Upk or Ipk value is less than or equal to 300% (approximately 600% when the crest factor is set to 6) of the lower range. • The measured Urms or Irms value is less than or equal to 105% of the lower range (the range to decrease to).
Rated voltage to ground	Voltage input terminals: 1000 V Current input terminals with /EX1 to /EX6 option*: 1000 V (maximum allowable voltage that can be measured) 600 V (rating voltage of EN61010-2-030) without /EX1 to /EX6 option: 1000 V External current sensor input connector: 600 V

* Do not touch the inside of the external current sensor input BNC connector.

6.2 Display

Item	Specifications
Display	8.4-inch color TFT LCD
Resolution of the entire screen*	1024 × 768 dots (H × V)
Display update rate	Same as the data update rate. However, 1) When only the numeric display is in use and the data update rate is 50 ms, 100 ms, or 200 ms, the display update rate is a value in the range of 200 ms to 500 ms (the rate varies depending on the number of displayed items). 2) When a display other than the numeric display (including the Custom display) is in use and the data update rate is 50 ms, 100 ms, 200 ms, or 500 ms, the display update rate is 1 s. 3) If the measurement mode display is set to Normal Mode (Trg), measurement takes place from when a trigger is detected over the data update interval. The following amount of time is required for the WT1800 to compute the measured data, process it for displaying, and so on, and become ready for the next trigger. • When the data update interval is 50 ms to 500 ms: Approx. 1 s • When the data update interval is 1 s to 5 s: Data update interval + 500 ms In this case, storage, communication output, and D/A output operate in sync with the triggers. If the measurement mode display is set to Normal Mode, storage, communication output, and D/A output operate in sync with the data update interval.

* Relative to the total number of pixels, 0.002% of the LCD screen may be defective.

6.3 Displayed Items

Numeric Display

Measurement Functions Determined for Each Input Element

For details about how the measurement function values are computed and determined, see appendix 1.

Item	Symbols and Meanings
Voltage (V)	Urms: true rms value, Umn: rectified mean value calibrated to the rms value, Udc: simple average, Urmn: rectified mean value, Uac: AC component
Current (A)	Irms: true rms value, Imn: rectified mean value calibrated to the rms value, Idc: simple average, Irmn: rectified mean value, Iac: AC component
Active power (W)	P
Apparent power (VA)	S
Reactive power (var)	Q
Power factor	λ
Phase difference (°)	Φ
Frequency (Hz)	fU (FreqU): voltage frequency, fI (FreqI): current frequency You can simultaneously measure three frequencies from the frequencies fU and fI of all the installed elements. On models with the add-on frequency measurement option, the fU and fI of all elements can be measured simultaneously. For signals that are not selected, [--------] (no data) is displayed.
Voltage max. and min. (V)	U+pk: maximum voltage, U-pk: minimum voltage
Current max. and min. (A)	I+pk: maximum current, I-pk: minimum current
Power max. and min. (W)	P+pk: maximum power, P-pk: minimum power
Crest factor (peak-to-rms ratio)	CfU: voltage crest factor, CfI: current crest factor
Corrected power (W)	Pc Applicable standards IEC76-1 (1976), IEC76-1 (1993)
Integration	Time: integration time WP: sum of positive and negative watt hours WP+: sum of positive P (consumed watt hours) WP-: sum of negative P (watt hours returned to the power supply) q: sum of positive and negative ampere hours q+: sum of positive I (ampere hours) q-: sum of negative I (ampere hours) WS: volt-ampere hours WQ: var hours By using the current mode setting, you can select to integrate the ampere hours using Irms, Imn, Idc, Irmn, or Iac.

Measurement Functions (Σ Functions) Determined for Each Wiring Unit (ΣA, ΣB, and ΣC)

For details about how Σ function values are computed and determined, see appendix 1.

Item	Symbols and Meanings
Voltage (V)	UrmsΣ: true rms value, UmnΣ: rectified mean value calibrated to the rms value, UdcΣ: simple average, UrmnΣ: rectified mean value, UacΣ: AC component
Current (A)	IrmsΣ: true rms value, ImnΣ: rectified mean value calibrated to the rms value, IdcΣ: simple average, IrmnΣ: rectified mean value, IacΣ: AC component
Active power (W)	PΣ
Apparent power (VA)	SΣ
Reactive power (var)	QΣ
Power factor	λΣ
Phase difference (°)	ΦΣ
Corrected power(W)	PcΣ Applicable standards IEC76-1 (1976), IEC76-1 (1993)
Integration	WPΣ: sum of positive and negative watt hours WP+Σ: sum of positive P (consumed watt hours) WP-Σ: sum of negative P (watt hours returned to the power supply) qΣ: sum of positive and negative ampere hours q+Σ: sum of positive I (ampere hours) q-Σ: sum of negative I (ampere hours) WSΣ: integrated value of SΣ WQΣ: integrated value of QΣ

Harmonic Measurement (Option)

Measurement Functions Determined for Each Input Element

Item	Symbols and Meanings	
Voltage (V)	U(k): rms voltage value of harmonic order k[1]	U: total rms voltage[2]
Current (A)	I(k): rms current value of harmonic order k	I: total rms current[2]
Active power (W)	P(k): active power of harmonic order k	P: total active power[2]
Apparent power (VA)	S(k): apparent power of harmonic order k	S: total apparent power[2]
Reactive power (var)	Q(k): reactive power of harmonic order k	Q: total reactive power[2]
Power factor	λ(k): power factor of harmonic order k	λ: total power factor[2]
Phase difference (°)	Φ(k): phase difference between the voltage and current of harmonic order k, Φ: total phase difference ΦU(k): phase difference between harmonic voltage U(k) and the fundamental wave U(1) ΦI(k): phase difference between harmonic current I(k) and the fundamental wave I(1)	
Load circuit impedance (Ω)	Z(k): impedance of the load circuit in relation to harmonic order k	
Load circuit resistance and reactance (Ω)	Rs(k):resistance of the load circuit in relation to harmonic order k when resistor R, inductor L, and capacitor C are connected in series Xs(k):reactance of the load circuit in relation to harmonic order k when resistor R, inductor L, and capacitor C are connected in series Rp(k): resistance of the load circuit in relation to harmonic order k when R, L, and C are connected in parallel Xp(k):reactance of the load circuit in relation to harmonic order k when R, L, and C are connected in parallel	
Harmonic distortion factor (%)	Uhdf(k): ratio of harmonic voltage U(k) to U(1) or U Ihdf(k): ratio of harmonic current I(k) to I(1) or I Phdf(k): ratio of harmonic active power P(k) to P(1) or P	
Total harmonic distortion (%)	Uthd: ratio of the total harmonic voltage to U(1) or U[3] Ithd: ratio of the total harmonic current to I(1) or I[3] Pthd: ratio of the total harmonic active power to P(1) or P[3]	
Telephone harmonic factor (applicable standard: IEC34-1 (1996))	Uthf: voltage telephone harmonic factor, Ithf: current telephone harmonic factor	
Telephone influence factor (applicable standard: IEEE Std 100 (1996))	Utif: voltage telephone influence factor, Itif: current telephone influence factor	
Harmonic voltage factor[4]	hvf: harmonic voltage factor	
Harmonic current factor[4]	hcf: harmonic current factor	
K-factor	Ratio of the sum of squares whose harmonic components are weighted to the sum of squares of the electric current harmonics	

1 Harmonic order k is an integer from 0 to the upper limit of harmonic analysis. The 0th order is the DC component. The upper limit is determined automatically according to the PLL source frequency. It can go up to the 500th harmonic order.
2 The total value is determined according to the equation on page App-4 from the fundamental wave (1st order) and all harmonic components (2nd order to the upper limit of harmonic analysis). The DC component can also be included.
3 Total harmonic values are determined from all harmonic components (the 2nd order to the upper limit of harmonic analysis) according to the equations on App-5.
4 The expression may vary depending on the definitions in the standard. For details, see the corresponding standard.

Measurement Functions that Indicate Fundamental Voltage and Current Phase Differences between Input Elements

These measurement functions indicate the phase differences between the fundamental voltage U(1) of the smallest numbered input element in a wiring unit and the fundamental voltages U(1) or currents I(1) of other input elements. The following table indicates the measurement functions for a wiring unit that combines elements 1, 2, and 3.

Item	Symbols and Meanings
Phase angle U1-U2 (°)	ΦU1-U2: phase angle between the fundamental voltage of element 1, which is expressed as U1(1), and the fundamental voltage of element 2, which is expressed as U2(1)
Phase angle U1-U3 (°)	ΦU1-U3: phase angle between U1(1) and the fundamental voltage of element 3, U3(1)
Phase angle U1-I1 (°)	ΦU1-I1: phase angle between U1(1) and the fundamental current of element 1, I1(1)
Phase angle U2-I2 (°)	ΦU2-I2: phase angle between U2(1) and the fundamental current of element 2, I2(1)
Phase angle U3-I3 (°)	ΦU3-I3: phase angle between U3(1) and the fundamental current of element 3, I3(1)
EaU1 to EaU6 (°), EaI1 to EaI6 (°)	Φ × 2/N, where Φ is the phase angle of the fundamental wave of U1 to I6 with the rising edge of the signal received through the Z terminal of the motor evaluation function (option) as the reference. N is the number of poles that have been specified for the motor evaluation function.

6

Specifications

Measurement Functions (Σ Functions) Determined for Each Wiring Unit (ΣA, ΣB, and ΣC)

Item	Symbols and Meanings	
Voltage (V)	UΣ(1): rms voltage of harmonic order 1	UΣ: total rms voltage*
Current (A)	IΣ(1): rms current of harmonic order 1	IΣ: total rms current*
Active power (W)	PΣ(1): active power of harmonic order 1	PΣ: total active power*
Apparent power (VA)	SΣ(1): apparent power of harmonic order 1	SΣ: total apparent power*
Reactive power (var)	QΣ(1): reactive power of harmonic order 1	QΣ: total reactive power*
Power factor	λΣ(1): power factor of harmonic order 1	λΣ: total power factor*

* The total value is determined according to the equation on page App-4 from the fundamental wave (1st order) and all harmonic components (2nd order to the upper limit of harmonic analysis). The DC component can also be included.

Delta Computation (Option)

Item	Delta Computation Setting	Symbols and Meanings
Voltage (V)	difference	ΔU1: differential voltage between u1 and u2 determined through computation
	3P3W->3V3A	ΔU1: unmeasured line voltage computed in a three-phase, three-wire system
	DELTA->STAR	ΔU1, ΔU2, ΔU3: phase voltage computed in a three-phase, three-wire (3V3A) system ΔUΣ = (ΔU1 + ΔU2 + ΔU3)/3
	STAR->DELTA	ΔU1, ΔU2, ΔU3: line voltage computed in a three-phase, four-wire system ΔUΣ = (ΔU1 + ΔU2 + ΔU3)/3
Current (A)	difference	ΔI: differential current between i1 and i2 determined through computation
	3P3W->3V3A	ΔI: unmeasured phase current
	DELTA->STAR	ΔI: neutral line current
	STAR->DELTA	ΔI: neutral line current
Power (W)	difference	—
	3P3W->3V3A	—
	DELTA->STAR	ΔP1, ΔP2, ΔP3: phase power computed in a three-phase, three-wire (3V3A) system ΔPΣ = ΔP1 + ΔP2 + ΔP3
	STAR->DELTA	—

Waveforms and Trends

Item	Specifications
Waveform display	Displays voltage, current, torque, speed, AUX1, and AUX2 waveforms for elements 1 to 6
Trend display	Displays a line graph of measurement function numeric data trends Number of measurement channels: up to 16

Bar Graphs and Vectors (Option)

Item	Specifications
Bar graph display	Displays a bar graph of the amplitude of each harmonic
Vector display	Displays the phase difference between the fundamental voltage signal and fundamental current signal as a vector.

6.4 Accuracy

Voltage and Current

Item	Specifications
Accuracy (at 6 months)	Conditions Temperature: 23°C ± 5°C. Humidity: 30%RH to 75%RH. Input waveform: Sine wave. λ (power factor): 1. Common-mode voltage: 0 V. Crest factor: 3. Line filter: Off. Frequency filter: Set to 1 kHz. After the warm-up time has elapsed. Wired condition after zero-level compensation or measurement range change. The unit of f in the accuracy equations is kHz.

Voltage

Frequency	Accuracy ±(reading error + measurement range error)
DC	±(0.05% of reading + 0.1% of range)
0.1 Hz ≤ f < 10 Hz	±(0.1% of reading + 0.2% of range)
10 Hz ≤ f < 45 Hz	±(0.1% of reading + 0.1% of range)
45 Hz ≤ f ≤ 66 Hz	±(0.1% of reading + 0.05% of range)
66 Hz < f ≤ 1 kHz	±(0.1% of reading + 0.1% of range)
1 kHz < f ≤ 50 kHz	±(0.3% of reading + 0.1% of range)
50 kHz < f ≤ 100 kHz	±(0.6% of reading + 0.2% of range)
100 kHz < f ≤ 500 kHz	±{(0.006 × f)% of reading + 0.5% of range}
500 kHz < f ≤ 1 MHz	±{(0.022 × f−8)% of reading + 1% of range}
Frequency bandwidth	5 MHz (−3 dB, typical)

Current

Frequency	Accuracy ±(reading error + measurement range error)
DC	±(0.05% of reading + 0.1% of range)
0.1 Hz ≤ f < 10 Hz	±(0.1% of reading + 0.2% of range)
10 Hz ≤ f < 45 Hz	±(0.1% of reading + 0.1% of range)
45 Hz ≤ f ≤ 66 Hz	±(0.1% of reading + 0.05% of range)
66 Hz < f ≤ 1 kHz	±(0.1% of reading + 0.1% of range) Direct input of a 50 A input element ±(0.2% of reading + 0.1% of range)
1 kHz < f ≤ 50 kHz	±(0.3% of reading + 0.1% of range) 50 mV, 100 mV, or 200 mV range of an external current sensor’s input ±(0.5% of reading + 0.1% of range) Direct input of a 50 A input element ±{(0.1 × f + 0.2)% of reading + 0.1% of range}
50 kHz < f ≤ 100 kHz	±(0.6% of reading + 0.2% of range) Direct input of a 50 A input element ±{(0.1 × f + 0.2)% of reading + 0.1% of range}
100 kHz < f ≤ 200 kHz	±{(0.00725 × f − 0.125)% of reading + 0.5% of range} Direct input of a 50 A input element ±{(0.05 × f + 5)% of reading + 0.5% of range}
200 kHz < f ≤ 500 kHz	±{(0.00725 × f − 0.125)% of reading + 0.5% of range} Direct input of a 50 A input element Accuracy is not defined.
500 kHz < f ≤ 1 MHz	±{(0.022 × f − 8)% of reading + 1% of range} Direct input of a 50 A input element Accuracy is not defined.
Frequency bandwidth	5 MHz (−3 dB, typical), 5 A input element External current sensor input of a 50 A input element

Power

Item	Specifications	
Accuracy (at 6 months)	Conditions Same as the conditions for the voltage and current accuracies	
	Frequency	Accuracy ±(reading error + measurement range error)
	DC	±(0.05% of reading + 0.1% of range)
	0.1 Hz ≤ f < 10 Hz	±(0.3% of reading + 0.2% of range)
	10 Hz ≤ f < 45 Hz	±(0.1% of reading + 0.2% of range)
	45 Hz ≤ f ≤ 66 Hz	±(0.1% of reading + 0.05% of range)
	66 Hz < f ≤ 1 kHz	±(0.2% of reading + 0.1% of range)
	1 kHz < f ≤ 50 kHz	±(0.3% of reading + 0.2% of range) 50 mV, 100 mV, or 200 mV range of an external current sensor's input ±(0.5% of reading + 0.2% of range) Direct input of a 50 A input element ±{(0.1 × f + 0.2)% of reading + 0.2% of range}
	50 kHz < f ≤ 100 kHz	±(0.7% of reading + 0.3% of range) Direct input of a 50 A input element ±{(0.3 × f − 9.5)% of reading + 0.3% of range}
	100 kHz < f ≤ 200 kHz	±{(0.0105 × f − 0.25)% of reading + 1% of range)} Direct input of a 50 A input element ±{(0.09 × f + 11)% of reading + 1% of range}
	200 kHz < f ≤ 500 kHz	±{(0.0105 × f − 0.25)% of reading + 1% of range)} Direct input of a 50 A input element Accuracy is not defined.
	500 kHz < f ≤ 1 MHz	±{0.048 × f − 20)% of reading + 2% of range)} Direct input of a 50 A input element Accuracy is not defined.

- For the external current sensor range, add the following values to the accuracies listed above:
  DC current accuracy: 50 μV
  DC power accuracy: (50 μV/rated value of the external current sensor range) × 100% of range
- For the direct current input range, add the following values to the accuracies listed above:
  50 A input elements:
    DC current accuracy: 1 mA
    DC power accuracy: (1 mA/rated value of the direct current input range) × 100% of range
  5 A input elements:
    DC current accuracy: 10 μA
    DC power accuracy: (10 μA/rated value of the direct current input range) × 100% of range
- For the accuracies of waveform display data functions Upk and Ipk:
  Add the following values (reference values) to the accuracies listed above. The effective input range is within ±300% (±600% when the crest factor is set to 6) of the range.
    Voltage input: {1.5 × √(15/range) + 0.5}% of range
    Direct current input range:
      50 A input element: 3 × √(1/range)% of range + 10 mA
      5 A input element: {10 × √(10m/range) + 0.5}% of range
    External current sensor input range:
      50 mV to 200 mV range: {10 × √(0.01/range) + 0.5}% of range
      500 mV to 10 V range: {10 × √(0.05/range) + 0.5}% of range
- Influence of temperature changes after zero-level compensation or range change
  Add the following values to the accuracies listed above.
    DC voltage accuracy: 0.02% of range/°C
    Direct current input DC accuracy
      50 A input element: 1 mA/°C
      5 A input element: 10 μA/°C
      External current sensor input DC accuracy: 50 μV/°C
    DC power accuracy: the product of the voltage influence and the current influence
- Influence of self-generated heat caused by voltage input
  Add the following values to the voltage and power accuracies:
    AC input signal: 0.0000001 × U^2% of reading
    DC input signal: 0.0000001 × U^2% of reading + 0.0000001 × U^2% of range
    U is the voltage reading (V).
  Even if the voltage input decreases, the influence from self-generated heat continues until the temperature of the input resistor decreases.
- Influence of self-generated heat caused by current input
  Add the following values to the current and power accuracies of 50 A input elements.
    AC input signal: 0.00006 × I^2% of reading
    DC input signal: 0.00006 × I^2% of reading + 0.004 × I^2 mA

Add the following values to the current and power accuracies of 5 A input elements.
AC input signal: $0.006 \times I^2$% of reading
DC input signal: $0.006 \times I^2$% of reading + $0.004 \times I$% of reading
I is the current reading (A). Even if the current input decreases, the influence from self-generated heat continues until the shunt resistor temperature decreases.

- Accuracy changes caused by data update interval
  When the data update interval is 50 ms, add 0.1% of the reading. When the interval is 100 ms, add 0.05% of the reading.
- Guaranteed accuracy ranges for frequency, voltage, and current
  All accuracy figures for 0.1 Hz to 10 Hz are reference values.
  The voltage and power accuracy figures for 30 kHz to 100 kHz when the voltage exceeds 750 V are reference values.
  The current and power accuracy figures for DC, 10 Hz to 45 Hz, and 400 Hz to 100 kHz when the current exceeds 20 A are reference values.
- The accuracy when the crest factor is 6 is the same as that when the crest factor is 3 after doubling the measurement range.

<table>
<tr><th>Item</th><th>Specifications</th></tr>
<tr><td>Power factor (λ) influence</td><td>When $\lambda = 0$
Apparent power reading × 0.1% in the range of 45 Hz to 66 Hz.
For other frequency ranges, see below. Be aware that these figures are reference values.
5 A input element and external sensor input: apparent power reading × (0.1 + 0.05 × f [kHz])%
50 A input element and direct input: apparent power reading × (0.1 + 0.3 × f [kHz])%
When $0 < \lambda < 1$
(Power reading) × [(power reading error %) + (power range error %) × (power range/indicated apparent power value) + {tan Φ × (influence when λ = 0)%}],
where Φ is the phase angle between the voltage and current.</td></tr>
<tr><td>Line filter influence</td><td>When the cutoff frequency (fc) is 100 Hz to 100 kHz
Voltage and current
Up to approx. (fc/2) Hz: Add $2 \times [1 - \sqrt{1/(1 + (f/fc)^4)}] \times 100 + (20 \times f/300k)$% of reading
Applies to frequencies less than or equal to 30 kHz
Power
Up to approx. (fc/2) Hz: Add $4 \times [1 - \sqrt{1/(1 + (f/fc)^4)}] \times 100 + (40 \times f/300k)$% of reading
Applies to frequencies less than or equal to 30 kHz
When the cutoff frequency (fc) is 300 kHz to 1 MHz
Voltage and current
Up to approx. (fc/10) Hz: Add (20 × f/fc)% of reading.
Power
Up to approx. (fc/10) Hz: Add (40 × f/fc)% of reading.</td></tr>
<tr><td>Lead and lag detection
(Phase angle Φ's
D (lead) and G (lag))</td><td>The lead and lag of the voltage and current inputs can be detected correctly for the following:
• Sine waves
• When the measured value is 50% or more (100% or more when the crest factor is 6) of the measurement range
• Frequency: 20 Hz to 10 kHz
• Phase difference: ±(5° to 175°)</td></tr>
<tr><td>Symbol s in the reactive power QΣ computation</td><td>s is the sign for the lead and lag of each element. It is negative when the voltage leads the current.</td></tr>
<tr><td>Temperature coefficient</td><td>Add ±0.03% of reading/°C within the range of 5°C to 18°C or 28°C to 40°C.</td></tr>
<tr><td>Effective input range</td><td>Udc, Idc: 0% to ±110% of the measurement range
Urms, Irms: 1% to ±110% of the measurement range
Umn, Imn: 10% to 110% of the measurement range
Urmn, Irmn: 10% to 110% of the measurement range
Power:
DC measurement: 0% to ±110%
AC measurement: 1% to 110% of the voltage and current ranges; up to ±110% of the power range
However, the synchronization source level must meet the frequency measurement input signal level. When the crest factor is set to 6, the lower limits are multiplied by 2.</td></tr>
<tr><td>Maximum display</td><td>140% of the rated voltage or current range</td></tr>
<tr><td>Minimum display</td><td>Depending on the measurement range, the following are the minimum values that are displayed:
• Urms, Uac, Irms, and Iac: 0.3% (0.6% when the crest factor is set to 6)
• Umn, Urmn, Imn, and Irmn: 2% (4% when the crest factor is set to 6)
Any values less than these lower limits are displayed as zero. The integrated current q is dependent on the current value.</td></tr>
<tr><td>Lower limit of measurement frequency</td><td><table>
<tr><td>Data update rate</td><td>50 ms</td><td>100 ms</td><td>200 ms</td><td>500 ms</td><td>1 s</td><td>2 s</td><td>5 s</td><td>10 s</td><td>20 s</td></tr>
<tr><td>Lower limit of measurement frequency</td><td>45 Hz</td><td>25 Hz</td><td>12.5 Hz</td><td>5 Hz</td><td>2.5 Hz</td><td>1.25 Hz</td><td>0.5 Hz</td><td>0.2 Hz</td><td>0.1 Hz</td></tr>
</table></td></tr>
<tr><td>Accuracy of apparent power S</td><td>Voltage accuracy + current accuracy</td></tr>
<tr><td>Accuracy of reactive power Q</td><td>Accuracy of apparent power + $(\sqrt{1.0004 - \lambda^2} - \sqrt{1 - \lambda^2}) \times 100$% of range</td></tr>
<tr><td>Accuracy of power factor λ</td><td>$\pm[(\lambda - \lambda/1.0002) + |\cos\Phi - \cos\{\Phi + \sin^{-1}($(influence from the power factor when λ = 0)%/100$)\}|] \pm$ 1 digit. The voltage and current must be within their rated ranges.</td></tr>
<tr><td>Accuracy of phase angle Φ</td><td>$\pm[|\Phi - \{\cos^{-1}(\lambda/1.0002)\}| + \sin^{-1}\{$(influence from the power factor when λ = 0)%/100$\}]$ deg ± 1 digit. The voltage and current must be within their rated ranges.</td></tr>
<tr><td>Accuracy at 1 year</td><td>1.5 times the reading errors for the accuracy at 6 months</td></tr>
</table>

6.5 Features

Measurement Features and Measurement Conditions

Item	Specifications
Crest factor	300 for the minimum effective input 3 or 6 for the measurement range's rated direct input
Measurement period	Period used to determine and compute measurement functions. • Except for watt hours (Wp) and DC ampere hours (q), the measurement period is set using the zero crossing points of the reference signal (synchronization source). • When displaying harmonics: The measurement period is the first 1024 or 8192 points from the beginning of the data update interval at the harmonic sampling frequency.
Wiring system	(1) 1P2W, single-phase, two-wire; (2) 1P3W, single-phase, three-wire; (3) 3P3W, three-phase, three-wire; (4) 3P4W, three-phase, four-wire; and (5) 3P3W(3V3A), three-phase, three wire system that uses a three-voltage, three-current method The selectable wiring systems vary depending on the number of input elements that are installed.
Scaling	Set the current sensor conversion ratio, VT ratio, CT ratio, and power coefficient in the range of 0.0001 to 99999.9999 when applying the external current sensor, VT, or CT output to the instrument.
Averaging	• Using one of the following methods, perform averaging on the normal measurement items: voltage U, current I, power P, apparent power S, or reactive power Q. Power factor λ and phase difference angle Φ are determined from the averaged P and S values. • Select either exponential averages or moving averages. • Exponential average Select the attenuation constant from a value between 2 and 64. • Moving average Select the average count from a value between 8 and 64. • Harmonic measurement Only exponential averaging is valid.
Data update rate	Select from 50 ms, 100 ms, 200 ms, 500 ms, 1 s, 2 s, 5 s, 10 s, and 20 s.
Response time	Data update rate × 2 or less (only during numeric display)
Hold	Holds the data display
Single	Executes a single measurement while measurements are held
Zero-level compensation/ Null	Performs zero-level compensation. Null compensation range: ±10% of range You can configure the null setting individually for each of the following input signals: • Each input element's voltage and current • Rotating speed and torque • AUX1 and AUX2

Frequency Measurement

Item	Specifications
DUT	Up to three of the voltage or current frequencies applied to an input element can be selected and measured. On models with the add-on frequency measurement option, the voltage and current frequencies of all input elements can be measured.
Measurement method	Reciprocal method
Measurement range	

Data Update Rate	Measurement Range
50 ms	45 Hz ≤ f ≤ 1 MHz
100 ms	25 Hz ≤ f ≤ 1 MHz
200 ms	12.5 Hz ≤ f ≤ 500 kHz
500 ms	5 Hz ≤ f ≤ 200 kHz
1 s	2.5 Hz ≤ f ≤ 100 kHz
2 s	1.25 Hz ≤ f ≤ 50 kHz
5 s	0.5 Hz ≤ f ≤ 20 kHz
10 s	0.25 Hz ≤ f ≤ 10 kHz
20 s	0.15 Hz ≤ f ≤ 5 kHz

Item	Specifications
Accuracy	±0.06% of reading ± 0.1 mHz, when the input signal level is 30% or more (60% or more when the crest factor is set to 6) of the measurement range. The equation above holds true given that: • The input signal is less than or equal to two times the frequency lower limit written above. • The input signal is less than or equal to two times the frequency lower limit written above . • The range is 10 mA for the 5 A element. • The range is 1 A for the 50 A element. • The 100 Hz frequency filter is on for frequencies between 0.15 Hz and 100 Hz and the 1 kHz frequency filter is on for frequencies between 100 Hz and 1 kHz.
Number of Displayed Digits (Display Resolution)	5 (99999)
Minimum frequency resolution	0.0001 Hz
Frequency measurement filter	Select from off, 100 Hz, and 1 kHz.

Integration

Item	Specifications
Mode	Manual, normal, continuous, real-time normal, and real-time continuous
Integration timer	Integration can be stopped automatically by a timer that can be set to: 0000h00m00s to 10000h00m00s
Count overflow	When the maximum integration time (10000 hours) is reached or when an integrated value reaches the maximum or minimum displayable integrated value,* the integration time and value at that point are held and integration is stopped. * WP: ±999999 MWh q: ±999999 MAh WS: ±999999 MVAh WQ: ±999999 Mvarh
Accuracy	±(normal measurement accuracy + 0.02% of reading)
Timer accuracy	±0.02% of reading

6

Specifications

6.6 Harmonic Measurement (Option)

Item	Specifications
DUT	All installed elements
Method	PLL synchronization method (no external sampling clock)
Frequency range	The range for the fundamental frequency of the PLL source is 0.5 Hz to 2.6 kHz.
PLL source	• Select the voltage or current of each input element or an external clock. • On models with the /G6 option, you can select two PLL sources and perform dual harmonic measurement. On models with the /G5 option, you can select one PLL source. • Input level With voltage input, 15 V range or higher With direct current input, 50 mA range or higher With external current sensor input, 200 mV range or higher 50% or more of the rated measurement range when the crest factor is 3. 100% or more of the rated measurement range when the crest factor is 6. 20 Hz to 1 kHz for 1 A and 2 A ranges of 50 A elements. • The conditions in which frequency filters are turned on are the same as those for frequency measurements.
FFT data length	1024 when the data update rate is 50 ms, 100 ms, or 200 ms. 8192 when the data update rate is 500 ms, 1 s, 2 s, 5s, 10 s, or 20 s.
Window function	Rectangular
Anti-aliasing filter	Set using the line filter

Sample rates, window widths, and upper limits of harmonic analysis

Number of FFT points: 1024 (when the data update rate is 50 ms, 100 ms, or 200 ms)

			Upper Limit of Harmonic Analysis	
Fundamental Frequency	Sample Rate	Window Width	U, I, P, Φ, ΦU, ΦI	Other Measured Values
15 Hz to 600 Hz	f × 1024	1	500	100
600 Hz to 1200 Hz	f × 512	2	255	100
1200 Hz to 2600 Hz	f × 256	4	100	100

Number of FFT points: 8192 (when the data update rate is 500 ms, 1 s, 2 s, 5 s, 10 s, or 20 s)

			Upper Limit of Harmonic Analysis	
Fundamental Frequency	Sample Rate	Window Width	U, I, P, Φ, ΦU, ΦI	Other Measured Values
0.5 Hz to 1.5 Hz	f × 8192	1	500	100
1.5 Hz to 5 Hz	f × 4096	2	500	100
5 Hz to 10 Hz	f × 2048	4	500	100
10 Hz to 600 Hz	f × 1024	8	500	100
600 Hz to 1200 Hz	f × 512	16	255	100
1200 Hz to 2600 Hz	f × 256	32	100	100

However, when the data update rate is 50 ms, the maximum harmonic order that can be measured is 100.

Item	Specifications
Accuracy	Add the following accuracy values to the normal measurement accuracy values.

• When line filters are turned off

Frequency	Voltage	Current	Power
0.5 Hz ≤ f < 10 Hz	0.05% of reading + 0.25% of range	0.05% of reading + 0.25% of range	0.1% of reading + 0.5% of range
10 Hz ≤ f < 45 Hz	0.05% of reading + 0.25% of range	0.05% of reading + 0.25% of range	0.1% of reading + 0.5% of range
45 Hz ≤ f ≤ 66 Hz	0.05% of reading + 0.25% of range	0.05% of reading + 0.25% of range	0.1% of reading + 0.5% of range
66 Hz < f ≤ 440 Hz	0.05% of reading + 0.25% of range	0.05% of reading + 0.25% of range	0.1% of reading + 0.5% of range
440 Hz < f ≤ 1 kHz	0.05% of reading + 0.25% of range	0.05% of reading + 0.25% of range	0.1% of reading + 0.5% of range
1 kHz < f ≤ 10 kHz	0.5% of reading + 0.25% of range	0.5% of reading + 0.25% of range	1% of reading + 0.5% of range
10 kHz < f ≤ 100 kHz	0.5% of range	0.5% of range	1% of range
100 kHz < f ≤ 260 kHz	1% of range	1% of range	2% of range

• When line filters are turned on
Add the line filter accuracy values to the accuracy values when the line filters are turned off.

The items listed below apply to the tables in this section.
- The crest factor is set to 3.
- λ (the power factor) is 1.
- Power figures that exceed 2.6 kHz are reference values.
- Add the following values when a voltage range is being used:
  Voltage accuracy: 25 mV
  Power accuracy: (25 mV/rated voltage range) × 100% of range
- Add the following values when direct current input is being used:
  5 A elements:
    Current accuracy: 50 μA
    Power accuracy: (50 μA/rated current range) × 100% of range
  50 A elements:
    Current accuracy: 4 mA
    Power accuracy: (4 mA/rated current range) × 100% of range
- Add the following values when an external current sensor range is being used:
  Current accuracy: 2 mV
  Power accuracy: (2 mV/rated external current sensor range) × 100% of range
- Add (n/500)% of reading to the n^{th} component of the voltage and current. Add (n/250)% of reading to the n^{th} component of the power.
- The accuracy when the crest factor is 6 is the same as the accuracy when the crest factor is 3 after doubling the measurement range.
- The guaranteed accuracy ranges for frequency, voltage, and current, are the same as the guaranteed ranges for normal measurement.
- The neighboring harmonic orders may be affected by the side lobes from the input harmonic order.
- When the frequency of the PLL source is 2 Hz or greater, for n^{th} order component input, add ({n/(m + 1)}/50)% of (the n^{th} order reading) to the n + m^{th} order and n − m^{th} order of the voltage and current, and add ({n/(m + 1)}/25)% of (the n^{th} order reading) to the n + m^{th} order and n − m^{th} order of the power.
- When the frequency of the PLL source is less than 2 Hz, for n^{th} order component input, add ({n/(m + 1)}/20)% of (the n^{th} order reading) to the n + m^{th} order and n − m^{th} order of the voltage and current, and add ({n/(m + 1)}/10)% of (the n^{th} order reading) to the n + m^{th} order and n − m^{th} order of the power.

6.7 Motor Evaluation Function (Option)

Item	Specifications
Input terminal	TORQUE, SPEED (A, B, Z)
Input resistance	Approx. 1 MΩ
Input connector type	Isolated BNC

Analog Input

(SPEED is being applied to terminal A.)

Item	Specifications
Range	1 V, 2 V, 5 V, 10 V, 20 V
Input range	±110%
Line filter	Off, 100 kHz, 1 kHz
Continuous maximum allowable input	±22 V
Maximum common-mode voltage	±42 Vpeak
Sampling interval	Approx. 200 kS/s
Resolution	16 bits
Accuracy	±(0.05% of reading + 0.05% of range)
Temperature coefficient	±0.03% of range/°C

Pulse Input

(If you do not need to detect the direction, apply SPEED to terminal A. If you need to detect the direction, apply phase A and phase B of a rotary encoder to terminals A and B, respectively. If you are measuring the electrical angle, apply phase Z of a rotary encoder to terminal Z.)

Item	Specifications
Input range	±12 Vpeak
Frequency measurement range	2 Hz to 1 MHz
Maximum common-mode voltage	±42 Vpeak
Accuracy	±(0.05 + f/500)% of reading ± 1 mHz The unit of f is kHz.
Z terminal input fall time and electrical angle measurement start time	500 ns or less
Detection level	H level: approx. 2 V or more L level: approx. 0.8 V or less
Pulse width	500 ns or more

To measure electrical angles, you need the harmonic measurement option (/G5 or /G6).

6.8 Auxiliary Input (Option)

Item	Specifications
Input terminal	AUX1, AUX2
Input format	Analog
Input resistance	Approx. 1 MΩ
Input connector type	Isolated BNC
Range	50 mV, 100 mV, 200 mV, 500 mV, 1 V, 2 V, 5 V, 10 V, 20 V
Input range	±110%
Line filter	Off, 100 Hz, 1 kHz
Continuous maximum allowable input	±22 V
Maximum common-mode voltage	±42 Vpeak
Sampling interval	Approx. 200 kS/s
Resolution	16 bits
Accuracy	±(0.05% of reading + 0.05% of range) • Add 20 µV/°C for temperature changes after zero-level compensation or range change.
Temperature coefficient	±0.03% of range/°C

6.9 D/A Output and Remote Control (Option)

D/A Output

Item	Specifications
D/A conversion resolution	16 bits
Output voltage	Each rated value ±5 V FS (maximum of approx. ±7.5 V)
Update interval	Same as the WT1800 data update interval (if the waveform display is enabled and the trigger mode is set to Auto or Normal, the data update interval depends on the trigger operation)
Number of outputs	20 channels (the output items can be set for each channel)
Accuracy	±(each measurement function's accuracy + 0.1% of FS); FS = 5 V
Minimum load	100 kΩ
Temperature coefficient	±0.05% of FS/°C
Continuous maximum common-mode voltage	±42 Vpeak or less

Remote Control

Item	Specifications
Signal	EXT START, EXT STOP, EXT RESET,INTEG BUSY, EXT HOLD,EXT SINGLE, EXT PRINT
Input level	0 V to 5 V

6.10 High Speed Data Capturing (Option)

Item	Specifications
Data capturing interval	• 5 ms when External Sync is set to OFF • 1 ms to 100 ms when External Sync is set to ON; synchronized with the external signal applied to the MEAS START terminal
Display update interval	1 s (the last data acquired in a 1 s interval is displayed)
Measurement functions	• Voltage, current, and power (all elements, Σ) Select rms, mean, dc, or r-mean. • Torque, speed, and motor output (option) or AUX1 and AUX2 (option)
Wiring systems	•1P2W, single-phase, two-wire system (DC signal) • 3P4W, three-phase, four-wire system • 3P3W(3V3A), three-phase, three wire system
Line filter	Always on Cutoff frequency: 100 Hz to 100 kHz (in steps of 100 Hz) or 300 kHz
Peak over Status	The indicator lights if a peak over-range occurs even once from start to stop.
Data output destination	• Storage medium: Internal RAM disk or USB memory • Communication interface: GP-IB, Ethernet, or USB-PC Interface The captured data for each second is output together.
Data capture start	Data capturing starts after Start in the HS Settings menu is pressed or the WT1800 receives a communication command, and the trigger conditions are met.
HS filter	Off, 1 Hz to 1000 Hz (in steps of 1 Hz)

6.11 Computations and Event Feature

Item	Specifications
User-defined functions	Used to compute equations that are created by combining measurement function symbols and operators (up to 20 equations can be created).
Efficiency equation	Up to four efficiencies can be displayed by setting the items to measure with the efficiency equation.
User-defined events	Event: Set conditions for measured values. Auto printing, storage, and D/A output can be performed as the result of an event occurring.

6.12 Display

Numeric Display

Item	Specifications
Number of Displayed Digits (Display Resolution)	If the value is less than or equal to 60000: Five digits. If the value is greater than 60000: Four digits.
Number of displayed items	Select from 4, 8, 16, Matrix, ALL, Hrm List Single, Hrm List Dual, and Custom.

Waveform Display

Item	Specifications
Display format	Peak-to-peak compressed data If the time axis setting is set so that there are not enough sampled data, the missing data values are filled using the previous data value.
Time axis	In the range of 0.05 ms to 2 s/div. Must be less than or equal to 1/10 of the data update rate.
Trigger	• Trigger type Edge • Trigger mode Select from off, auto, and normal. Triggering is automatically switched off during integration. • Trigger source Can be set to an external clock signal or to a voltage or current applied to an input element. • Trigger slope Select from rising, falling, and rising and falling. • Trigger level • When the trigger source is set to the voltage or current applied to an input element, the trigger level can be set to a value that is within the range defined by the middle of the screen ± 100% (to the top and bottom edges of the screen). Resolution: 0.1% • When the trigger source is Ext Clk (external clock): TTL level
Time axis zoom feature	None

6.13 Data Storage Feature

Item	Specifications
Storage	Numeric data is stored to the internal memory or to an external USB storage medium.
Maximum file size	1 GB
Storage interval	50 ms (when waveforms are turned off) to 99 hours 59 minutes 59 seconds (if the waveform display is enabled and the trigger mode is set to Auto or Normal, the data update interval depends on the trigger operation)

6.14 File Feature

Item	Specifications
Saving	Setup parameters, waveform display data, numeric data, and screen image data can be saved to a storage medium.
Loading	Saved setup parameters can be loaded from the storage medium.

6.15 Auxiliary I/O Section

External Start Signal I/O Section

To Apply the Master/Slave Synchronization Signal during Normal Measurement

Item	Specifications	
Connector type	BNC connector	(Same for both master and slave)
I/O level	TTL	(Same for both master and slave)
Output logic	Negative logic, falling edge	(Applies to the master)
Output hold time	Low level, 500 ns or more	(Applies to the master)
Input logic	Negative logic, falling edge	(Applies to slaves)
Minimum pulse width	Low level, 500 ns or more	(Applies to slaves)
Measurement start delay	Within 15 sample intervals Within 1 μs + 15 sample intervals	(Applies to the master) (Applies to slaves)

To Apply the External Synchronization Signal during High Speed Data Capturing

Item	Specifications
Connector type	BNC connector
Input level	TTL
Input logic	Negative logic, falling edge
Minimum pulse width	Low level, 500 ns or more
Measurement start delay	Within 1 μs + 15 sample intervals

External Clock Input Section

Common

Item	Specifications
Connector type	BNC connector
Input level	TTL

To Apply the Synchronization Source during Normal Measurement as Ext Clk

Item	Specifications
Frequency range	Same as the measurement ranges listed under “Frequency Measurement”
Input waveform	50% duty ratio rectangular wave

To Apply the PLL Source during Harmonic Measurement as Ext Clk

Item	Specifications
Frequency range	Harmonic measurement option (/G5 or /G6): 0.5 Hz to 2.6 kHz
Input waveform	50% duty ratio rectangular wave

To Apply Triggers

Item	Specifications
Minimum pulse width	1 μs
Trigger delay	Within (1 μs + 15 sample intervals)

RGB Output Section (Option)

Item	Specifications
Connector type	D-sub 15 pin (receptacle)
Output format	Analog RGB output

6.16 Computer Interface

GP-IB Interface

Item	Specifications
Usable devices	National Instruments Corporation • PCI-GPIB or PCI-GPIB+ • PCIe-GPIB or PCIe-GPIB+ • PCMCIA-GPIB or PCMCIA-GPIB+ • GPIB-USB-HS Use driver NI-488.2M Ver. 1.60 or later.
Electrical and mechanical specifications	Complies with IEEE St'd 488-1978 (JIS C 1901-1987)
Functional specifications	SH1, AH1, T6, L4, SR1, RL1, PP0, DC1, DT1, and C0
Protocol	Complies with IEEE St'd 488.2-1992
Code	ISO (ASCII)
Mode	Addressable mode
Address	0 to 30
Clearing remote mode	Press LOCAL to clear remote mode (except during Local Lockout).

Ethernet Interface

Item	Specifications
Ports	1
Connector type	RJ-45 connector
Electrical and mechanical specifications	Complies with IEEE802.3
Transmission system	Ethernet 1000Base-T, 100BASE-TX, 10BASE-T
Communication protocol	TCP/IP
Supported services	FTP server, DHCP, DNS, remote control (VXI-11), SNTP, and FTP client

USB PC Interface

Item	Specifications
Number of ports	1
Connector	Type B connector (receptacle)
Electrical and mechanical specifications	Complies with USB Rev. 2.0
Supported transfer modes	HS (High Speed; 480 Mbps) and FS (Full Speed; 12 Mbps)
Supported protocols	USBTMC-USB488 (USB Test and Measurement Class Ver. 1.0)
PC system requirements	A PC with a USB port, running the English or Japanese version of Windows 7 (32 bit), Windows Vista (32 bit), or Windows XP (32 bit, SP2 or later)

6.17 USB for Peripherals

Item	Specifications
Number of ports	2
Connector type	USB type A (receptacle)
Electrical and mechanical specifications	Complies with USB Rev. 2.0
Supported transfer modes	HS (High Speed; 480 Mbps), FS (Full Speed; 12 Mbps), LS (Low Speed; 1.5 Mbps)
Compatible devices	Mass storage devices that comply with USB Mass Storage Class Ver. 1.1 104 or 109 keyboards that comply with USB HID Class Ver. 1.1 Mouse devices that comply with USB HID Class Ver. 1.1
Power supply	5 V, 500 mA (for each port) You cannot connect devices whose maximum current consumptions exceed 100 mA to two different ports on the WT1800 at the same time.

6.18 Built-in Printer (Option)

Item	Specifications
Print system	Thermal line dot system
Dot density	8 dots/mm
Sheet width	80 mm
Valid recording width	72 mm
Auto print	Set the interval at which you want to print measured values automatically. You can set the start and stop times.

6.19 Safety Terminal Adapter

Item	Specifications
Maximum allowable current	36 A
Dielectric strength	1000 V CATIII
Contact resistance	10 mΩ or less
Contact section	Nickel plating on brass or bronze
Insulator	Polyamide
Core wire	Maximum diameter 1.8 mm
Insulation	Maximum diameter 3.9 mm

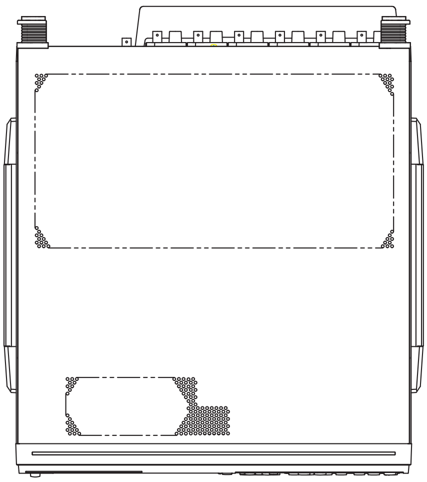
6.20 General Specifications

Item	Specifications
Warm-up time	Approx. 30 minutes
Operating environment	Temperature: 5°C to 40°C Humidity: 20%RH to 80%RH (No condensation)
Elevation	2000 m or less
Installation location	Indoors
Storage environment	Temperature: −25°C to 60°C Humidity: 20%RH to 80%RH (No condensation)
Rated supply voltage	100 VAC to 240 VAC
Permitted supply voltage range	90 VAC to 264 VAC
Rated supply frequency	50/60 Hz
Permitted supply voltage frequency range	48 Hz to 63 Hz
Maximum power consumption	150 VA (when the built-in printer is used)
External dimensions (See section 6.21.)	Approx. 426 (W) × 177 (H) × 459 (D) mm (When the printer cover is not attached; excluding the handle and other protruding parts.)
Weight	Approx. 15 kg (the weight of the main unit with six input elements and all options installed)
Battery backup	Setup parameters and the internal clock are backed up with a lithium battery.
Safety standards[1]	Compliant standard: EN61010-1, EN61010-2-030 The overvoltage category (installation category) is CAT II.[2] The measurement category is CAT II.[3] Pollution degree 2[4]
Emissions[1]	Compliant standards EN61326-1 Class A, EN61000-3-2, EN61000-3-3 EMC Regulatory Arrangement in Australia and New Zealand EN 55011 Class A, Group 1 Korea Electromagnetic Conformity Standard (한국 전자파적합성기준) This product is a Class A (for industrial environments) product. Operation of this product in a residential area may cause radio interference in which case the user is required to correct the interference. Cable conditions • EXT CLK, MEAS. START, motor evaluation function terminals, and AUX input terminals Use BNC cables.[5] • GP-IB interface connector Use a shielded GP-IB cable.[5] • RGB output connector Use a shielded D-sub 15 pin cable.[5] • USB port (PC) Use a shielded USB cable.[5] • USB port (for peripheral devices) Use a USB keyboard that has a shielded cable.[5] • Ethernet connector Use a category 5 or better Ethernet cable (STP).[6]
Immunity[1]	Compliant standard EN61326-1 Table 2 (for industrial locations) Influence in the immunity environment Measurement input: within ±20% of range (When the crest factor is set to 6, within ±40% of range.) D/A output: within ±20% of FS; FS = 5 V Cable conditions The same as the cable conditions listed above for emissions.
Environmental standard[1]	Compliant standard EN50581 Monitoring and control instruments including industrial monitoring and control instruments.

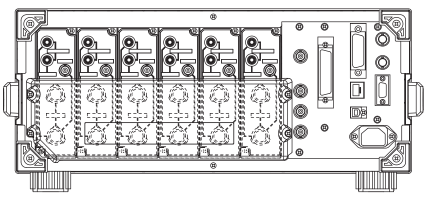
1 Applies to products with CE marks. For information on other products, contact your nearest YOKOGAWA dealer.
2 The overvoltage category (installation category) is a value used to define the transient overvoltage condition and includes the rated impulse withstand voltage. CAT II applies to electrical equipment that is powered through a fixed installation, such as a wall outlet wired to a distribution board.
3 Measurement Category II (CAT II) applies to electrical equipment that is powered through a fixed installation, such as a wall outlet wired to a distribution board, and to measurement performed on such wiring.
4 Pollution Degree applies to the degree of adhesion of a solid, liquid, or gas that deteriorates withstand voltage or surface resistivity. Pollution Degree 2 applies to normal indoor atmospheres (with only non-conductive pollution).
5 Use cables of length 3 m or less.
6 Use cables of length 30 m or less.

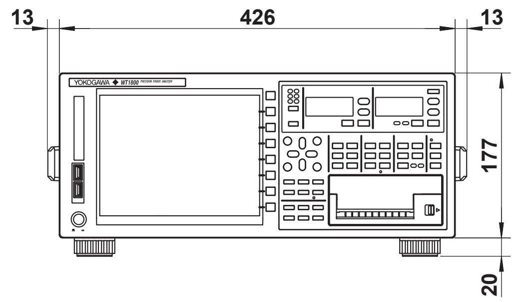
6.21 External Dimensions

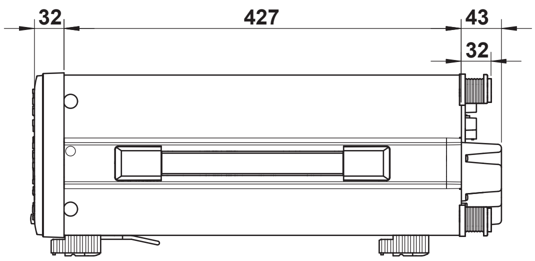
Unit: mm



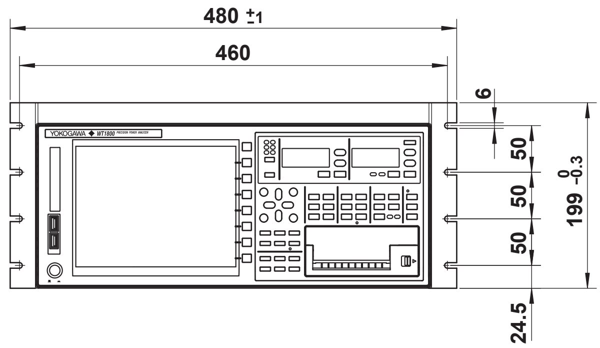
Rear view

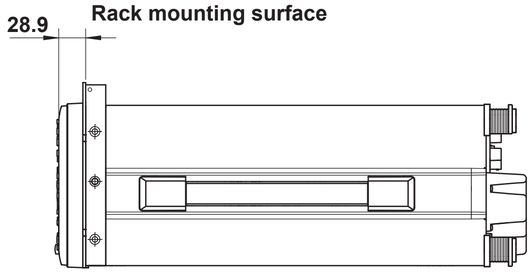




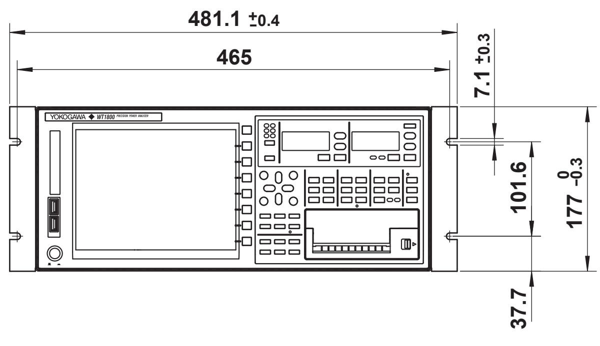


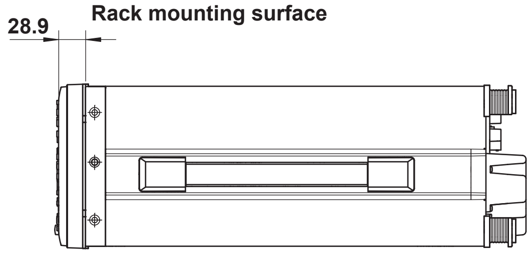
JIS rack mount dimensions





EIA rack mount dimensions





Unless otherwise specified, tolerances are ±3%
(however, tolerances are ±0.3 mm when below 10 mm).

Appendix 1 Symbols and Determination of Measurement Functions

Measurement Functions Used in Normal Measurement

(Table 1/3)

Measurement Function		Methods of Computation and Determination For information about the symbols in the equations, see the notes at the end of page App-3.				
Voltage U [V]	True rms value: Urms Rectified mean value calibrated to the rms value: Umn Simple average: Udc Rectified mean value: Urmn AC component: Uac	Urms	Umn	Udc	Urmn	Uac
		$\sqrt{AVG[u(n)^2]}$	$\frac{\pi}{2\sqrt{2}} AVG[\lvert u(n) \rvert]$	AVG[u(n)]	$AVG[\lvert u(n) \rvert]$	$\sqrt{RMS^2\text{-}DC^2}$
Current I [A]	True rms value: Irms Rectified mean value calibrated to the rms value: Imn Simple average: Idc Rectified mean value: Irmn AC component: Iac	Irms	Imn	Idc	Irmn	Iac
		$\sqrt{AVG[i(n)^2]}$	$\frac{\pi}{2\sqrt{2}} AVG[\lvert i(n) \rvert]$	AVG[i(n)]	$AVG[\lvert i(n) \rvert]$	$\sqrt{RMS^2\text{-}DC^2}$
Active power P [W]		AVG[u(n) · i(n)]				
Apparent power S [VA]	TYPE1, TYPE2	Select from Urms • Irms, Umn • Imn, Udc • Idc, Umn • Irms, and Urmn • Irmn.				
	TYPE3	$\sqrt{P^2 + Q^2}$				
Reactive power Q [var]	TYPE1, TYPE2	$s \cdot \sqrt{S^2 - P^2}$ s is -1 for a lead phase and 1 for a lag phase				
	TYPE3	$\sum_{k=min}^{max} Q(k)$ Q(k) = Ur(k) • Ij(k) –Uj(k) • Ir(k) Ur(k) and Ir(k) are the real number components of U(k) and I(k) Uj(k) and Ij(k) are the imaginary components of U(k) and I(k) Valid only when harmonics are being measured correctly.				
Power factor λ		$\frac{P}{S}$				
Phase difference Φ [˚]		$\cos^{-1}\left(\frac{P}{S}\right)$ The phase angle can be switched between lead (D)/lag (G) display and 360˚ display.				
Voltage frequency: fU (FreqU) [Hz] Current frequency: fI (FreqI) [Hz]		The voltage frequency (fU) and current frequency (fI) are measured by detecting the zero-crossing points. You can simultaneously measure three frequencies from the frequencies fU and fI of all the installed elements. On models with the add-on frequency measurement option, the fU and fI of all elements can be measured simultaneously.				
Maximum voltage: U + pk [V]		The maximum u(n) for every data update				
Minimum voltage: U – pk [V]		The minimum u(n) for every data update				
Maximum current: I + pk [A]		The maximum i(n) for every data update				
Minimum current: I - pk [A]		The minimum i(n) for every data update				
Maximum power: P + pk [W]		The maximum u(n) • i(n) for every data update				
Minimum power: P – pk [W]		The minimum u(n) • i(n) for every data update				
Voltage crest factor: CfU Current crest factor: CfI		Voltage crest factor CfU = $\frac{Upk}{Urms}$ Upk = $\lvert$U + pk$\rvert$ or $\lvert$U – pk$\rvert$ whichever is larger		Current crest factor CfI = $\frac{Ipk}{Irms}$ Ipk = $\lvert$I + pk$\rvert$ or $\lvert$I – pk$\rvert$ whichever is larger		
Corrected Power Pc [W]		IEC76-1(1976), IEEE C57.12.90-1993		IEC76-1(1993)		
		$\frac{P}{P1 + P2\left(\frac{Urms}{Umn}\right)^2}$ P1, P2: coefficients defined in the applicable standards		$P\left(1 + \frac{Umn - Urms}{Umn}\right)$		

(Continued on next page)

(Table 2/3)

Measurement Function			Methods of Computation and Determination For information about the symbols in the equations, see the notes at the end of page App-3.
Integration	Integration time [h:m:s]	Time	Time from integration start to integration stop
	Watt hours [Wh]	WP WP+ WP–	When the watt-hour integration method for each polarity is Charge/Discharge $\left[\frac{1}{N}\sum_{n=1}^{N}\{u(n)\cdot i(n)\}\right]\cdot \text{Time}$ N is the integration time sampling count. The unit of Time is hours. WP is the sum of positive and negative watt hours. WP+ is the sum of the above equations for all iterations where u(n) • i(n) is positive. WP– is the sum of the above equations for all iterations where u(n) • i(n) is negative.
			When the watt-hour integration method for each polarity is Sold/Bought $\left[\frac{1}{N}\sum_{n=1}^{N}\{u(n)\cdot i(n)\}\right]\cdot \text{Time}$ N is the integration time sampling count. The unit of Time is hours. WP is the sum of positive and negative watt hours. WP+ is the sum of the positive power values at each data update interval. WP- is the sum of the negative power values at each data update interval.
	Ampere hours [Ah] q q+ q–	rms, mean, r-mean, ac	$\frac{1}{N}\sum_{n=1}^{N} I(n) \cdot \text{Time}$ I(n) is the nth measured current value. N is the number of data updates. The unit of time is hours.
		dc	$\frac{1}{N}\sum_{n=1}^{N} i(n) \cdot \text{Time}$ i(n) is the nth sampled data of the current signal. N is the number of data samples. The unit of time is hours. q is the sum of i(n)'s positive and negative ampere hours. q+ is the sum of the above equations for all iterations where i(n) is positive. q– is the sum of the above equations for all iterations where i(n) is negative.
	Volt-ampere hours WS[VAh]		$\frac{1}{N}\sum_{n=1}^{N} S(n) \cdot \text{Time}$ S(n) is the nth measured apparent power value. N is the number of data updates. The unit of time is hours.
	Var hours WQ[varh]		$\frac{1}{N}\sum_{n=1}^{N} \lvert Q(n)\rvert \cdot \text{Time}$ Q(n) is the nth measured reactive power value. N is the number of data updates. The unit of time is hours.

Σ functions		Single-phase, three-wire 1P3W	Three-phase, three-wire 3P3W	Three-phase, three-wire with three-voltage, three-current method. 3P3W(3V3A)	Three-phase, four-wire 3P4W
Wiring system					
UΣ [V]		(U1 + U2) / 2		(U1 + U2 + U3) / 3	
IΣ [A]		(I1 + I2) / 2		(I1 + I2 + I3) / 3	
PΣ [W]		P1 + P2			P1 + P2 + P3
SΣ [VA]	TYPE1, TYPE2	S1 + S2	$\frac{\sqrt{3}}{2}(S1 + S2)$	$\frac{\sqrt{3}}{3}(S1 + S2 + S3)$	S1 + S2 + S3
	TYPE3	$\sqrt{P\Sigma^2 + Q\Sigma^2}$			
QΣ [var]	TYPE1	Q1 + Q2			Q1 + Q2 + Q3
	TYPE2	$\sqrt{S\Sigma^2 - P\Sigma^2}$			
	TYPE3	Q1 + Q2			Q1 + Q2 + Q3
PcΣ [W]		Pc1 + Pc2			Pc1 + Pc2 + Pc3

(Table 3/3)

Measurement Function			Methods of Computation and Determination For information about the symbols in the equations see the notes.			
Σ functions	Wiring system		Single-phase, three-wire 1P3W	Three-phase, three-wire 3P3W	Three-phase, three-wire with three-voltage, three-current method. 3P3W(3V3A)	Three-phase, four-wire 3P4W
	WPΣ [Wh]	WPΣ	WP1 + WP2			WP1 + WP2 + WP3
		WP+Σ	When the watt-hour integration method for each polarity is Charge/Discharge WP+1 + WP+2			WP+1 + WP+2 + WP+3
			When the watt-hour integration method for each polarity is Sold/Bought WP+Σ is the sum of the positive active power WPΣ values at each data update interval.			
		WP–Σ	When the watt-hour integration method for each polarity is Charge/Discharge WP–1 + WP–2			WP–1 + WP–2 + WP–3
			When the watt-hour integration method for each polarity is Sold/Bought WP-Σ is the sum of the negative active power WPΣ values at each data update interval.			
	qΣ [Ah]	qΣ	q1 + q2			$q_1 + q_2 + q_3$
		q+Σ	q+1 + q+2			$q_{+1} + q_{+2} + q_{+3}$
		q–Σ	q–1 + q–2			$q_{-1} + q_{-2} + q_{-3}$
	WSΣ [VAh]		$\frac{1}{N}\sum_{n=1}^{N} S\Sigma(n) \cdot Time$ SΣ(n) is the nth apparent power Σ function. N is the number of data updates. The unit of time is hours.			
	WQΣ [varh]		$\frac{1}{N}\sum_{n=1}^{N} \lvert Q\Sigma(n) \rvert \cdot Time$ QΣ(n) is the nth reactive power Σ function. N is the number of data updates. The unit of time is hours.			
	λΣ		$\frac{P\Sigma}{S\Sigma}$			
	ΦΣ [°]		$\cos^{-1}\left(\frac{P\Sigma}{S\Sigma}\right)$			

Note

- u(n) denotes the instantaneous voltage.
- i(n) denotes the instantaneous current.
- n denotes the n^{th} measurement period. The measurement period is determined by the synchronization source setting.
- AVG[ ] denotes the simple average of the item in brackets determined over the data measurement interval. The data measurement interval is determined by the synchronization source setting.
- PΣ denotes the active power of wiring unit Σ. Input elements are assigned to wiring unit Σ differently depending on the number of input elements that are installed in the WT1800 and the selected wiring system pattern.
- The numbers 1, 2, and 3 used in the equations for UrmsΣ, UmnΣ, UrmnΣ, UdcΣ, UacΣ, IrmsΣ, ImnΣ, IrmnΣ, IdcΣ, IacΣ, PΣ, SΣ, QΣ, PcΣ, WPΣ, and qΣ indicate the case when input elements 1, 2, and 3 are set to the wiring system shown in the table.
- Equation Type 3 for SΣ and QΣ can only be selected on models with the harmonic measurement option.
- On the WT1800, S, Q, λ, and Φ are derived through the computation of the measured values of voltage, current, and active power (however, when Type 3 is selected, Q is calculated directly from the sampled data). Therefore, for distorted signal input, the value obtained on the WT1800 may differ from that obtained on other instruments that use a different method.
- For Q [var], when the current leads the voltage, the Q value is displayed as a negative value; when the current lags the voltage, the Q value is displayed as a positive value. The value of QΣ may be negative, because it is calculated from the Q of each element with the signs included.

Measurement Functions Used in Harmonic Measurement (Option)

(Table 1/4)

Measurement Function	Methods of Computation and Determination			
	Numbers and Characters in the Parentheses			Total Value (Total) (No parentheses)
	dc (when k = 0)	1 (when k = 1)	k (when k = 1 to max)	
Voltage U( ) [V]	$U(dc) = U_r(0)$	$U(k) = \sqrt{U_r(k)^2 + U_j(k)^2}$		$U = \sqrt{\sum_{k=min}^{max} U(k)^2}$
Current I( ) [A]	$I(dc) = I_r(0)$	$I(k) = \sqrt{I_r(k)^2 + I_j(k)^2}$		$I = \sqrt{\sum_{k=min}^{max} I(k)^2}$
Active power P( ) [W]	$P(dc) = U_r(0) \cdot I_r(0)$	$P(k) = U_r(k) \cdot I_r(k) + U_j(k) \cdot I_j(k)$		$P = \sum_{k=min}^{max} P(k)$
Apparent power S( ) [VA] (TYPE3)*	$S(dc) = P(dc)$	$S(k) = \sqrt{P(k)^2 + Q(k)^2}$		$S = \sqrt{P^2 + Q^2}$
Reactive power Q( ) [var] (TYPE3)*	$Q(dc) = 0$	$Q(k) = U_r(k) \cdot I_j(k) - U_j(k) \cdot I_r(k)$		$Q = \sum_{k=min}^{max} Q(k)$
Power factor λ ( )	$\lambda(dc) = \frac{P(dc)}{S(dc)}$	$\lambda(k) = \frac{P(k)}{S(k)}$		$\lambda = \frac{P}{S}$
Phase difference Φ ( ) [°]	—	$\Phi(k) = \tan^{-1}\left\{\frac{Q(k)}{P(k)}\right\}$		$\Phi = \tan^{-1}\left(\frac{Q}{P}\right)$
Phase difference with U(1) ΦU( ) [°]	—	—	ΦU(k) = The phase difference between U(k) and U(1)	—
Phase difference with I(1) ΦI( ) [°]	—	—	ΦI(k) = The phase difference between I(k) and I(1)	—
Impedance of the load circuit Z( ) [Ω]	$Z(dc) = \left\lvert\frac{U(dc)}{I(dc)}\right\rvert$	$Z(k) = \left\lvert\frac{U(k)}{I(k)}\right\rvert$		—
Series resistance of the load circuit Rs( ) [Ω]	$Rs(dc) = \frac{P(dc)}{I(dc)^2}$	$Rs(k) = \frac{P(k)}{I(k)^2}$		—
Series reactance of the load circuit Xs( ) [Ω]	$Xs(dc) = \frac{Q(dc)}{I(dc)^2}$	$Xs(k) = \frac{Q(k)}{I(k)^2}$		—
Parallel resistance of the load circuit Rp( ) [Ω] (= 1/G)	$Rp(dc) = \frac{U(dc)^2}{P(dc)}$	$Rp(k) = \frac{U(k)^2}{P(k)}$		—
Parallel reactance of the load circuit Xp( ) [Ω] (= 1/B)	$Xp(dc) = \frac{U(dc)^2}{Q(dc)}$	$Xp(k) = \frac{U(k)^2}{Q(k)}$		—
Frequency of PLL source 1 FreqPLL1[Hz]	Frequency of the PLL source of harmonic group 1 (PLL source 1)			
Frequency of PLL source 2 FreqPLL2[Hz]	Frequency of the PLL source of harmonic group 2 (PLL source 2)			

(Continued on next page)

* For details about the S and Q formula type settings, see "8 Computation", "Apparent Power, Reactive Power, and Corrected Power Equations (Formula)." in the features guide, IM WT1801-01EN.

Note

- k denotes a harmonic order, r denotes the real part, and j denotes the imaginary part.
- U(k), Ur(k), Uj(k), I(k), Ir(k), and Ij(k) are expressed using rms values.
- The minimum harmonic order is denoted by min. min can be set to either 0 (the dc component) or 1 (the fundamental component).
- The upper limit of harmonic analysis is denoted by max. max is either an automatically determined value or the specified maximum measured harmonic order, whichever is smaller.

(Table 2/4)

Measurement Function	Methods of Computation and Determination. The numbers and characters in the parentheses are dc (when k = 0) or k (when k = 1 to max). When the Denominator of the Distortion Factor Equation Is the Total Value (Total)	When the Denominator of the Distortion Factor Equation Is the Fundamental Wave (Fundamental)
Harmonic voltage distortion factor Uhdf( ) [%]	$\frac{U(k)}{U(Total)^{*2}} \cdot 100$	$\frac{U(k)}{U(1)} \cdot 100$
Harmonic current distortion factor Ihdf( ) [%]	$\frac{I(k)}{I(Total)^{*2}} \cdot 100$	$\frac{I(k)}{I(1)} \cdot 100$
Harmonic active power distortion factor Phdf( ) [%]	$\frac{P(k)}{P(Total)^{*2}} \cdot 100$	$\frac{P(k)}{P(1)} \cdot 100$
Total harmonic voltage distortion Uthd [%]	$\frac{\sqrt{\sum_{k=2}^{max} U(k)^2}}{U(Total)^{*2}} \cdot 100$	$\frac{\sqrt{\sum_{k=2}^{max} U(k)^2}}{U(1)} \cdot 100$
Total harmonic current distortion Ithd [%]	$\frac{\sqrt{\sum_{k=2}^{max} I(k)^2}}{I(Total)^{*2}} \cdot 100$	$\frac{\sqrt{\sum_{k=2}^{max} I(k)^2}}{I(1)} \cdot 100$
Total harmonic active power distortion Pthd [%]	$\left\lvert \frac{\sum_{k=2}^{max} P(k)}{P(Total)^{*2}} \right\rvert \cdot 100$	$\left\lvert \frac{\sum_{k=2}^{max} P(k)}{P(1)} \right\rvert \cdot 100$
Voltage telephone harmonic factor Uthf [%] Current telephone harmonic factor Ithf [%]	$Uthf = \frac{1}{U(Total)^{*2}} \sqrt{\sum_{k=1}^{max} \{\lambda(k) \cdot U(k)\}^2} \cdot 100$ $Ithf = \frac{1}{I(Total)^{*2}} \sqrt{\sum_{k=1}^{max} \{\lambda(k) \cdot I(k)\}^2} \cdot 100$ λ(k): coefficient defined in the applicable standard (IEC34-1 (1996))	
Voltage telephone influence factor Utif Current telephone influence factor Itif	$Utif = \frac{1}{U(Total)^{*2}} \sqrt{\sum_{k=1}^{max} \{T(k) \cdot U(k)\}^2}$ $Itif = \frac{1}{I(Total)^{*2}} \sqrt{\sum_{k=1}^{max} \{T(k) \cdot I(k)\}^2}$ T(k): coefficient defined in the applicable standard (IEEE Std 100 (1992))	
Harmonic voltage factor hvf [%]*1 Harmonic current factor hcf [%]*1	$hvf = \frac{1}{U(Total)^{*2}} \sqrt{\sum_{k=2}^{max} \frac{U(k)^2}{k}} \cdot 100$ $hcf = \frac{1}{I(Total)^{*2}} \sqrt{\sum_{k=2}^{max} \frac{I(k)^2}{k}} \cdot 100$	
K-factor	$K\text{-factor} = \frac{\sum_{k=1}^{max} \{I(k)^2 \cdot k^2\}}{\sum_{k=1}^{max} I(k)^2}$	

*1 The expression varies depending on the definitions in the standard. For more details, see the standard (IEC34-1: 1996).

*2 $U(Total) = \sqrt{\sum_{k=min}^{max} U(k)^2}$, $I(Total) = \sqrt{\sum_{k=min}^{max} I(k)^2}$, $P(Total) = \sum_{k=min}^{max} P(k)$

Note

- k denotes a harmonic order, r denotes the real part, and j denotes the imaginary part.
- The minimum harmonic order is denoted by min.
- The upper limit of harmonic analysis is denoted by max. max is either an automatically determined value or the specified maximum measured harmonic order, whichever is smaller.

(Table 3/4)

Measurement Function		Methods of Computation and Determination			
Σ Function	Wiring system	Single-Phase, Three-Wire (1P3W)	Three-Phase, Three-Wire (3P3W)	Three-Voltage, Three-Current Method (3V3A)	Three-Phase, Four-Wire (3P4W)
	UΣ [V]	(U1 + U2) / 2		(U1 + U2 + U3) / 3	
	IΣ [A]	(I1 + I2) / 2		(I1 + I2 + I3) / 3	
	PΣ [W]	P1 + P2			P1 + P2 + P3
	SΣ [VA] (TYPE3)*	$\sqrt{P\Sigma^2 + Q\Sigma^2}$			
	QΣ [var] (TYPE3)*	Q1 + Q2			Q1 + Q2 + Q3
	λΣ	$\frac{P\Sigma}{S\Sigma}$			

* For details about the SΣ and QΣ formula type settings, see “8 Computation”, “Apparent Power, Reactive Power, and Corrected Power Equations (Formula).” in the features guide, IM WT1801-01EN.

Note

- The numbers 1, 2, and 3 used in the equations for UΣ, IΣ, PΣ, SΣ, and QΣ, indicate the case when input elements 1, 2, and 3 are set to the wiring system shown in the table.
- Only the total value and the fundamental wave (1st harmonic) are computed for Σ.

(Table 4/4)

Measurement Function	Methods of Computation and Determination
ΦU1-U2(°)	Phase angle between U1(1) and the fundamental voltage of element 2, U2(1)
ΦU1-U3(°)	Phase angle between U1(1) and the fundamental voltage of element 3, U3(1)
ΦU1-I1(°)	Phase angle between U1(1) and the fundamental current of element 1, I1(1)
ΦU2-I2(°)	Phase angle between U2(1) and the fundamental current of element 2, I2(1)
ΦU3-I3(°)	Phase angle between U3(1) and the fundamental current of element 3, I3(1)
EaU1(°)	Electrical angle: Phase angle of U1 to I6 with the falling edge of the signal received through the Z terminal of the motor evaluation function (option) as the reference.
EaU2(°)	
EaU3(°)	
EaU4(°)	
EaU5(°)	
EaU6(°)	
EaI1(°)	
EaI2(°)	
EaI3(°)	
EaI4(°)	
EaI5(°)	
EaI6(°)	

Note

The numbers 1, 2, and 3 used in the equations indicate the case when input elements 1, 2, and 3 are set to the wiring system shown in the table.

Measurement Functions Used in Delta Computation (Option)

Computed results are determined by substituting all of the sampled data in the table into the equations for voltage U and current I.* The synchronization source used in delta computation is the same source as the source of the first input element (the input element with the smallest number) in the wiring unit that is subject to delta computation.

Measurement Function	Delta Computation Type	Data Determined with the Delta Computation and Corresponding Symbols The computation mode for ΔU1 to ΔU3, ΔUΣ, and ΔI can be set to rms, mean, dc, r-mean, or ac.		Substituted Sampled Data u (t), i (t)
Voltage [V]	Difference	Computed differential voltage	ΔU1[Udiff]	u1 – u2
	3P3W→3V3A	Unmeasured line voltage computed in a three-phase, three-wire system	ΔU1[Urs]	u1 – u2
	Delta→Star	Phase voltage computed in a three-phase, three-wire (3V3A) system	ΔU1[Ur]	$u1 - \frac{(u1 + u2)}{3}$
			ΔU2[Us]	$u2 - \frac{(u1 + u2)}{3}$
			ΔU3[Ut]	$-\frac{(u1 + u2)}{3}$
		Wiring unit voltage $\Delta U\Sigma = \frac{(\Delta U1 + \Delta U2 + \Delta U3)}{3}$	ΔUΣ[UΣ]	—
	Star→Delta	Line voltage computed in a three-phase, four-wire system	ΔU1[Urs]	u1 – u2
			ΔU2[Ust]	u2 – u3
			ΔU3[Utr]	u3 – u1
		Wiring unit voltage $\Delta U\Sigma = \frac{(\Delta U1 + \Delta U2 + \Delta U3)}{3}$	ΔUΣ[UΣ]	—
Current [A]	Difference	Computed differential current	ΔI[Idiff]	i1 – i2
	3P3W→3V3A	Unmeasured phase current	ΔI[It]	–i1 – i2
	Delta→Star	Neutral line current	ΔI[In]	i1 + i2 + i3
	Star→Delta	Neutral line current	ΔI[In]	i1 + i2 + i3
Power [W]	Difference	—	—	—
	3P3W→3V3A	—	—	—
	Delta→Star	Phase power computed in a three-phase, three-wire (3V3A) system	ΔP1[Pr]	$\left\{u1 - \frac{(u1 + u2)}{3}\right\} \cdot i1$
			ΔP2[Ps]	$\left\{u2 - \frac{(u1 + u2)}{3}\right\} \cdot i2$
			ΔP3[Pt]	$\left\{-\frac{(u1 + u2)}{3}\right\} \cdot i3$
		Wiring unit power $\Delta P\Sigma = \Delta P1 + \Delta P2 + \Delta P3$	ΔPΣ[PΣ]	—
	Star→Delta	—	—	—

For the 3P3W→3V3A computation, it is assumed that i1 + i2 + i3 = 0.
For the Delta→Star computation, it is assumed that the center of the delta connection is computed as the center of the star connection.

* The equations for voltage U and current I listed in “Symbols and Determination of Measurement Functions.”

Note

- u1, u2, and u3 represent the sampled voltage data of elements 1, 2, and 3, respectively. i1, i2, and i3 represent the sampled current data of elements 1, 2, and 3, respectively.
- The numbers (1, 2, and 3) that are attached to delta computation measurement function symbols have no relation to the element numbers.
- For details on the rms, mean, dc, rmean, and ac equations of delta computation mode, see page App-1.
- We recommend that you set the measurement range and scaling (conversion ratios and coefficients) of the elements that are undergoing delta computation as closely as possible. Using different measurement ranges or scaling causes the measurement resolutions of the sampled data to be different. This results in errors.

Measurement Functions Used in the Motor Evaluation Function (Option)

Measurement Function	Methods of Computation and Determination
Rotating speed	When the input signal from the revolution sensor is DC voltage (an analog signal): **S(AX + B) – NULL** S: scaling factor A: slope of the input signal X: input voltage from the revolution sensor B: offset NULL: null value When the input signal from the revolution sensor is the number of pulses: $S\frac{X}{N} - NULL$ S: scaling factor X: number of input pulses from the revolution sensor per minute N: number of pulses per revolution NULL: null value
Torque	When the input signal from the torque meter is DC voltage (an analog signal): **S(AX + B) – NULL** S: scaling factor A: slope of the input signal X: input voltage from the torque meter B: offset NULL: null value When the input signal from the torque meter is a pulse signal: **S(AX + B) – NULL** S: scaling factor A: torque pulse coefficient X: pulse frequency B: torque pulse offset NULL: null value The WT1800 computes the torque pulse coefficient and torque pulse offset from torque values (the unit is N•m) at the upper and lower frequency limits. Normally use a scaling factor of 1. If you are using a unit other than N•m, set the unit conversion ratio.
Synchronous speed **SyncSp**	$\frac{120 \cdot \text{the frequency of the frequency measurement source (Hz)}}{\text{Number of motor poles}}$ • The unit of synchronous speed is fixed to min – 1 or rpm. • Normally use the voltage or current supplied by the motor as the frequency measurement source. If you use any other signals, the synchronous speed may not be computed correctly.
Slip **Slip [%]**	$\frac{SyncSp - Speed}{SyncSp} \cdot 100$
Monitor output **Pm**	$\frac{2\pi \cdot Speed \cdot Torque}{60} \cdot \text{Scaling factor}$ When the unit of **speed** is min – 1 or rpm, the unit of **torque** is N•m, and the scaling factor is 1, the unit of motor output **Pm** is W.

Measurement Function		Methods of Computation and Determination
Electrical angle [°]	EaU	$\tan^{-1}\frac{U_r(1)}{U_j(1)} - B$ Ur(1): real part of the fundamental voltage Uj(1): imaginary part of the fundamental voltage B: offset
	EaI	$\tan^{-1}\frac{I_r(1)}{I_j(1)} - B$ Ir(1): real part of the fundamental current Ij(1): imaginary part of the fundamental current B: offset

Use the efficiency equation and the user-defined functions to set the motor efficiency and total efficiency.

Measurement Functions for Auxiliary Input (Option)

Measurement Function	Methods of Computation and Determination
AUX1	**S(AX + B) – NULL** S: scaling factor A: slope of the external signal X: average value of the external signal's input voltage (AVG[AUX_input1(n)]) B: offset NULL: null value
AUX2	**S(AX + B) – NULL** S: scaling factor A: slope of the external signal X: average value of the external signal's input voltage (AVG[AUX_input2(n)]) B: offset NULL: null value

Note

- AUX_input1(n) and AUX_input2(n) denote the instantaneous auxiliary input.
- n denotes the n^{th} measurement period. The measurement period is determined by the synchronization source setting.
- AVG[ ] denotes the simple average of the item in brackets determined over the data measurement interval. The data measurement interval is determined by the synchronization source setting.

Measurement Functions for High Speed Data Capturing (Option)

Measurement Function		Methods of Computation and Determination
U[V]*1	rms	True rms value $\sqrt{\frac{1}{N}\sum_{n=0}^{N-1} \text{HSFilter}[u(n)^2]}$
	mean	Rectified mean value calibrated to the rms value $\frac{\pi}{2\sqrt{2}} \times \frac{1}{N}\sum_{n=0}^{N-1} \text{HSFilter}[\lvert u(n)\rvert]$
	rmean	Rectified mean value $\frac{1}{N}\sum_{n=0}^{N-1} \text{HSFilter}[\lvert u(n)\rvert]$
	dc	Simple average $\frac{1}{N}\sum_{n=0}^{N-1} \text{HSFilter}[u(n)]$

(Continued on next page)

Measurement Function		Methods of Computation and Determination
I[A]*1	rms	True rms value $\frac{1}{N}\sqrt{\sum_{n=0}^{N-1} \text{HSFilter}\,[i(n)^2]}$
	mean	Rectified mean value calibrated to the rms value $\frac{\pi}{2\sqrt{2}} \times \frac{1}{N}\sum_{n=0}^{N-1} \text{HSFilter}\,[\lvert i(n)\rvert]$
	rmean	Rectified mean value $\frac{1}{N}\sum_{n=0}^{N-1} \text{HSFilter}\,[\lvert i(n)\rvert]$
	dc	Simple average $\frac{1}{N}\sum_{n=0}^{N-1} \text{HSFilter}\,[i(n)]$
P[W]*1		Active power $\frac{1}{N}\sum_{n=0}^{N-1} \text{HSFilter}\,[u(n)\times i(n)]$
ΣU[V] Three-phase, four-wire 3P4W	rms	True rms value $\sqrt{\frac{1}{N}\sum_{n=0}^{N-1} \text{HSFilter}\,[\{u1(n)^2+u2(n)^2+u3(n)^2\}/3]}$
	mean*1	Rectified mean value calibrated to the rms value $\frac{\pi}{2\sqrt{2}} \times \frac{1}{N}\sum_{n=0}^{N-1} \text{HSFilter}\,[\{\lvert u1(n)\rvert+\lvert u2(n)\rvert+\lvert u3(n)\rvert\}/3]$
	rmean*1	Rectified mean value $\frac{1}{N}\sum_{n=0}^{N-1} \text{HSFilter}\,[\{\lvert u1(n)\rvert+\lvert u2(n)\rvert+\lvert u3(n)\rvert\}/3]$
	dc	Simple average $\frac{1}{N}\sum_{n=0}^{N-1} \text{HSFilter}\,[\{u1(n)+u2(n)+u3(n)\}/3]$
ΣU[V] Three-phase, three-wire with three-voltage, three-current method. 3P3W(3V3A)	rms	True rms value $\sqrt{\frac{1}{N}\sum_{n=0}^{N-1} \text{HSFilter}\,[\{u1(n)^2+u2(n)^2+u3(n)^2\}/3]}$
	mean*1	Rectified mean value calibrated to the rms value $\frac{\pi}{2\sqrt{2}} \times \frac{1}{N}\sum_{n=0}^{N-1} \text{HSFilter}[\{\lvert u1(n)\rvert+\lvert u2(n)\rvert+\lvert u3(n)\rvert\}/3]$
	rmean*1	Rectified mean value $\frac{1}{N}\sum_{n=0}^{N-1} \text{HSFilter}\,[\{\lvert u1(n)\rvert+\lvert u2(n)\rvert+\lvert u3(n)\rvert\}/3]$
	dc*2	Simple average $\frac{1}{N}\sum_{n=0}^{N-1} \text{HSFilter}\,[\{u1(n)+u2(n)+u3(n)\}/3]$
ΣI[A] Three-phase, four-wire 3P4W	rms	True rms value $\sqrt{\frac{1}{N}\sum_{n=0}^{N-1} \text{HSFilter}\,[\{i1(n)^2+i2(n)^2+i3(n)^2\}/3]}$
	mean*1	Rectified mean value calibrated to the rms value $\frac{\pi}{2\sqrt{2}} \times \frac{1}{N}\sum_{n=0}^{N-1} \text{HSFilter}\,[\{\lvert i1(n)\rvert+\lvert i2(n)\rvert+\lvert i3(n)\rvert\}/3]$
	rmean*1	Rectified mean value $\frac{1}{N}\sum_{n=0}^{N-1} \text{HSFilter}\,[\{\lvert i1(n)\rvert+\lvert i2(n)\rvert+\lvert i3(n)\rvert\}/3]$
	dc	Simple average $\frac{1}{N}\sum_{n=0}^{N-1} \text{HSFilter}\,[\{i1(n)+i2(n)+i3(n)\}/3]$

(Continued on next page)

Measurement Function		Methods of Computation and Determination
ΣI[A] Three-phase, three-wire with three-voltage, three-current method. 3P3W(3V3A)	rms	True rms value $\sqrt{\frac{1}{N}\sum_{n=0}^{N-1}\text{HSFilter}\,[\{i1(n)^2+i2(n)^2+i3(n)^2\}/3]}$
	mean*1	Rectified mean value calibrated to the rms value $\frac{\pi}{2\sqrt{2}}\times\frac{1}{N}\sum_{n=0}^{N-1}\text{HSFilter}\,[\{\lvert i1(n)\rvert+\lvert i2(n)\rvert+\lvert i3(n)\rvert\}/3]$
	rmean*1	Rectified mean value $\frac{1}{N}\sum_{n=0}^{N-1}\text{HSFilter}\,[\{\lvert i1(n)\rvert+\lvert i2(n)\rvert+\lvert i3(n)\rvert\}/3]$
	dc*1	Simple average $\frac{1}{N}\sum_{n=0}^{N-1}\text{HSFilter}\,[\{i1(n)+i2(n)+i3(n)\}/3]$
ΣP[W] Three-phase, four-wire 3P4W		Active power $\frac{1}{N}\sum_{n=0}^{N-1}\text{HSFilter}\,[u1(n)\times i1(n)+u2(n)\times i2(n)+u3(n)\times i3(n)]$
ΣP[W] Three-phase, three-wire with three-voltage, three-current method. 3P3W(3V3A)		Active power $\frac{1}{N}\sum_{n=0}^{N-1}\text{HSFilter}\,[u1(n)\times i1(n)+u2(n)\times i2(n)]$
Torque		Simple average $\frac{1}{N}\sum_{n=0}^{N-1}\text{HSFilter}\,[\text{torque}(n)]$
Speed		Simple average $\frac{1}{N}\sum_{n=0}^{N-1}\text{HSFilter}\,[\text{speed}(n)]$
Pm		See page App-8, "Monitor output Pm".
AUX1		Simple average $\frac{1}{N}\sum_{n=0}^{N-1}\text{HSFilter}\,[\text{aux1}(n)]$
AUX2		Simple average $\frac{1}{N}\sum_{n=0}^{N-1}\text{HSFilter}\,[\text{aux2}(n)]$

*1 It is necessary to set the cutoff frequency of the HS filter to match the frequency of the circuit under measurement.

*2 This value does not have physical meaning when three-phase AC wiring is used.

Note

- In the above equations, u(n) and i(n) denote the nth instantaneous voltage value and the nth instantaneous current value, respectively.
- n indicates the nth item within the data capturing interval. N indicates the number of sampled data items within the data capturing interval. HSFilter indicates that the items enclosed in the brackets that follow have passed through an HS Filter low-pass filter.
- The HS filter is a second order Butterworth filter.
- When the HS filter is enabled, the characteristics of the second order Butterworth filter result in the attenuation (averaging) of the amplitude of the AC components. The response also becomes slower.
- The 16-bit data (instantaneous voltage and current values) from the A/D converter is converted to single-precision floating point data before it undergoes computation.

Appendix 2 Power Basics (Power, harmonics, and AC RLC circuits)

This section explains the basics of power, harmonics, and AC RLC circuits.

Power

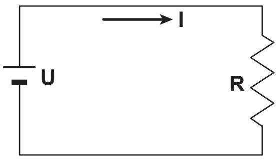
Electrical energy can be converted into other forms of energy and used. For example, it can be converted into the heat in an electric heater, the torque in a motor, or the light in a fluorescent or mercury lamp. In these kinds of examples, the work that electricity performs in a given period of time (or the electrical energy expended) is referred to as electric power. The unit of electric power is watts (W). 1 watt is equivalent to 1 joule of work performed in 1 second.

DC Power

The DC power P (in watts) is determined by multiplying the applied voltage U (in volts) by the current I (in amps).

$P = UI$ [W]

In the example below, the amount of electrical energy determined by the equation above is retrieved from the power supply and consumed by resistance R (in ohms) every second.

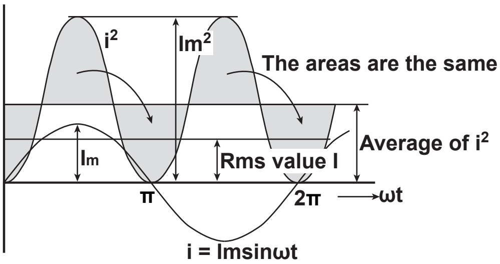


Alternating Current

Normally, the power supplied by power companies is alternating current with sinusoidal waveforms. The magnitude of alternating current can be expressed using values such as instantaneous, maximum, rms, and mean values. Normally, it is expressed using rms values.

The instantaneous value i of a sinusoidal alternating current is expressed by $I_m \sin\omega t$ (where Im is the maximum value of the current, ω is the angular velocity defined as $\omega = 2\pi f$, and f is the frequency of the sinusoidal alternating current). The thermal action of this alternating current is proportional to i^2, and varies as shown in the figure below.*

* Thermal action is the phenomenon in which electric energy is converted to heat energy when a current flows through a resistance.



The rms value (effective value) is the DC value that generates the same thermal action as the alternating current. With I as the DC value that produces the same thermal action as the alternating current:

$$I = \sqrt{\text{The mean of } i^2 \text{ over one period}} = \sqrt{\frac{1}{2\pi}\int_0^{2\pi} i^2\, d\omega t} = \frac{I_m}{\sqrt{2}}$$

Because this value corresponds to the root mean square of the instantaneous values over 1 period, the effective value is normally denoted using the abbreviation "rms."

To determine the mean value, the average is taken over 1 period of absolute values, because simply taking the average over 1 period of the sine wave results in a value of zero.
With Imn as the mean value of the instantaneous current i (which is equal to Imsinωt):

$$I_{mn} = \text{The mean of } |i| \text{ over one period} = \frac{1}{2\pi}\int_0^{2\pi} |i|\, d\omega t = \frac{2}{\pi} I_m$$

These relationships also apply to sinusoidal voltages.

The maximum value, rms value, and mean value of a sinusoidal alternating current are related as shown below. The crest factor and form factor are used to define the tendency of an AC waveform.

$$\text{Crest factor} = \frac{\text{Maximum value}}{\text{Rms value}}$$

$$\text{Form factor} = \frac{\text{Rms value}}{\text{Mean value}}$$

Vector Display of Alternating Current

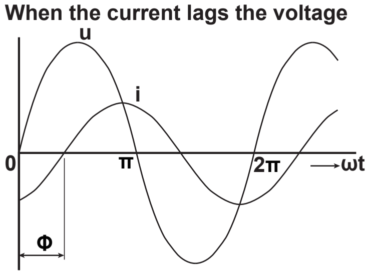
In general, instantaneous voltage and current values are expressed using the equations listed below.

Voltage: u = Umsinωt

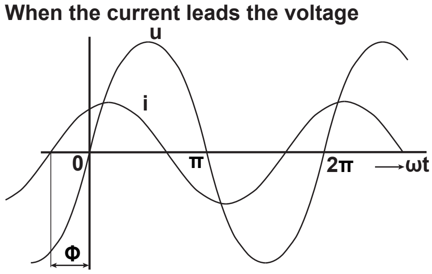
Current: i = Imsin(ωt – Φ)

The time offset between the voltage and current is called the phase difference, and Φ is the phase angle. The time offset is mainly caused by the load that the power is supplied to. In general, the phase difference is zero when the load is purely resistive. The current lags the voltage when the load is inductive (is coiled). The current leads the voltage when the load is capacitive.

When the current lags the voltage

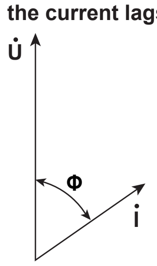


When the current leads the voltage

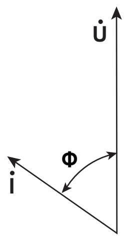


A vector display is used to clearly convey the magnitude and phase relationships between the voltage and current. A positive phase angle is represented by a counterclockwise angle with respect to the vertical axis.
Normally, a dot is placed above the symbol representing a quantity to explicitly indicate that it is a vector. The magnitude of a vector represents the rms value.

When the current lags the voltage

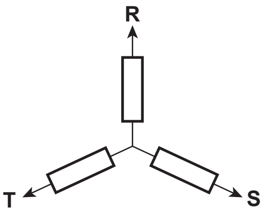


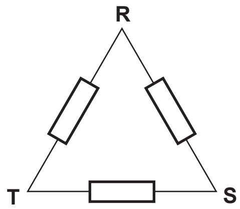
When the current leads the voltage



Three-Phase AC Wiring

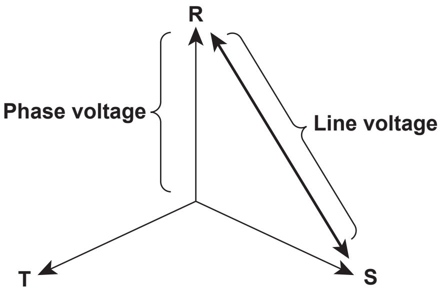
Generally three-phase AC power lines are connected in star wiring configurations or delta wiring configurations.





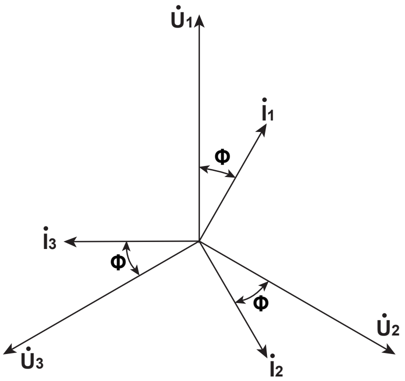
Vector Display of Three-Phase Alternating Current

In typical three-phase AC power, the voltage of each phase is offset by 120°. The figure below expresses this offset using vectors. The voltage of each phase is called the phase voltage, and the voltage between each phase is called the line voltage.



If a power supply or load is connected in a delta wiring configuration and no neutral line is present, the phase voltage cannot be measured. In this case, the line voltage is measured. Sometimes the line voltage is also measured when measuring three-phase AC power using two single-phase wattmeters (the two-wattmeter method). If the magnitude of each phase voltage is equal and each phase is offset by 120°, the magnitude of the line voltage is $\sqrt{3}$ times the magnitude of the phase voltage, and the line voltage phase is offset by 30°.

Below is a vector representation of the relationship between the phase voltages and line currents of a three-phase AC voltage when the current lags the voltage by Φ°.



AC Power

AC power cannot be determined as easily as DC power, because of the phase difference between the voltage and current caused by load.

If the instantaneous voltage $u = U_m \sin\omega t$ and the instantaneous current $i = I m \sin(\omega t - \Phi)$, the instantaneous AC power p is as follows:

$p = u \times i = U_m \sin\omega t \times I_m \sin(\omega t - \Phi) = UI\cos\Phi - UI\cos(2\omega t - \Phi)$

U and I represent the rms voltage and rms current, respectively.

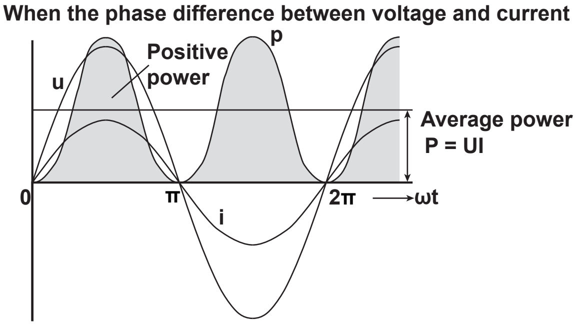
p is the sum of the time-independent term, $UI\cos\Phi$, and the AC component term of the voltage or current at twice the frequency, $-UI\cos(2\omega t - \Phi)$.

AC power refers to the mean power over 1 period. When the mean over 1 period is taken, AC power P is as follows:

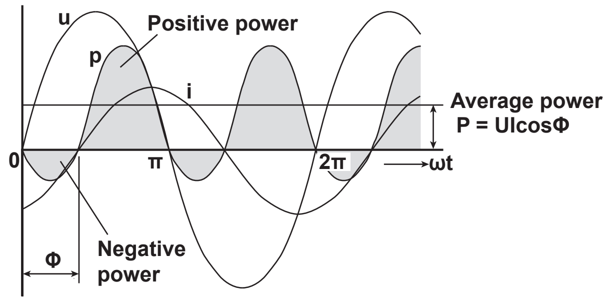
$P = UI\cos\Phi$ [W]

Even if the voltage and current are the same, the power varies depending on the phase difference Φ. The section above the horizontal axis in the figure below represents positive power (power supplied to the load), and the section below the horizontal axis represents negative power (power fed back from the load). The difference between the positive and negative powers is the power consumed by the load. As the phase difference between the voltage and current increases, the negative power increases. At $\Phi = \pi/2$, the positive and negative powers are equal, and the load consumes no power.

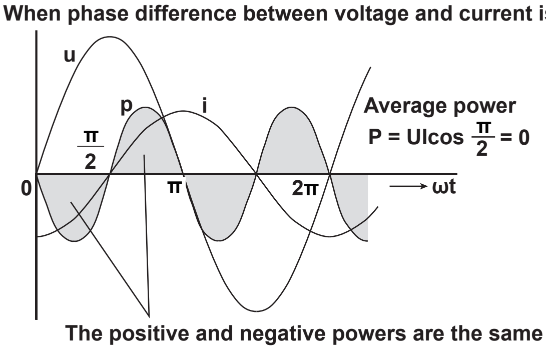
When the phase difference between voltage and current is 0



When the phase difference between voltage and current is Φ



When phase difference between voltage and current is $\frac{\pi}{2}$



Active Power and the Power Factor

In alternating electrical current, not all of the power calculated by the product of voltage and current, UI, is consumed. The product of U and I is called the apparent power. It is expressed as S. The unit of apparent power is the volt-ampere (VA). The apparent power is used to express the electrical capacity of a device that runs on AC electricity.
The true power that a device consumes is called active power (or effective power). It is expressed as P. This power corresponds to the AC power discussed in the previous section.

$S = UI$ [VA]

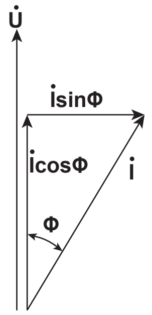
$P = UI\cos\Phi$ [W]

$\cos\Phi$ is called the power factor and is expressed as λ. It indicates the portion of the apparent power that becomes true power.

Reactive Power

If current I lags voltage U by Φ, current I can be broken down into a component in the same direction as voltage U, IcosΦ, and a perpendicular component, IsinΦ. Active power P, which is equal to UIcosΦ, is the product of voltage U and the current component IcosΦ. The product of voltage U and the current component IsinΦ is called the reactive power. It is expressed as Q. The unit of reactive power is the var.

$Q = UI\sin\Phi$ [var]



The relationship between S, the apparent power, P, the active power, and Q, the reactive power is as follows:

$S^2 = P^2 + Q^2$

Harmonics

Harmonics refer to all sine waves whose frequency is an integer multiple of the fundamental wave (normally a 50 Hz or 60 Hz sinusoidal power line signal) except for the fundamental wave itself. The input currents that flow through the power rectification circuits, phase control circuits, and other circuits used in various kinds of electrical equipment generate harmonic currents and voltages in power lines. When the fundamental wave and harmonic waves are combined, waveforms become distorted, and interference sometimes occurs in equipment connected to the power line.

Terminology

The terminology related to harmonics is described below.

- Fundamental wave (fundamental component)
  The sine wave with the longest period among the different sine waves contained in a periodic complex wave. Or the sine wave that has the fundamental frequency within the components of the complex wave.
- Fundamental frequency
  The frequency corresponding to the longest period in a periodic complex wave. The frequency of the fundamental wave.
- Distorted wave
  A wave that differs from the fundamental wave.
- Higher harmonic
  A sine wave with a frequency that is an integer multiple (twice or more) of the fundamental frequency.
- Harmonic component
  A waveform component with a frequency that is an integer multiple (twice or more) of the fundamental frequency.
- Harmonic distortion factor
  The ratio of the rms value of the specified n^{th} order harmonic contained in the distorted wave to the rms value of the fundamental wave (or all signals).
- Harmonic order
  The integer ratio of the harmonic frequency with respect to the fundamental frequency.
- Total harmonic distortion
  The ratio of the rms value of all harmonics to the rms value of the fundamental wave (or all signals).

Interference Caused by Harmonics

Some of the effects of harmonics on electrical devices and equipment are explained in the list below.

- Synchronization capacitors and series reactors
  Harmonic current reduces circuit impedance. This causes excessive current flow, which can result in vibration, humming, overheat, or burnout.
- Cables
  Harmonic current flow through the neutral line of a three-phase, four-wire system will cause the neutral line to overheat.
- Voltage transformers
  Harmonics cause magnetostrictive noise in the iron core and increase iron and copper loss.
- Breakers and fuses
  Excessive harmonic current can cause erroneous operation and blow fuses.
- Communication lines
  The electromagnetic induction caused by harmonics creates noise voltage.
- Controllers
  Harmonic distortion of control signals can lead to erroneous operation.
- Audio visual equipment
  Harmonics can cause degradation of performance and service life, noise-related video flickering, and damaged parts.

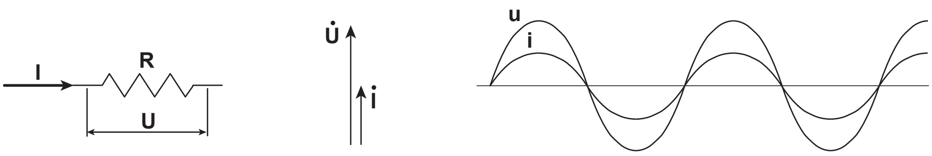
AC RLC Circuits

Resistance

The current i when an AC voltage whose instantaneous value $u = U_m\sin\omega t$ is applied to load resistance R [Ω] is expressed by the equation below. I_m denotes the maximum current.

$$i = \frac{U_m}{R}\sin\omega t = I_m\sin\omega t$$

Expressed using rms values, the equation is I = U/R.
There is no phase difference between the current flowing through a resistive circuit and the voltage.

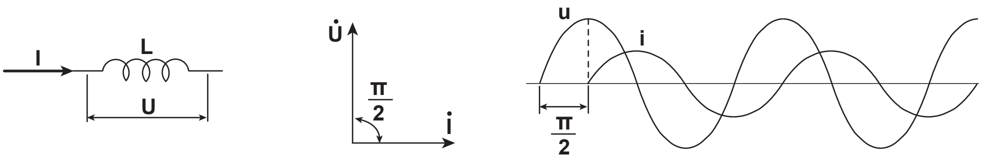


Inductance

The current i when an AC voltage whose instantaneous value $u = U_m\sin\omega t$ is applied to a coil load of inductance L [H] is expressed by the equation below.

$$i = \frac{U_m}{X_L}\sin\left(\omega t - \frac{\pi}{2}\right) = I_m\sin\left(\omega t - \frac{\pi}{2}\right)$$

Expressed using rms values, the equation is $I = U/X_L$. X_L is called inductive reactance and is defined as $X_L = \omega_L$. The unit of inductive reactance is Ω.
Inductance works to counter current changes (increase or decrease), and causes the current to lag the voltage.

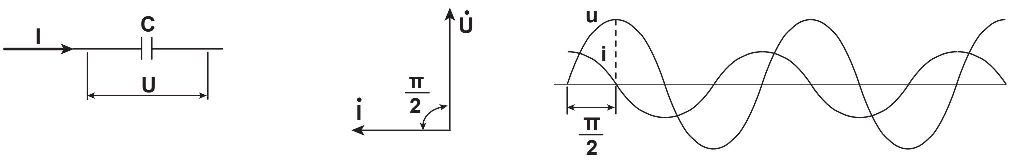


Capacitance

The current i when an AC voltage whose instantaneous value $u = U_m\sin\omega t$ is applied to a capacitive load C [F] is expressed by the equation below.

$$i = \frac{U_m}{X_C}\sin\left(\omega t + \frac{\pi}{2}\right) = I_m\sin\left(\omega t + \frac{\pi}{2}\right)$$

Expressed using rms values, the equation is $I = U/X_C$. X_C is called capacitive reactance and is defined as $X_C = 1/\omega C$. The unit of capacitive reactance is Ω.
When the polarity of the voltage changes, the largest charging current with the same polarity as the voltage flows through the capacitor. When the voltage decreases, discharge current with the opposite polarity of the voltage flows. Thus, the current phase leads the voltage.



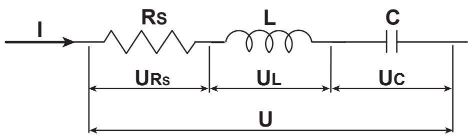
Series RLC Circuits

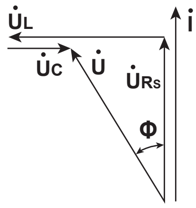
The equations below express the voltage relationships when resistance R_S [Ω], inductance L [H], and capacitance C [F] are connected in series.

$$U = \sqrt{(U_{Rs})^2 + (U_L - U_C)^2} = \sqrt{(IR_S)^2 + (IX_L - IX_C)^2}$$

$$= I\sqrt{(R_S)^2 + (X_L - X_C)^2} = I\sqrt{R_S^2 + X_S^2}$$

$$I = \frac{U}{\sqrt{R_S^2 + X_S^2}}, \quad \Phi = \tan^{-1}\frac{X_S}{R_S}$$





The relationship between resistance R_S, reactance X_S, and impedance Z is expressed by the equations below.

$$X_S = X_L - X_C$$

$$Z = \sqrt{R_S^2 + X_S^2}$$

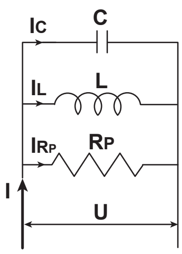
Parallel RLC Circuits

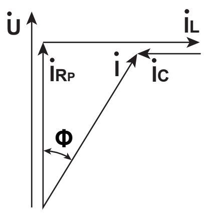
The equations below express the current relationships when resistance R_P [Ω], inductance L [H], and capacitance C [F] are connected in parallel.

$$I = \sqrt{(I_{RP})^2 + (I_L - I_C)^2} = \sqrt{\left(\frac{U}{R_P}\right)^2 + \left(\frac{U}{X_L} - \frac{U}{X_C}\right)^2}$$

$$= U\sqrt{\left(\frac{1}{R_P}\right)^2 + \left(\frac{1}{X_L} - \frac{1}{X_C}\right)^2} = U\sqrt{\left(\frac{1}{R_P}\right)^2 + \left(\frac{1}{X_P}\right)^2}$$

$$U = \frac{IR_PX_P}{\sqrt{R_P^2 + X_P^2}}, \quad \Phi = \tan^{-1}\frac{R_P}{X_P}$$





The relationship between resistance R_P, reactance X_P, and impedance Z is expressed by the equations below.

$$X_P = \frac{X_LX_C}{X_C - X_L}$$

$$Z = \frac{R_PX_P}{\sqrt{R_P^2 + X_P^2}}$$

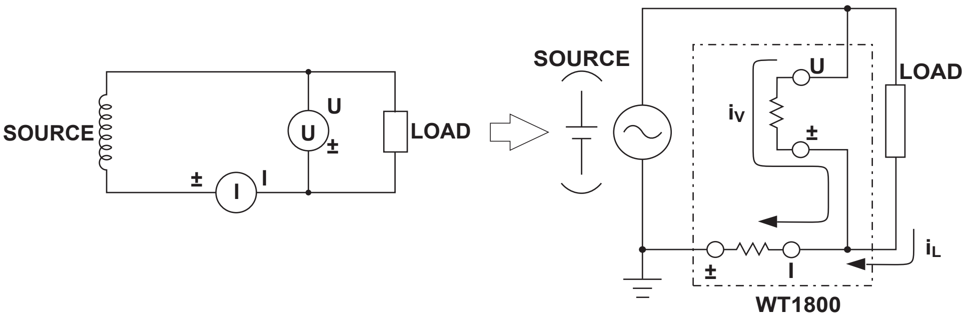
Appendix 3 How to Make Accurate Measurements

Effects of Power Loss

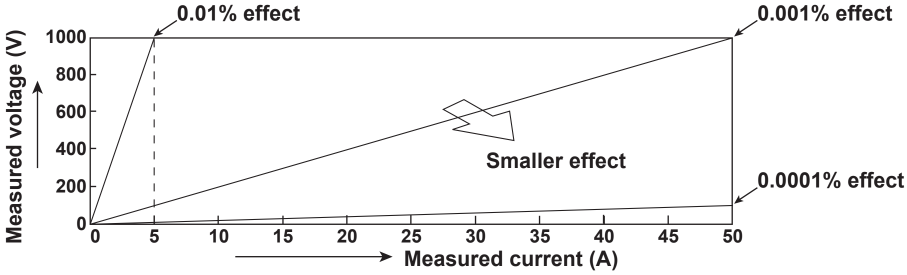
By wiring a circuit to match the load, you can minimize the effects of power loss on measurement accuracy. We will discuss the wiring of the DC power supply (SOURCE) and a load resistance (LOAD) below.

When the Measured Current Is Relatively Large

Connect the voltage measurement circuit between the current measurement circuit and the load. The current measurement circuit measures the sum of i_L and i_V. i_L is the current flowing through the load of the circuit under measurement, and i_V is the current flowing through the voltage measurement circuit. Because the current flowing through the circuit under measurement is i_L, only i_V reduces measurement accuracy. The input resistance of the voltage measurement circuit of the WT1800 is approximately 2 MΩ. If the input voltage is 1000 V, i_V is approximately 0.5 mA (1000 V/2 MΩ). If the load current i_L is 5 A or more (load resistance is 200 Ω or less), the effect of i_V on the measurement accuracy is 0.01% or less. If the input voltage is 100 V and the current is 5 A, i_V = 0.05 mA (100 V/2 MΩ), so the effect of i_V on the measurement accuracy is 0.001% (0.05 mA/5 A).

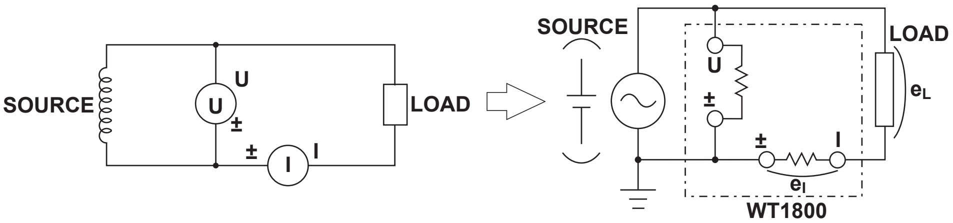


As a reference, the relationships between the voltages and currents that produce effects of 0.01%, 0.001%, and 0.0001% are shown in the figure below.



When the Measured Current Is Relatively Small

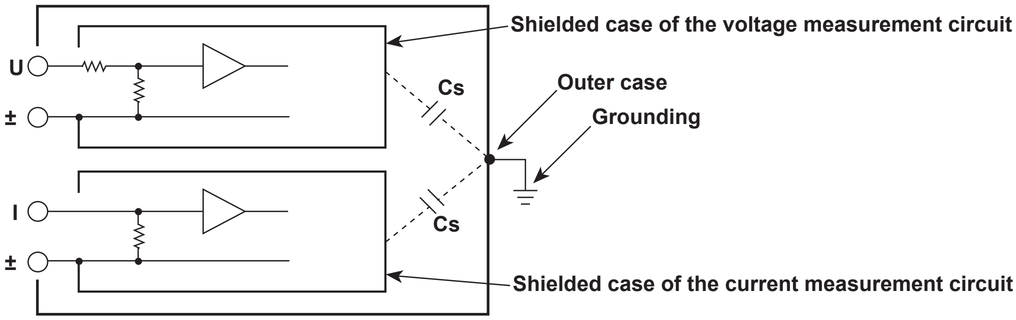
Connect the current measurement circuit between the voltage measurement circuit and the load. In this case, the voltage measurement circuit measures the sum of e_L and e_I. e_L is the load voltage, and e_I is the voltage drop across the current measurement circuit. Only e_I reduces measurement accuracy. The input resistance of the current measurement circuit of the WT1800 is approximately 100 mΩ for the 5 A input terminals and approximately 2 mΩ for the 50 A input terminals. If the load resistance is 1 kΩ, the effect of e_I on the measurement accuracy is approximately 0.01% (100 mΩ/1 kΩ) for the 5 A input terminals and approximately 0.0002% (2 mΩ/1 kΩ) for the 50 A input terminals.



Effects of Stray Capacitance

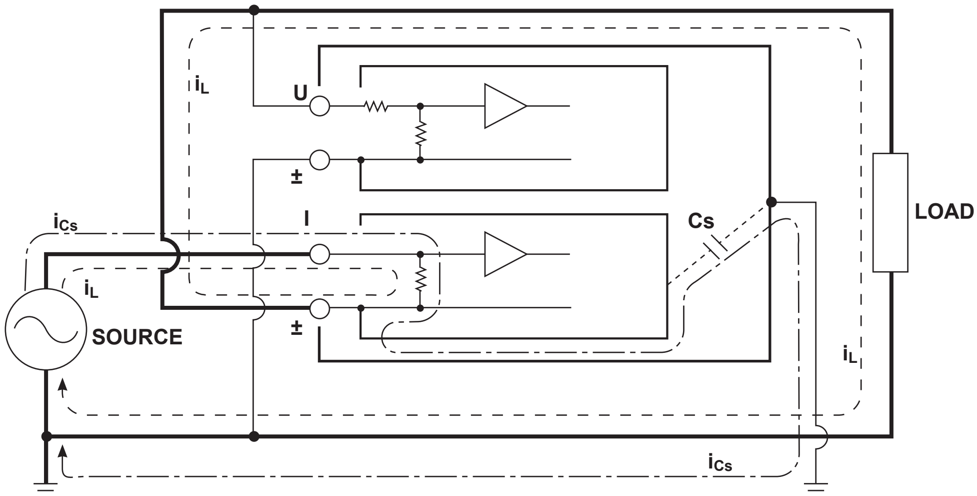
The effects of stray capacitance on measurement accuracy can be minimized by connecting the WT1800 current input terminal to the side of the power supply (SOURCE) that is closest to its earth potential.

The internal structure of the WT1800 is explained below.
The voltage and current measurement circuits are each enclosed in shielded cases. These shielded cases are contained within an outer case. The shielded case of the voltage measurement circuit is connected to the positive and negative voltage input terminals, and the shielded case of the current measurement circuit is connected to the positive and negative current input terminals.
Because the outer case is insulated from the shielded cases, there is stray capacitance, which is expressed as Cs. Cs is approximately 40 pF. The current generated by stray capacitance Cs causes errors.



As an example, we will consider the case when the outer case and one side of the power supply are grounded.
In this case, there are two conceivable current flows, i_L and i_{CS}. i_L is the load current, and i_{CS} is the current that flows through the stray capacitance. i_L flows through the current measurement circuit, then through the load, and returns to the power supply (shown with a dotted line). i_{CS} flows through the current measurement circuit, the stray capacitance, and the earth ground of the outer case, and then returns to the power supply (shown with a dot-dash line).
Therefore, the current measurement circuit ends up measuring the sum of i_L and i_{CS}, even if the objective is just to measure i_L. Only i_{CS} reduces measurement accuracy. If the voltage applied to Cs is V_{CS} (common mode voltage), i_{CS} can be found using the equation shown below. Because the phase of i_{CS} is ahead of the voltage by 90°, the effect of i_{CS} on the measurement accuracy increases as the power factor gets smaller.

$i_{CS} = V_{CS} \times 2\pi f \times CS$



Because the WT1800 measures high frequencies, the effects of i_{CS} cannot be ignored.
If you connect the WT1800 current input terminal to the side of the power supply (SOURCE) that is close to its earth potential, the WT1800 current measurement circuit positive and negative terminals are close to the earth potential, so V_{CS} becomes approximately zero and very little i_{CS} flows. This reduces the effect on measurement accuracy.

Appendix 4 Power Range

The table below shows actual voltage and current range combinations and the power ranges that result from them. The values are for when the voltage and current ranges of each element are the same. The table shows the active power range (unit: W). The same ranges are set for apparent power (unit: VA) and reactive power (unit: var). Just read the unit as VA or var. The number of displayed digits (display resolution) is as follows:

- If the value is less than or equal to 60000: Five digits.
- If the value is greater than 60000: Four digits.

When the Crest Factor Is Set to CF3

Active Power Range of Each Element

Current Range	Voltage Range [V]					
[A]	1.5000	3.0000	6.0000	10.000	15.000	30.000
10.000m	15.000 mW	30.000 mW	60.000 mW	100.00 mW	150.00 mW	300.00 mW
20.000m	30.000 mW	60.000 mW	120.00 mW	200.00 mW	300.00 mW	600.00 mW
50.000m	75.00 mW	150.00 mW	300.00 mW	500.00 mW	0.7500 W	1.5000 W
100.00m	150.00 mW	300.00 mW	600.00 mW	1.0000 W	1.5000 W	3.0000 W
200.00m	300.00 mW	600.00 mW	1.2000 W	2.0000 W	3.0000 W	6.0000 W
500.00m	0.7500 W	1.5000 W	3.0000 W	5.0000 W	7.500 W	15.000 W
1.0000	1.5000 W	3.0000 W	6.0000 W	10.000 W	15.000 W	30.000 W
2.0000	3.0000 W	6.0000 W	12.000 W	20.000 W	30.000 W	60.000 W
5.0000	7.500 W	15.000 W	30.000 W	50.000 W	75.00 W	150.00 W
10.000	15.000 W	30.000 W	60.000 W	100.00 W	150.00 W	300.00 W
20.000	30.000 W	60.000 W	120.00 W	200.00 W	300.00 W	600.00 W
50.000	75.00 W	150.00 W	300.00 W	500.00 W	0.7500 kW	1.5000 kW

Current Range	Voltage Range [V]					
[A]	60.000	100.00	150.00	300.00	600.00	1000.0
10.000m	600.00 mW	1.0000 W	1.5000 W	3.0000 W	6.0000 W	10.000 W
20.000m	1.2000 W	2.0000 W	3.0000 W	6.0000 W	12.000 W	20.000 W
50.000m	3.0000 W	5.0000 W	7.500 W	15.000 W	30.000 W	50.000 W
100.00m	6.0000 W	10.000 W	15.000 W	30.000 W	60.000 W	100.00 W
200.00m	12.000 W	20.000 W	30.000 W	60.000 W	120.00 W	200.00 W
500.00m	30.000 W	50.000 W	75.00 W	150.00 W	300.00 W	500.00 W
1.0000	60.000 W	100.00 W	150.00 W	300.00 W	600.00 W	1.0000 kW
2.0000	120.00 W	200.00 W	300.00 W	600.00 W	1.2000 kW	2.0000 kW
5.0000	300.00 W	500.00 W	0.7500 kW	1.5000 kW	3.0000 kW	5.0000 kW
10.000	600.00 W	1.0000 kW	1.5000 kW	3.0000 kW	6.0000 kW	10.000 kW
20.000	1.2000 kW	2.0000 kW	3.0000 kW	6.0000 kW	12.000 kW	20.000 kW
50.000	3.0000 kW	5.0000 kW	7.500 kW	15.000 kW	30.000 kW	50.000 kW

Active Power Range of a Wiring Unit with a 1P3W or 3P3W System, or a 3P3W System That Uses a 3V3A Method

Current Range	Voltage Range [V]					
[A]	1.5000	3.0000	6.0000	10.000	15.000	30.000
10.000m	30.000 mW	60.000 mW	120.000 mW	200.00 mW	300.00 mW	600.00 mW
20.000m	60.000 mW	120.000 mW	240.00 mW	400.00 mW	600.00 mW	1200.00 mW
50.000m	150.00 mW	300.00 mW	600.00 mW	1000.00 mW	1.5000 W	3.0000 W
100.00m	300.00 mW	600.00 mW	1200.00 mW	2.0000 W	3.0000 W	6.0000 W
200.00m	600.00 mW	1200.00 mW	2.4000 W	4.0000 W	6.0000 W	12.0000 W
500.00m	1.5000 W	3.0000 W	6.0000 W	10.0000 W	15.000 W	30.000 W
1.0000	3.0000 W	6.0000 W	12.0000 W	20.000 W	30.000 W	60.000 W
2.0000	6.0000 W	12.0000 W	24.000 W	40.000 W	60.000 W	120.000 W
5.0000	15.000 W	30.000 W	60.000 W	100.000 W	150.00 W	300.00 W
10.000	30.000 W	60.000 W	120.000 W	200.00 W	300.00 W	600.00 W
20.000	60.000 W	120.000 W	240.00 W	400.00 W	600.00 W	1200.00 W
50.000	150.00 W	300.00 W	600.00 W	1000.00 W	1.5000 kW	3.0000 kW

Current Range [A]	Voltage Range [V]					
	60.000	100.00	150.00	300.00	600.00	1000.0
10.000m	1200.00 mW	2.0000 W	3.0000 W	6.0000 W	12.0000 W	20.000 W
20.000m	2.4000 W	4.0000 W	6.0000 W	12.0000 W	24.000 W	40.000 W
50.000m	6.0000 W	10.0000 W	15.000 W	30.000 W	60.000 W	100.000 W
100.00m	12.0000 W	20.000 W	30.000 W	60.000 W	120.000 W	200.00 W
200.00m	24.000 W	40.000 W	60.000 W	120.000 W	240.00 W	400.00 W
500.00m	60.000 W	100.000 W	150.00 W	300.00 W	600.00 W	1000.00 W
1.0000	120.000 W	200.00 W	300.00 W	600.00 W	1200.00 W	2.0000 kW
2.0000	240.00 W	400.00 W	600.00 W	1200.00 W	2.4000 kW	4.0000 kW
5.0000	600.00 W	1000.00 W	1.5000 kW	3.0000 kW	6.0000 kW	10.0000 kW
10.000	1200.00 W	2.0000 kW	3.0000 kW	6.0000 kW	12.0000 kW	20.000 kW
20.000	2.4000 kW	4.0000 kW	6.0000 kW	12.0000 kW	24.000 kW	40.000 kW
50.000	6.0000 kW	10.0000 kW	15.000 kW	30.000 kW	60.000 kW	100.000 kW

Active Power Range of a Wiring Unit with a 3P4W Wiring System

Current Range [A]	Voltage Range [V]					
	1.5000	3.0000	6.0000	10.000	15.000	30.000
10.000m	45.000 mW	90.000 mW	180.000 mW	300.00 mW	450.00 mW	900.00 mW
20.000m	90.000 mW	180.000 mW	360.00 mW	600.00 mW	900.00 mW	1800.00 mW
50.000m	225.00 mW	450.00 mW	900.00 mW	1500.00 mW	2.2500 W	4.5000 W
100.00m	450.00 mW	900.00 mW	1800.00 mW	3.0000 W	4.5000 W	9.0000 W
200.00m	900.00 mW	1800.00 mW	3.6000 W	6.0000 W	9.0000 W	18.0000 W
500.00m	2.2500 W	4.5000 W	9.0000 W	15.0000 W	22.500 W	45.000 W
1.0000	4.5000 W	9.0000 W	18.0000 W	30.000 W	45.000 W	90.000 W
2.0000	9.0000 W	18.0000 W	36.000 W	60.000 W	90.000 W	180.000 W
5.0000	22.500 W	45.000 W	90.000 W	150.000 W	225.00 W	450.00 W
10.000	45.000 W	90.000 W	180.000 W	300.00 W	450.00 W	900.00 W
20.000	90.000 W	180.000 W	360.00 W	600.00 W	900.00 W	1800.00 W
50.000	225.00 W	450.00 W	900.00 W	1500.00 W	2.2500 kW	4.5000 kW

Current Range [A]	Voltage Range [V]					
	60.000	100.00	150.00	300.00	600.00	1000.0
10.000m	1800.00 mW	3.0000 W	4.5000 W	9.0000 W	18.0000 W	30.000 W
20.000m	3.6000 W	6.0000 W	9.0000 W	18.0000 W	36.000 W	60.000 W
50.000m	9.0000 W	15.0000 W	22.500 W	45.000 W	90.000 W	150.000 W
100.00m	18.0000 W	30.000 W	45.000 W	90.000 W	180.000 W	300.00 W
200.00m	36.000 W	60.000 W	90.000 W	180.000 W	360.00 W	600.00 W
500.00m	90.000 W	150.000 W	225.00 W	450.00 W	900.00 W	1500.00 W
1.0000	180.000 W	300.00 W	450.00 W	900.00 W	1800.00 W	3.0000 kW
2.0000	360.00 W	600.00 W	900.00 W	1800.00 W	3.6000 kW	6.0000 kW
5.0000	900.00 W	1500.00 W	2.2500 kW	4.5000 kW	9.0000 kW	15.0000 kW
10.000	1800.00 W	3.0000 kW	4.5000 kW	9.0000 kW	18.0000 kW	30.000 kW
20.000	3.6000 kW	6.0000 kW	9.0000 kW	18.0000 kW	36.000 kW	60.000 kW
50.000	9.0000 kW	15.0000 kW	22.500 kW	45.000 kW	90.000 kW	150.000 kW

When the Crest Factor Is Set to CF6

Active Power Range of Each Element

Current Range [A]	Voltage Range [V]					
	0.7500	**1.5000**	**3.0000**	**5.0000**	**7.500**	**15.000**
5.0000m	3.7500 mW	7.500 mW	15.000 mW	2.5000 mW	37.500 mW	75.00 mW
10.000m	7.500 mW	15.000 mW	30.000 mW	50.000 mW	75.00 mW	150.00 mW
25.000m	18.750 mW	37.500 mW	75.00 mW	125.00 mW	187.50 mW	375.00 mW
50.000m	37.500 mW	75.00 mW	150.00 mW	250.00 mW	375.00 mW	0.7500 W
100.00m	75.00 mW	150.00 mW	300.00 mW	500.00 mW	0.7500 W	1.5000 W
250.00m	187.50 mW	375.00 mW	0.7500 W	1.2500 W	1.8750 W	3.7500 W
500.00m	375.00 mW	0.7500 W	1.5000 W	2.5000 W	3.7500 W	7.500 W
1.0000	0.7500 W	1.5000 W	3.0000 W	5.0000 W	7.500 W	15.000 W
2.5000	1.8750 W	3.7500 W	7.500 W	12.500 W	18.750 W	37.500 W
5.0000	3.7500 W	7.500 W	15.000 W	25.000 W	37.500 W	75.00 W
10.000	7.500 W	15.000 W	30.000 W	50.000 W	75.00 W	150.00 W
25.000	18.750 W	37.500 W	75.00 W	125.00 W	187.50 W	375.00 W

Current Range [A]	Voltage Range [V]					
	30.000	**50.000**	**75.00**	**150.00**	**300.00**	**500.00**
5.0000m	150.00 mW	250.00 mW	375.00 mW	0.7500 W	1.5000 W	2.5000 W
10.000m	300.00 mW	500.00 mW	0.7500 W	1.5000 W	3.0000 W	5.0000 W
25.000m	0.7500 W	1.2500 W	1.8750 W	3.7500 W	7.500 W	12.500 W
50.000m	1.5000 W	2.5000 W	3.7500 W	7.500 W	15.000 W	25.000 W
100.00m	3.0000 W	5.0000 W	7.500 W	15.000 W	30.000 W	50.000 W
250.00m	7.500 W	12.500 W	18.750 W	37.500 W	75.00 W	125.00 W
500.00m	15.000 W	25.000 W	37.500 W	75.00 W	150.00 W	250.00 W
1.0000	30.000 W	50.000 W	75.00 W	150.00 W	300.00 W	500.00 W
2.5000	75.00 W	125.00 W	187.50 W	375.00 W	0.7500 kW	1.2500 kW
5.0000	150.00 W	250.00 W	375.00 W	0.7500 kW	1.5000 kW	2.5000 kW
10.000	300.00 W	500.00 W	0.7500 kW	1.5000 kW	3.0000 kW	5.0000 kW
25.000	0.7500 kW	1.2500 kW	1.8750 kW	3.7500 kW	7.500 kW	12.500 kW

Active Power Range of a Wiring Unit with a 1P3W or 3P3W System, or a 3P3W System That Uses a 3V3A Method

Current Range [A]	Voltage Range [V]					
	0.7500	**1.5000**	**3.0000**	**5.0000**	**7.500**	**15.000**
5.0000m	7.5000 mW	15.000 mW	30.000 mW	50.000 mW	75.000 mW	150.00 mW
10.000m	15.000 mW	30.000 mW	60.000 mW	100.000 mW	150.00 mW	300.00 mW
25.000m	37.500 mW	75.000 mW	150.00 mW	250.00 mW	375.00 mW	750.00 mW
50.000m	75.000 mW	150.00 mW	300.00 mW	500.00 mW	750.00 mW	1.5000 W
100.00m	150.00 mW	300.00 mW	600.00 mW	1000.00 mW	1.5000 W	3.0000 W
250.00m	375.00 mW	750.00 mW	1.5000 W	2.5000 W	3.7500 W	7.5000 W
500.00m	750.00 mW	1.5000 W	3.0000 W	5.0000 W	7.5000 W	15.000 W
1.0000	1.5000 W	3.0000 W	6.0000 W	10.0000 W	15.000 W	30.000 W
2.5000	3.7500 W	7.5000 W	15.000 W	25.000 W	37.500 W	75.000 W
5.0000	7.5000 W	15.000 W	30.000 W	50.000 W	75.000 W	150.00 W
10.000	15.000 W	30.000 W	60.000 W	100.000 W	150.00 W	300.00 W
25.000	37.500 W	75.000 W	150.00 W	250.00 W	375.00 W	750.00 W

Current Range [A]	Voltage Range [V]					
	30.000	50.000	75.00	150.00	300.00	500.00
5.0000m	300.00 mW	500.00 mW	750.00 mW	1.5000 W	3.0000 W	5.0000 W
10.000m	600.00 mW	1000.00 mW	1.5000 W	3.0000 W	6.0000 W	10.0000 W
25.000m	1.5000 W	2.5000 W	3.7500 W	7.5000 W	15.000 W	25.000 W
50.000m	3.0000 W	5.0000 W	7.5000 W	15.000 W	30.000 W	50.000 W
100.00m	6.0000 W	10.0000 W	15.000 W	30.000 W	60.000 W	100.000 W
250.00m	15.000 W	25.000 W	37.500 W	75.000 W	150.00 W	250.00 W
500.00m	30.000 W	50.000 W	75.000 W	150.00 W	300.00 W	500.00 W
1.0000	60.000 W	100.000 W	150.00 W	300.00 W	600.00 W	1000.00 W
2.5000	150.00 W	250.00 W	375.00 W	750.00 W	1.5000 kW	2.5000 kW
5.0000	300.00 W	500.00 W	750.00 W	1.5000 kW	3.0000 kW	5.0000 kW
10.000	600.00 W	1000.00 W	1.5000 kW	3.0000 kW	6.0000 kW	10.0000 kW
25.000	1.5000 kW	2.5000 kW	3.7500 kW	7.5000 kW	15.000 kW	25.000 kW

Active Power Range of a Wiring Unit with a 3P4W Wiring System

Current Range [A]	Voltage Range [V]					
	0.7500	1.5000	3.0000	5.0000	7.500	15.000
5.0000m	11.2500 mW	22.500 mW	45.000 mW	75.000 mW	112.500 mW	225.00 mW
10.000m	22.500 mW	45.000 mW	90.000 mW	150.000 mW	225.00 mW	450.00 mW
25.000m	56.250 mW	112.500 mW	225.00 mW	375.00 mW	562.50 mW	1125.00 mW
50.000m	112.500 mW	225.00 mW	450.00 mW	750.00 mW	1125.00 mW	2.2500 W
100.00m	225.00 mW	450.00 mW	900.00 mW	1500.00 mW	2.2500 W	4.5000 W
250.00m	562.50 mW	1125.00 mW	2.2500 W	3.7500 W	5.6250 W	11.2500 W
500.00m	1125.00 mW	2.2500 W	4.5000 W	7.5000 W	11.2500 W	22.500 W
1.0000	2.2500 W	4.5000 W	9.0000 W	15.0000 W	22.500 W	45.000 W
2.5000	5.6250 W	11.2500 W	22.500 W	37.500 W	56.250 W	112.500 W
5.0000	11.2500 W	22.500 W	45.000 W	75.000 W	112.500 W	225.00 W
10.000	22.500 W	45.000 W	90.000 W	150.000 W	225.00 W	450.00 W
25.000	56.250 W	112.500 W	225.00 W	375.00 W	562.50 W	1125.00 W

Current Range [A]	Voltage Range [V]					
	30.000	50.000	75.00	150.00	300.00	500.00
5.0000m	450.00 mW	750.00 mW	1125.00 mW	2.2500 W	4.5000 W	7.5000 W
10.000m	900.00 mW	1500.00 mW	2.2500 W	4.5000 W	9.0000 W	15.0000 W
25.000m	2.2500 W	3.7500 W	5.6250 W	11.2500 W	22.500 W	37.500 W
50.000m	4.5000 W	7.5000 W	11.2500 W	22.500 W	45.000 W	75.000 W
100.00m	9.0000 W	15.0000 W	22.500 W	45.000 W	90.000 W	150.000 W
250.00m	22.500 W	37.500 W	56.250 W	112.500 W	225.00 W	375.00 W
500.00m	45.000 W	75.000 W	112.500 W	225.00 W	450.00 W	750.00 W
1.0000	90.000 W	150.000 W	225.00 W	450.00 W	900.00 W	1500.00 W
2.5000	225.00 W	375.00 W	562.50 W	1125.00 W	2.2500 kW	3.7500 kW
5.0000	450.00 W	750.00 W	1125.00 W	2.2500 kW	4.5000 kW	7.5000 kW
10.000	900.00 W	1500.00 W	2.2500 kW	4.5000 kW	9.0000 kW	15.0000 kW
25.000	2.2500 kW	3.7500 kW	5.6250 kW	11.2500 kW	22.500 kW	37.500 kW

Appendix 5 Setting the Measurement Period

To make correct measurements on the WT1800, you must set its measurement period properly.

The WT1800 uses its frequency measurement circuit (see appendix 11) to detect the period of the input signal that is selected using the measurement period setting. The measurement period is an integer multiple of this detected period. The WT1800 determines the measured values by averaging the data sampled in the measurement period. The input signal used to determine the measurement period is called the synchronization source.
The measurement period is automatically determined inside the WT1800 when you specify the synchronization source.

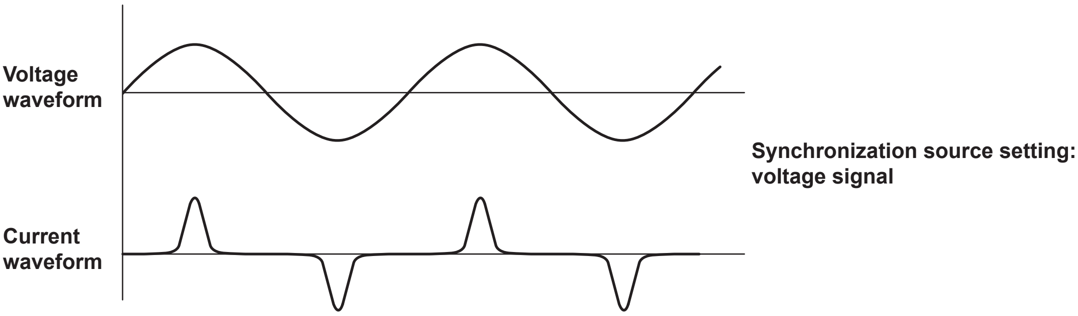
You can select the synchronization source signal from the options listed below.
U1, I1, U2, I2, U3, I3, U4, I4, U5, I5, U6, I6, Ext Clk (external clock), and None

* The available options vary depending on the installed elements.

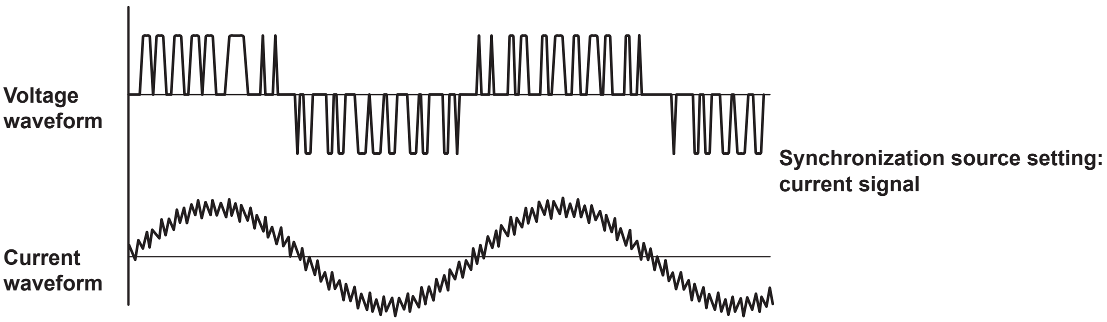
For example, if the synchronization source for input element 1 is set to I1, an integer multiple of the period of I1 becomes the measurement period. By averaging the sampled data in this measurement period, the WT1800 computes the measured values for input element 1, such as U1, I1, and P1.

Deciding Whether to Use Voltage or Current Input as the Synchronization Source

Select input signals with stable input levels and frequencies (with little distortion) as synchronization sources. Correct measured values can only be obtained if the period of the synchronization source signal is detected accurately. On the WT1800, display the frequency of the input signal that you have selected as the synchronization source, and confirm that the frequency is being measured correctly. The most suitable synchronization source is the input signal that is the most stable and that provides accurate measured results.
For example, if a switching power supply is being measured and the voltage waveform distortion is smaller than the current waveform distortion, set the synchronization source to the voltage signal.

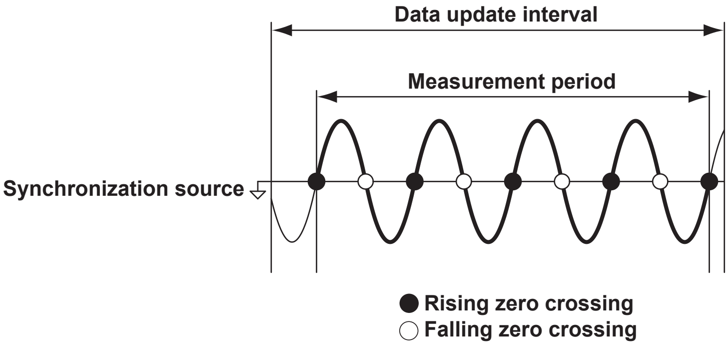


As another example, if an inverter is being measured and the current waveform distortion is smaller than the voltage waveform distortion, set the synchronization source to the current signal.



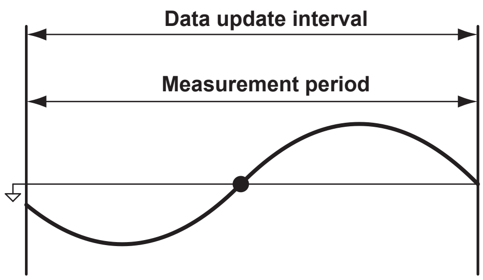
Zero Crossing

- The rising (or falling) zero crossing is the time when the synchronization source passes through level zero (the center of the amplitude) on a rising (or falling) slope. The measurement period on the WT1800 is between the first rising (or falling) zero crossing and the last rising (or falling) zero crossing in the data update interval.
- The WT1800 determines whether to define the measurement period using the rising or falling zero crossing automatically by choosing the method that will result in the longest measurement period.



When the Period of the Synchronization Source Cannot Be Detected

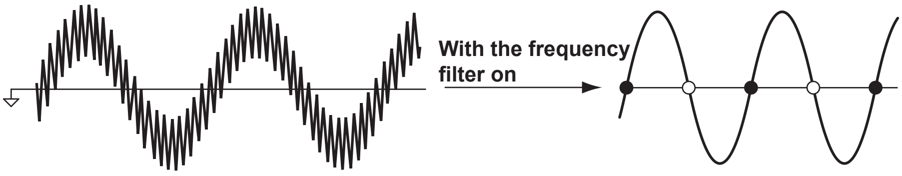
If the total number of rising and falling zero crossings on the input signal that has been set as the synchronization source is less than two within the data update interval, the period cannot be detected. Also, the period cannot be detected if the AC amplitude is small. (For information about the detectable frequency levels, see the conditions listed under “Accuracy” under “Frequency Measurement” in section 6.5, “Features.”) If the period cannot be detected, the entire data update interval becomes the measurement period, and the sampled data of the entire period is averaged.



Because of the reasons described above, the measured voltage and current values may be unstable. If this happens, lower the data update rate so that more periods of the input signal fit within the data update interval.

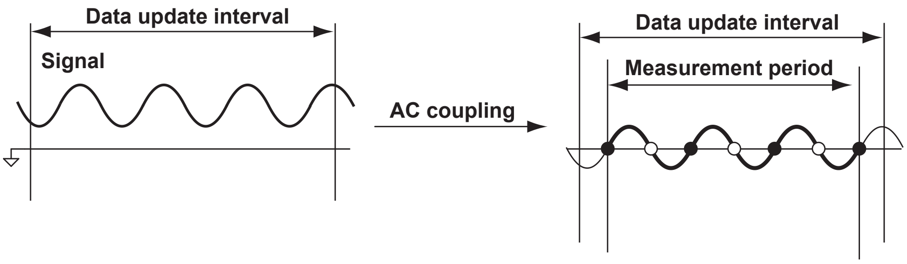
When the Waveform of the Synchronization Source Is Distorted

Change the synchronization source to a signal that allows for more stable detection of the period (switch from voltage to current or from current to voltage). Also, turn on the frequency filter.
The WT1800 reduces the effects of noise by using hysteresis when it detects zero crossings. If the synchronization source is distorted or harmonics and noise are superposed on the signal to a level exceeding this hysteresis, harmonic components will cause zero crossing detection to occur frequently, and the zero crossing of the fundamental frequency will not be detected stably. Consequently, the measured voltage and current may be unstable. When high frequency components are superposed on the current waveform such as in the aforementioned inverter example, turn the frequency filter on to stably detect zero crossings. Use of the filter is appropriate if it makes the measured frequency accurate and more stable. Because the frequency filter can be used to facilitate the detection of the synchronization source's zero crossings, it is sometimes called the synchronization source filter or the zero-crossing filter.



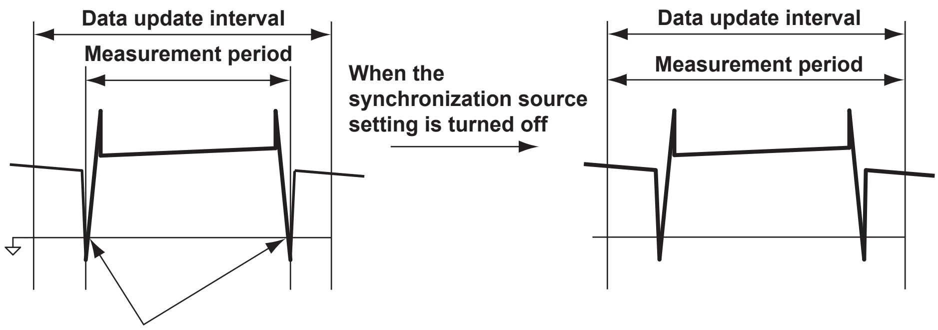
When Measuring a Signal That Has No Zero Crossings Because of a DC Offset Superposed on the AC Signal

The measured values may be unstable if the period of the AC signal cannot be detected accurately. Change the synchronization source to a signal that allows for more stable detection of the period (switch from voltage to current or from current to voltage). The frequency detection circuit is AC coupled. Even with AC signals in which there are no zero crossings because of an offset, the period can be detected if the AC amplitude is greater than or equal to the detection level of the frequency measurement circuit (see the conditions listed under "Accuracy" under "Frequency Measurement" in section 6.5, "Features"). With this feature, the measurement period is set to an integer multiple of the period of the AC signal.



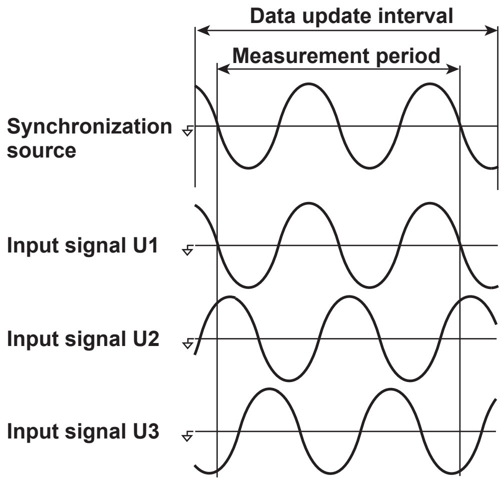
When Measuring a DC Signal

When there are ripples in the DC signal, if the level of the ripples is greater than or equal to the detection level of the frequency measurement circuit (see the conditions listed under "Accuracy" under "Frequency Measurement" in section 6.5, "Features") and the period can be detected accurately and stably, a more accurate DC measurement is possible. If a large AC signal is superposed on a DC signal, you can achieve a more stable measurement by detecting the AC signal period and averaging it.
In addition, if a small fluctuating pulse noise riding on the DC signal crosses level zero, that point is detected as a zero crossing. As a result, sampled data is averaged over an unintended period, and measured values such as voltage and current may be unstable. You can prevent these kinds of erroneous detections by setting the synchronization source to None. All of the sampled data in the data update interval is used to determine measured values. Set the synchronization source according to the signal under measurement and the measurement objective.



Setting the Synchronization Period When Measuring a Three-Phase Device

If a three-phase device is measured with input elements 1 and 2 using a three-phase, three-wire system, set the synchronization source of input elements 1 and 2 to the same signal. For example, set the synchronization source of input elements 1 and 2 to U1 or I1. The measurement periods of input elements 1 and 2 will match, and it will be possible to measure the Σ voltage, Σ current, and Σ power of a three-phase device more accurately.
Likewise, if a three-phase device is measured with input elements 1, 2, and 3 using a three-phase, four-wire system, set the synchronization source of input elements 1, 2, and 3 to the same signal.
To facilitate this sort of configuration, the synchronization source setting on the WT1800 is linked to the Σ wiring unit of the wiring system (when independent input element configuration is turned off).
If independent input element configuration is turned on, the synchronization source of each input element in the Σ wiring unit can be set independently.



Synchronization Source Setup Example	
Input element 1	U1 (or I1)
Input element 2	
Input element 3	

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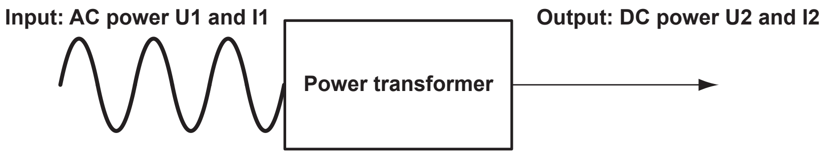
Appendix

Setting the Synchronization Period When Measuring the Efficiency of a Power Transformer

- **Power Transformer with Single-Phase Input and Single-Phase Output**

  If you are using input elements 1 and 2 to measure a device that converts single-phase AC power to single-phase DC power, set the synchronization source of input elements 1 and 2 to the voltage (or current) on the AC power end. In the example shown in the figure below, set the synchronization source of input elements 1 and 2 to U1 (or I1).

  The measurement periods of input element 1 (input end) and input element 2 (output end) will match, and it will be possible to measure the power conversion efficiency at the input and output ends of the power transformer more accurately.



Synchronization Source Setup Example	
Input element 1	U1 (or I1)
Input element 2	

  Likewise, if you are using input elements 1 (DC end) and 2 (AC end) to measure a device that converts single-phase DC power to single-phase AC power, set the synchronization source of input elements 1 and 2 to the voltage (or current) on the AC power end (input element 2). In the example shown in the figure below, set the synchronization source of input elements 1 and 2 to U2 (or I2).

Synchronization Source Setup Example	
Input element 1	U2 (or I2)
Input element 2	

- **Power Transformer with Single-Phase DC Input and Three-Phase AC Output**

  If you are using the connections shown on the next page to measure a device that converts single-phase DC power to three-phase AC power, set the synchronization source of all input elements to the same signal: the voltage or current of element 2 or 3 on the AC power end.

  In this example, set the synchronization source of input elements 1, 2, and 3 to U2 (or I2, U3, or I3). The measurement periods of the input signal and all output signals will match, and it will be possible to measure the power conversion efficiency of the power transformer more accurately.
  - Single-phase DC power: Connect to input element 1.
  - Three-phase AC power: Connect to input elements 2 and 3 using a three-phase, three-wire system.

Synchronization Source Setup Example	
Input element 1	U2 (or I2, U3, or I3)
Input element 2	
Input element 3	

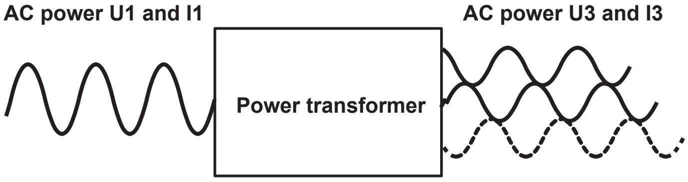
- **Power Transformer with Single-Phase AC Input and Three-Phase AC Output**

  If you are using the connections shown in the figure below to measure a device that converts single-phase AC power to three-phase AC power, set the synchronization source of input elements on the input end to the same signal and do the same for input elements on the output end.

  In this example, set the synchronization source of input element 1 to U1 (or I1), and set the synchronization source of input elements 2 and 3 to U2 (or I2, U3, or I3).

  In this case, AC signals of different frequencies are measured. If the synchronization source of all input elements is set to the same signal, the measurement period of either the input signal or the output signal will not be an integer multiple of the signal.

  - Single-phase AC power: Connect to input element 1.
  - Three-phase AC power: Connect to input elements 2 and 3 using a three-phase, three-wire system.



Synchronization Source Setup Example	
Input element 1	U1 (or I1)
Input element 2	U2 (or I2, U3, or I3)
Input element 3	

Note

- The measurement period for determining the numeric data of the peak voltage or peak current is the entire span of the data update interval, regardless of the measurement period settings discussed above. Therefore, the measurement period for the measurement functions that are determined using the maximum voltage or current value (U+pk, U-pk, I+pk, I-pk, CfU, and CfI) is also the entire span of the data update interval.
- For details on the measurement period for measurement functions related to harmonic measurement, see the features guide.

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Appendix

Appendix 6 User-Defined Function Operands

The following is a list of operands that can be used in user-defined functions.

Measurement Functions Used in Normal Measurement

Measurement Function	User-Defined Function		Parameter in ( )	
			Element	Wiring Unit
		Example	E1 to E6	E7 to E9
Urms	URMS( )	URMS(E1)	Yes	Yes
Umn	UMN( )	UMN(E1)	Yes	Yes
Udc	UDC( )	UDC(E1)	Yes	Yes
Urmn	URMN( )	URMN(E1)	Yes	Yes
Uac	UAC( )	UAC(E1)	Yes	Yes
Irms	IRMS( )	IRMS(E1)	Yes	Yes
Imn	IMN( )	IMN(E1)	Yes	Yes
Idc	IDC( )	IDC(E1)	Yes	Yes
Irmn	IRMN( )	IRMN(E1)	Yes	Yes
Iac	IAC( )	IAC(E1)	Yes	Yes
P	P( )	P(E1)	Yes	Yes
S	S( )	S(E1)	Yes	Yes
Q	Q( )	Q(E1)	Yes	Yes
λ	LAMBDA( )	LAMBDA(E1)	Yes	Yes
Φ	PHI( )	PHI(E1)	Yes	Yes
fU	FU( )	FU(E1)	Yes	No
fI	FI( )	FI(E1)	Yes	No
U+pk	UPPK( )	UPPK(E1)	Yes	No
U-pk	UMPK( )	UMPK(E1)	Yes	No
I+pk	IPPK( )	IPPK(E1)	Yes	No
I-pk	IMPK( )	IMPK(E1)	Yes	No
P+pk	PPPK( )	PPPK(E1)	Yes	No
P-pk	PMPK( )	PMPK(E1)	Yes	No
CfU	CFU( )	CFU(E1)	Yes	No
CfI	CFI( )	CFI(E1)	Yes	No
Pc	PC( )	PC(E1)	Yes	Yes

Integrated Power (Watt hour)

Measurement Function	User-Defined Function		Parameter in ( )	
			Element	Wiring Unit
		Example	E1 to E6	E7 to E9
Wp	WH( )	WH(E1)	Yes	Yes
Wp+	WHP( )	WHP(E1)	Yes	Yes
Wp-	WHM( )	WHM(E1)	Yes	Yes
q	AH( )	AH(E1)	Yes	Yes
q+	AHP( )	AHP(E1)	Yes	Yes
q-	AHM( )	AHM(E1)	Yes	Yes
WS	SH( )	SH(E1)	Yes	Yes
WQ	QH( )	QH(E1)	Yes	Yes
Time	TI( )	TI(E1)	Yes	No

Efficiency

Measurement Function	User-Defined Function		Parameter in ( )	
			Element	Wiring Unit
		Example	E1 to E6	E7 to E9
η1	ETA1( )	ETA1( )	None or space*	
η2	ETA2( )	ETA2( )	None or space*	
η3	ETA3( )	ETA3( )	None or space*	
η4	ETA4( )	ETA4( )	None or space*	

* You cannot omit the parentheses.

User-Defined Functions

Measurement Function	User-Defined Function		Parameter in ( )	
			Element	Wiring Unit
		Example	E1 to E6	E7 to E9
F1	F1( )	F1( )	None or space*	
F2	F2( )	F2( )	None or space*	
F3	F3( )	F3( )	None or space*	
F4	F4( )	F4( )	None or space*	
F5	F5( )	F5( )	None or space*	
F6	F6( )	F6( )	None or space*	
F7	F7( )	F7( )	None or space*	
F8	F8( )	F8( )	None or space*	
F9	F9( )	F9( )	None or space*	
F10	F10( )	F10( )	None or space*	
F11	F11( )	F11( )	None or space*	
F12	F12( )	F12( )	None or space*	
F13	F13( )	F13( )	None or space*	
F14	F14( )	F14( )	None or space*	
F15	F15( )	F15( )	None or space*	
F16	F16( )	F16( )	None or space*	
F17	F17( )	F17( )	None or space*	
F18	F18( )	F18( )	None or space*	
F19	F19( )	F19( )	None or space*	
F20	F20( )	F20( )	None or space*	

* You cannot omit the parentheses.

User-Defined Events

Measurement Function	User-Defined Function		Parameter in ( )	
			Element	Wiring Unit
		Example	E1 to E6	E7 to E9
Ev1	EV1( )	EV1( )	None or space*	
Ev2	EV2( )	EV2( )	None or space*	
Ev3	EV3( )	EV3( )	None or space*	
Ev4	EV4( )	EV4( )	None or space*	
Ev5	EV5( )	EV5( )	None or space*	
Ev6	EV6( )	EV6( )	None or space*	
Ev7	EV7( )	EV7( )	None or space*	
Ev8	EV8( )	EV8( )	None or space*	

* You cannot omit the parentheses.

MAX Hold

Measurement Function	User-Defined Function		Parameter in ( )	
			Element	Wiring Unit
		Example	E1 to E6	E7 to E9
Rms voltage	URMSMAX( )	URMSMAX(E1)	Yes	Yes
Voltage mean	UMEANMAX( )	UMEANMAX(E1)	Yes	Yes
Voltage simple average	UDCMAX( )	UDCMAX(E1)	Yes	Yes
Voltage rectified mean value	URMEANMAX( )	URMEANMAX(E1)	Yes	Yes
Voltage AC component	UACMAX( )	UACMAX(E1)	Yes	Yes
Rms current	IRMSMAX( )	IRMSMAX(E1)	Yes	Yes
Current mean	IMEANMAX( )	IMEANMAX(E1)	Yes	Yes
Current simple average	IDCMAX( )	IDCMAX(E1)	Yes	Yes
Current rectified mean value	IRMEANMAX( )	IRMEANMAX(E1)	Yes	Yes
Current AC component	IACMAX( )	IACMAX(E1)	Yes	Yes
Active power	PMAX( )	PMAX(E1)	Yes	Yes
Apparent power	SMAX( )	SMAX(E1)	Yes	Yes
Reactive power	QMAX( )	QMAX(E1)	Yes	Yes
Positive peak voltage	UPPEAKMAX( )	UPPEAKMAX(E1)	Yes	No
Negative peak voltage	UMPEAKMAX( )	UMPEAKMAX(E1)	Yes	No
Positive peak current	IPPEAKMAX( )	IPPEAKMAX(E1)	Yes	No
Negative peak current	IMPEAKMAX( )	IMPEAKMAX(E1)	Yes	No
Positive peak power	PPPEAKMAX( )	PPPEAKMAX(E1)	Yes	No
Negative peak power	PMPEAKMAX( )	PMPEAKMAX(E1)	Yes	No

Motor Evaluation Option

Measurement Function	User-Defined Function		Parameter in ( )	
			Element	Wiring Unit
		Example	E1 to E6	E7 to E9
Speed	SPEED( )	SPEED( )	None or space*	
Torque	TORQUE( )	TORQUE( )	None or space*	
Pm	PM( )	PM( )	None or space*	
Slip	SLIP( )	SLIP( )	None or space*	
SyncSp	SYNC( )	SYNC( )	None or space*	

* You cannot omit the parentheses.

Auxiliary Input Option

Measurement Function	User-Defined Function		Parameter in ( )	
			Element	Wiring Unit
		Example	E1 to E6	E7 to E9
Aux1	AUX1( )	AUX1( )	None or space*	
Aux2	AUX2( )	AUX2( )	None or space*	

* You cannot omit the parentheses.

Delta Computation Option

Measurement Function	User-Defined Function		Parameter in ( )	
			Element	Wiring Unit
		Example	E1 to E6	E7 to E9
ΔU1( )	DELTAU1( )	DELTAU1(E7)	No	Yes
ΔU2( )	DELTAU2( )	DELTAU2(E7)	No	Yes
ΔU3( )	DELTAU3( )	DELTAU3(E7)	No	Yes
ΔUΣ( )	DELTAUSIG( )	DELTAUSIG(E7)	No	Yes
ΔI( )	DELTAI( )	DELTAI(E7)	No	Yes
ΔP1( )	DELTAP1( )	DELTAP1(E7)	No	Yes
ΔP2( )	DELTAP2( )	DELTAP2(E7)	No	Yes
ΔP3( )	DELTAP3( )	DELTAP3(E7)	No	Yes
ΔPΣ( )	DELTAPSIG( )	DELTAPSIG(E7)	No	Yes
ΔU1rms( )	DELTAU1RMS( )	DELTAU1RMS(E7)	No	Yes
ΔU2rms( )	DELTAU2RMS( )	DELTAU2RMS(E7)	No	Yes
ΔU3rms( )	DELTAU3RMS( )	DELTAU3RMS(E7)	No	Yes
ΔUΣrms( )	DELTAUSIGRMS( )	DELTAUSIGRMS(E7)	No	Yes
ΔU1mean( )	DELTAU1MN( )	DELTAU1MN(E7)	No	Yes
ΔU2mean( )	DELTAU2MN( )	DELTAU2MN(E7)	No	Yes
ΔU3mean( )	DELTAU3MN( )	DELTAU3MN(E7)	No	Yes
ΔUΣmean( )	DELTAUSIGMN( )	DELTAUSIGMN(E7)	No	Yes
ΔU1rmean( )	DELTAU1RMN( )	DELTAU1RMN(E7)	No	Yes
ΔU2rmean( )	DELTAU2RMN( )	DELTAU2RMN(E7)	No	Yes
ΔU3rmean( )	DELTAU3RMN( )	DELTAU3RMN(E7)	No	Yes
ΔUΣrmean( )	DELTAUSIGRMN( )	DELTAUSIGRMN(E7)	No	Yes
ΔU1dc( )	DELTAU1DC( )	DELTAU1DC(E7)	No	Yes
ΔU2dc( )	DELTAU2DC( )	DELTAU2DC(E7)	No	Yes
ΔU3dc( )	DELTAU3DC( )	DELTAU3DC(E7)	No	Yes
ΔUΣdc( )	DELTAUSIGDC( )	DELTAUSIGDC(E7)	No	Yes
ΔU1ac( )	DELTAU1AC( )	DELTAU1AC(E7)	No	Yes
ΔU2ac( )	DELTAU2AC( )	DELTAU2AC(E7)	No	Yes
ΔU3ac( )	DELTAU3AC( )	DELTAU3AC(E7)	No	Yes
ΔUΣac( )	DELTAUSIGAC( )	DELTAUSIGAC(E7)	No	Yes
ΔIrms( )	DELTAIrms( )	DELTAIRMS(E7)	No	Yes
ΔImean( )	DELTAIMN( )	DELTAIMN(E7)	No	Yes
ΔIrmean( )	DELTAIRMN( )	DELTAIRMN(E7)	No	Yes
ΔIdc( )	DELTAIDC( )	DELTAIDC(E7)	No	Yes
ΔIac( )	DELTAIAC( )	DELTAIAC(E7)	No	Yes

Harmonic Measurement Option or Simultaneous Dual Harmonic Measurement Option

Measurement Function	User-Defined Function		Left Parameter in (,) or Parameter in ( )		Right Parameter in (,)			
			Element	Wiring Unit	Harmonic Order			
					Total Value	DC	Fundamental Wave	Harmonics
		Example	E1 to E6	E7 to E9	ORT	OR0	OR1	OR2 to OR100 (500)
U_k	UK(,)	UK(E1,OR3)	Yes	Yes	Yes	Yes	Yes	Up to OR500
I_k	IK(,)	IK(E1,OR3)	Yes	Yes	Yes	Yes	Yes	Up to OR500
P_k	PK(,)	PK(E1,OR3)	Yes	Yes	Yes	Yes	Yes	Up to OR500
S_k	SK(,)	SK(E1,OR3)	Yes	Yes	Yes	Yes	Yes	Up to OR500
Q_k	QK(,)	QK(E1,OR3)	Yes	Yes	Yes	Yes	Yes	Up to OR500
λ_k	LAMBDAK(,)	LAMBDAK(E1,OR3)	Yes	Yes	Yes	Yes	Yes	Up to OR500
Φ_k	PHIK(,)	PHIK(E1,OR3)	Yes	No	Yes	No	Yes	Up to OR500
ΦU	UPHI(,)	UPHI(E1,OR3)	Yes	No	No	No	No	Up to OR500
ΦI	IPHI(,)	IPHI(E1,OR3)	Yes	No	No	No	No	Up to OR500
Z	ZK(,)	ZK(E1,OR3)	Yes	No	No	Yes	Yes	Up to OR100
Rs	RSK(,)	RSK(E1,OR3)	Yes	No	No	Yes	Yes	Up to OR100
Xs	XSK(,)	XSK(E1,OR3)	Yes	No	No	Yes	Yes	Up to OR100
Rp	RPK(,)	RPK(E1,OR3)	Yes	No	No	Yes	Yes	Up to OR100
Xp	XPK(,)	XPK(E1,OR3)	Yes	No	No	Yes	Yes	Up to OR100
Uhdf	UHDF(,)	UHDF(E1,OR3)	Yes	No	No	Yes	Yes	Up to OR500
Ihdf	IHDF(,)	IHDF(E1,OR3)	Yes	No	No	Yes	Yes	Up to OR500
Phdf	PHDF(,)	PHDF(E1,OR3)	Yes	No	No	Yes	Yes	Up to OR500
Uthd	UTHD( )	UTHD(E1)	Yes	No				
Ithd	ITHD( )	ITHD(E1)	Yes	No				
Pthd	PTHD( )	PTHD(E1)	Yes	No				
Uthf	UTHF( )	UTHF(E1)	Yes	No				
Ithf	ITHF( )	ITHF(E1)	Yes	No				
Utif	UTIF( )	UTIF(E1)	Yes	No				
Itif	ITIF( )	ITIF(E1)	Yes	No				
hvf	HVF( )	HVF(E1)	Yes	No				
hcf	HCF( )	HCF(E1)	Yes	No				
K-factor	KFACT( )	KFACT(E1)	Yes	No				
EaU*	EAU( )	EAU(E1)	Yes	No				
EaI*	EAI( )	EAI(E1)	Yes	No				
FreqPLL1	PLLFRQ1( )	PLLFRQ1( )	No	No				
FreqPLL2	PLLFRQ2( )	PLLFRQ2( )	No	No				
ΦU1-U2	PHIU1U2( )	PHIU1U2(E7)	No	Yes				
ΦU1-U3	PHIU1U3( )	PHIU1U3(E7)	No	Yes				
ΦU1-I1	PHIU1I1( )	PHIU1I1(E7)	Yes	Yes				
ΦU2-I2	PHIU2I2( )	PHIU2I2(E7)	No	Yes				
ΦU3-I3	PHIU3I3( )	PHIU3I3(E7)	No	Yes				

* Available on models with the motor evaluation function (option)

Appendix 7 USB Keyboard Key Assignments

104 Keyboard (US)

Key	When the Ctrl Key Is Held Down on the USB Keyboard		When the Soft Keyboard Is Displayed on the WT1800		Other	
		When the WT1800 Shift Is On		+Shift on the USB Keyboard		When the WT1800 Shift Is On
a	AVG menu		a	A		
b	Execute STORE START	STORE SET menu	b	B		
c	SCALING menu	MOTOR/AUX SET menu	c	C		
d	Execute HOLD		d	D		
e	Execute ELEMENT	Execute ELEMENT ALL	e	E		
f	FILE menu	Same as left	f	F		
g	INTEG menu		g	G		
h	HRM SET menu		h	H		
i	Execute IMAGE SAVE	IMAGE SAVE menu	i	I		
j	Execute NULL	NULL SET menu	j	J		
k	Execute STORE STOP	Execute STORE RESET	k	K		
l	LINE FILTER menu	FREQ FILTER menu	l	L		
m	MEASURE menu	FREQ MEASURE menu	m	M		
n	Execute NUMERIC		n	N		
o	OTHERS menu		o	O		
p	Execute PRINT	PRINT menu	p	P		
q	FORM menu	CURSOR menu	q	Q		
r	Execute RESET	Same as left	r	R		
s	SHIFT on	SHIFT off	s	S		
t	ITEM menu		t	T		
u	UPDATE RATE menu		u	U		
v	WIRING menu		v	V		
w	Execute WAVE		w	W		
x	Execute EXT-SENSOR	SENSOR RATIO menu	x	X		
y	SYNC SOURCE menu		y	Y		
z	Execute SINGLE	Execute CAL	z	Z		
1			1	!		
2			2	@		
3			3	#		
4			4	$		
5			5	%		
6			6	^		
7			7	&		
8			8	*		
9			9	(		
0			0	)		
Enter	Execute SET	Same as left	Enter	Same as left	Execute SET	Same as left
Esc	Execute ESC	Same as left	Escape	Same as left	Execute ESC	Same as left
Back Space			Back Space	Same as left		
Tab						
Space Bar			Space	Same as left		
`			`	~		
-			-	=		
=			=	+		
[			[	{		
]			]	}		
\			\	|		
;			;	:		
’			’	”		
,			,	<		
.	UTILITY menu		.	>		
/	Execute HELP	Same as left	/	?		
Caps Lock			Caps Lock	Same as left		

(Shaded box): No feature is assigned to the key.

Appendix 7 USB Keyboard Key Assignments

Key	When the Ctrl Key Is Held Down on the USB Keyboard		When the Soft Keyboard Is Displayed on the WT1800		Other	
		When the WT1800 Shift Is On		+Shift on the USB Keyboard		When the WT1800 Shift Is On
F1	Execute U RANGE UP		Select soft key 1	Same as left	Select soft key 1	Same as left
F2	Execute U RANGE DOWN		Select soft key 2	Same as left	Select soft key 2	Same as left
F3	Execute U CONFIG		Select soft key 3	Same as left	Select soft key 3	Same as left
F4	Execute U AUTO		Select soft key 4	Same as left	Select soft key 4	Same as left
F5	Execute I RANGE UP		Select soft key 5	Same as left	Select soft key 5	Same as left
F6	Execute I RANGE DOWN		Select soft key 6	Same as left	Select soft key 6	Same as left
F7	Execute I CONFIG	Execute DIRECT/MEASURE	Select soft key 7	Same as left	Select soft key 7	Same as left
F8	Execute I AUTO					
F9	Execute U,I,P					
F10	Execute S,Q,λ,Φ					
F11	Execute WP,q,TIME		μ	Same as left		
F12	Execute FU,FI,η		Ω	Same as left		
Print Screen	Execute PRINT	PRINT menu				
Scroll Lock	Execute IMAGE SAVE	IMAGE SAVE menu				
Pause						
Insert	Execute INPUT INFO					
Home	Execute U/I MODE					
Page Up	Execute PAGE UP	Execute PAGE TOP			Execute PAGE UP	Execute PAGE TOP
Delete						
End	ELEMENT	ALL				
Page Down	Execute PAGE DOWN	Execute PAGE END			Execute PAGE DOWN	Execute PAGE END
→	Move cursor to the right	Same as left	Move cursor to the right	Same as left	Move cursor to the right	Same as left
←	Move cursor to the left	Same as left	Move cursor to the left	Same as left	Move cursor to the left	Same as left
↓	Move cursor down	Same as left			Move cursor down	Same as left
↑	Move cursor up	Same as left			Move cursor up	Same as left

Numeric Keypad	When the Ctrl Key Is Held Down on the USB Keyboard		When the Soft Keyboard Is Displayed on the WT1800		Other	
		When the WT1800 Shift Is On		+Shift on the USB Keyboard		+Shift on the USB Keyboard
Num Lock						
/			/	Same as left		
*			*	Same as left		
-			-	Same as left		
+			+	Same as left		
Enter	Execute SET	Same as left	Enter	Same as left		Execute SET
1			1			
2	Move cursor down	Same as left	2			Move cursor down
3	Execute PAGE DOWN	Execute PAGE END	3			Execute PAGE DOWN
4	Move cursor to the left	Same as left	4	Move cursor to the left		Move cursor to the left
5			5			
6	Move cursor to the right	Same as left	6	Move cursor to the right		Move cursor to the right
7			7			
8	Move cursor up	Same as left	8			Move cursor up
9	Execute PAGE UP	Execute PAGE TOP	9			Execute PAGE UP
0			0			
.			.			

(shaded box) : No feature is assigned to the key.

109 Keyboard (Japanese)

Key	When the Ctrl Key Is Held Down on the USB Keyboard		When the Soft Keyboard Is Displayed on the WT1800		Other	
		When the WT1800 Shift Is On		+Shift on the USB Keyboard		When the WT1800 Shift Is On
a	AVG menu		a	A		
b	Execute STORE START	STORE SET menu	b	B		
c	SCALING menu	MOTOR/AUX SET menu	c	C		
d	Execute HOLD		d	D		
e	Execute ELEMENT	Execute ELEMENT ALL	e	E		
f	FILE menu	Same as left	f	F		
g	INTEG menu		g	G		
h	HRM SET menu		h	H		
i	Execute IMAGE SAVE	IMAGE SAVE menu	i	I		
j	Execute NULL	NULL SET menu	j	J		
k	Execute STORE STOP	Execute STORE RESET	k	K		
l	LINE FILTER menu	FREQ FILTER menu	l	L		
m	MEASURE menu	FREQ MEASURE menu	m	M		
n	Execute NUMERIC		n	N		
o	OTHERS menu		o	O		
p	Execute PRINT	PRINT menu	p	P		
q	FORM menu	CURSOR menu	q	Q		
r	Execute RESET	Same as left	r	R		
s	SHIFT on	SHIFT off	s	S		
t	ITEM menu		t	T		
u	UPDATE RATE menu		u	U		
v	WIRING menu		v	V		
w	Execute WAVE		w	W		
x	Execute EXT-SENSOR	SENSOR RATIO menu	x	X		
y	SYNC SOURCE menu		y	Y		
z	Execute SINGLE	Execute CAL	z	Z		
1			1	!		
2			2	”		
3			3	#		
4			4	$		
5			5	%		
6			6	&		
7			7	’		
8			8	(		
9			9	)		
0			0			
Enter	Execute SET	Same as left	Enter	Same as left	Execute SET	Same as left
Esc	Execute ESC	Same as left	Escape	Same as left	Execute ESC	Same as left
BS			Back Space	Same as left		
Tab						
Space			Space	Same as left		
-			-	=		
^			^	~		
\			\	|		
@			@	`		
[			[	{		
;			;	+		
:			:	*		
]			]	}		
,			,	<		
.	UTILITY menu		.	>		
/	Execute HELP	Same as left	/	?		
\			\	_		
Caps Lock			Caps Lock	Same as left		

(shaded): No feature is assigned to the key.

Appendix 7 USB Keyboard Key Assignments

Key	When the Ctrl Key Is Held Down on the USB Keyboard		When the Soft Keyboard Is Displayed on the WT1800		Other	
		When the WT1800 Shift Is On		+Shift on the USB Keyboard		When the WT1800 Shift Is On
F1	Execute U RANGE UP		Select soft key 1	Same as left	Select soft key 1	Same as left
F2	Execute U RANGE DOWN		Select soft key 2	Same as left	Select soft key 2	Same as left
F3	Execute U CONFIG		Select soft key 3	Same as left	Select soft key 3	Same as left
F4	Execute U AUTO		Select soft key 4	Same as left	Select soft key 4	Same as left
F5	Execute I RANGE UP		Select soft key 5	Same as left	Select soft key 5	Same as left
F6	Execute I RANGE DOWN		Select soft key 6	Same as left	Select soft key 6	Same as left
F7	Execute I CONFIG	Execute DIRECT/MEASURE	Select soft key 7	Same as left	Select soft key 7	Same as left
F8	Execute I AUTO					
F9	Execute U,I,P					
F10	Execute S,Q,λ,Φ					
F11	Execute WP,q,TIME		μ	Same as left		
F12	Execute FU,FI,η		Ω	Same as left		
Print Screen	Execute PRINT	PRINT menu				
Scroll Lock	Execute IMAGE SAVE	IMAGE SAVE menu				
Pause						
Insert	Execute INPUT INFO					
Home	Execute U/I MODE					
Page Up	Execute PAGE UP	Execute PAGE TOP			Execute PAGE UP	Execute PAGE TOP
Delete						
End	ELEMENT	ALL				
Page Down	Execute PAGE DOWN	Execute PAGE END			Execute PAGE DOWN	Execute PAGE END
→	Move cursor to the right	Same as left	Move cursor to the right	Same as left	Move cursor to the right	Same as left
←	Move cursor to the left	Same as left	Move cursor to the left	Same as left	Move cursor to the left	Same as left
↓	Move cursor down	Same as left			Move cursor down	Same as left
↑	Move cursor up	Same as left			Move cursor up	Same as left

Numeric Keypad	When the Ctrl Key Is Held Down on the USB Keyboard		When the Soft Keyboard Is Displayed on the WT1800		Other	
		When the WT1800 Shift Is On		+Shift on the USB Keyboard		+Shift on the USB Keyboard
Num Lock						
/			/	Same as left		
*			*	Same as left		
-			-	Same as left		
+			+	Same as left		
Enter	Execute SET	Same as left	Enter	Same as left		Execute SET
1			1			
2	Move cursor down	Same as left	2			Move cursor down
3	Execute PAGE DOWN	Execute PAGE END	3			Execute PAGE DOWN
4	Move cursor to the left	Same as left	4	Move cursor to the left		Move cursor to the left
5			5			
6	Move cursor to the right	Same as left	6	Move cursor to the right		Move cursor to the right
7			7			
8	Move cursor up	Same as left	8			Move cursor up
9	Execute PAGE UP	Execute PAGE TOP	9			Execute PAGE UP
0			0			
.			.			

(grey box) : No feature is assigned to the key.

Appendix 8 List of Initial Settings and Numeric Data Display Order

Factory Default Settings (Example for a model with six input elements installed)

The default settings vary depending on the number of installed input elements and what options are installed.

Item	Setting			
RANGE	5 A Input Element			50 A Input Element
U Range	1000V			1000V
I Input Terminal	Direct			Direct
I Direct input Range	5A			50A
External Sensor Range*	10V			10V
SENSOR RATIO*	10.0000mV/A			
WIRING				
Wiring Setting	1P2W			
η Formula				
η1	PΣB/PΣA			
η2	PΣA/PΣB			
η3	Off/Off			
η4	Off/Off			
Udef1	P1+None+None+None			
Udef2	P1+None+None+None			
Element Independent	Off			
ΔMeasure (displayed on models with the delta computation option)				
ΔMeasure Type	-			
ΔMeasure Mode	rms			
SCALING				
Scaling	Off			
VT Scaling	1.0000			
CT Scaling	1.0000			
Scaling Factor	1.0000			
LINE FILTER	Normal measurement mode: Off (Cutoff 0.5kHz) High speed data capturing mode: On (Cutoff 300kHz)			
FREQ FILTER	Off			
AVG				
Averaging	Off			
Averaging Type	Exp.			
Exp. Count	2			
Lin. Count	8			
MEASURE				
User-Defined Function	On/Off	Name	Unit	Expression
Function1	Off	Avg-W	W	WH(E1)/(TI(E1)/3600)
Function2	Off	P-loss	W	P(E1)-P(E2)
Function3	Off	U-ripple	%	(UPPK(E1)-UMPK(E1))/2/UDC(E1)*100
Function4	Off	I-ripple	%	(IPPK(E1)-IMPK(E1))/2/IDC(E1)*100
Function5	Off	D-UrmsR	V	DELTAU1RMS(E7)
Function6	Off	D-UrmsS	V	DELTAU2RMS(E7)
Function7	Off	D-UrmsT	V	DELTAU3RMS(E7)
Function8	Off	D-UmnR	V	DELTAU1MN(E7)
Function9	Off	D-UmnS	V	DELTAU2MN(E7)
Function10	Off	D-UmnT	V	DELTAU3MN(E7)
Function11	Off	PhiU3-U2	deg	360-PHIU1U3(E7)+PHIU1U2(E7)
Function12	Off	PhiI1-I2	deg	PHIU1I2(E7)-PHIU1I1(E7)
Function13	Off	PhiI2-I3	deg	PHIU3I3(E7)-PHIU2I2(E7)-F11()
Function14	Off	PhiI3-I1	deg	(360-PHIU3I3(E7))+PHIU1I1(E7)+(360-PHIU1U3(E7))
Function15	Off	Pp-p	W	PPPK(E1)-PMPK(E1)
Function16	Off	F16	V	DELTAU1RMN(E7)
Function17	Off	F17	V	DELTAU2RMN(E7)
Function18	Off	F18	V	DELTAU3RMN(E7)
Function19	Off	F19	V	DELTAU1DC(E7)
Function20	Off	F20	V	DELTAU2DC(E7)
Max Hold	Off			

* Available on models with the external current sensor input option

Item	Setting					
User-Defined Event	On/Off	Event Name	True	False	Expression	
Event No.1	Off	Ev1	True	False	URMS(E1) > 0.00000	
Event No.2	Off	Ev2	True	False	IRMS(E1) > 0.00000	
Event No.3	Off	Ev3	True	False	EV1() & EV2()	
Event No.4	OFF	Ev4	True	False	No expression	
Event No.5	Off	Ev5	True	False	No expression	
Event No.6	Off	Ev6	True	False	No expression	
Event No.7	Off	Ev7	True	False	No expression	
Event No.8	Off	Ev8	True	False	No expression	
Formula						
S Formula	Urms*Irms					
S,Q Formula	Type1					
Pc Formula	IEC76-1(1976)					
IEC76-1(1976)'s P1 and P2	P1 = 0.5000, P2 = 0.5000					
Sampling Frequency	Auto					
Phase	180 Lead/Lag					
Sync Measure	Master					
FREQ MEASURE (Available on models without the add-on frequency measurement option)						
Freq Items	U1, I1, U2					
SYNC SOURCE						
Element Object	Element1	Element2	Element3	Element4	Element5	Element6
Sync Source	I1	I2	I3	I4	I5	I6
HRM SET (Available on models with the harmonic measurement option or the simultaneous dual harmonic measurement option)						
Element Settings*	Element1 to Element6: Hrm1					
Hrm1 PLL Source	U1					
Hrm1 Min Order	1					
Hrm1 Max Order	100					
Hrm1 Thd Formula	1/Total					
Hrm2 PLL Source*	U1					
Hrm2 Min Order*	1					
Hrm2 Max Order*	100					
Hrm2 Thd Formula*	1/Total					
MOTOR SET (Available on models with the motor evaluation function; option)						
	Speed		Torque		Pm	
Scaling	1.0000		1.0000		1.0000	
Unit	rpm		Nm		W	
Sense Type	Analog		Analog			
Analog Auto Range	Off		Off			
Analog Range	20V		20V			
Linear Scale A	1.000		1.000			
Linear Scale B	0.000		0.000			
Calculation						
Point1X	0.000		0.000			
Point1Y	0.000		0.000			
Point2X	0.000		0.000			
Point2Y	0.000		0.000			
Line Filter	Off					
Sync Source	None					
Pulse Range Upper	10000.0000		50.0000			
Pulse Range Lower	0.0000		-50.0000			
Rated Upper			50.0000			
Rated Upper (Rated Freq)			15000Hz			
Rated Lower			-50.0000			
Rated Lower (Rated Freq)			5000Hz			
Pulse N (Speed)	60					
Sync Speed						
Pole	2					
Source	I1					

* Available on models with the simultaneous dual harmonic measurement option

Item	Setting	
Electrical Angle Measurement	Off	
Electrical Angle Offset		
Offset Value	0.00	
Auto Enter Target	U1	
AUX SET (Available on models with the auxiliary input option)		
Aux Name	AUX1	AUX2
Scaling	1.0000	1.0000
Unit	kW/m2	kW/m2
Analog Auto Range	Off	Off
Analog Range	20V	20V
Linear Scale A	1.000	1.000
Linear Scale B	0.000	0.000
Calculation		
Point1X	0.000	0.000
Point1Y	0.000	0.000
Point2X	0.000	0.000
Point2Y	0.000	0.000
Line Filter	Off	
UPDATE RATE		
Update Rate	500ms	
HOLD		
Hold	Off	
INTEG		
Integrator Status	Reset condition	
Independent Control	Off	
Integ Set		
Mode	Normal	
Integ Timer	00000:00:00	
Integ Start	2011/01/01 00:00:00	
Integ End	2011/01/01 01:00:00	
Auto Cal	Off	
WP±Type		
Setting	Each	
Element1 to Element6	Charge/Discharge	
q mode		
Setting	Each	
Element1 to Element6	dc	
D/A Output Rated Time	00001:00:00 (Displayed on models with the D/A output option)	
ITEM (Numeric)		
Item No.	1	
Function	Urms	
Element/Σ	Element1	
Order	-	
Display Frame	On	
FORM (Numeric)		
Numeric Form	4 Items	
ITEM (Wave)		
Display On	U1 to I6, Speed,[1] Torque,[1] Aux1,[2] Aux2[2]	
Vertical Zoom	×1	
Vertical Position	0.000%	

1 Available on models with the motor evaluation function (option)

2 Available on models with the auxiliary input option

Appendix 8 List of Initial Settings and Numeric Data Display Order

Item	Setting		
FORM (Wave)			
Format	Single		
Time/div	5ms		
Trigger Settings			
Mode	Auto (This features covers firmware versions 2.21 or before of the WT1800.) Off (This features covers firmware versions 2.22 or later of the WT1800.)		
Source	U1		
Slope	Rise		
Level	0.0%		
Display Setting			
Interpolate	Line		
Graticule	Grid(▦)		
Scale Value	On		
Wave Label	Off		
Wave Mapping			
Mode	Auto		
User Setting	U1: 0, I1: 0, U2: 1, I2: 1, U3: 2, I3: 2, U4: 3, I4: 3, U5: 4, I5: 4, U6: 5, I6: 5, Speed: 0,[1] Torque: 0,[1] Aux1: 0,[2] Aux2: 0[2]		
ITEM (Trend)			
Display On	T1 to T8		
Function	T1: Urms, T2: Irms, T3: P, T4: S, T5: Q, T6: λ, T7: Φ, T8: FreqU, T9 to T16: Urms		
Element	Element1		
Order	-		
Scaling	Auto		
Upper Scale	1.000E+02		
Lower Scale	-1.000E+02		
FORM (Trend)			
Trend Format	Single		
Time/div	3s		
Display Setting	Same as those listed under FORM (Wave)		
ITEM (Bar; displayed on models with the harmonic measurement option or simultaneous dual harmonic measurement option)			
Bar Item No.	1	2	3
Function	U	I	P
Element	Element1	Element1	Element1
Scale Mode	Fixed	Fixed	Fixed
FORM (Bar; displayed on models with the harmonic measurement option or simultaneous dual harmonic measurement option)			
Format	Single		
Start Order	1		
End Order	100		
ITEM (Vector; displayed on models with the harmonic measurement option or simultaneous dual harmonic measurement option)			
Vector Item No	1	2	
Object	ΣA	Element1	
U Mag	1.000	1.000	
I Mag	1.000	1.000	
FORM (Vector; displayed on models with the harmonic measurement option or simultaneous dual harmonic measurement option)			
Format	Single		
Numeric	ON		

1 Available on models with the motor evaluation function (option)

2 Available on models with the auxiliary input option

Item	Setting
FORM (High speed data capturing; displayed on models with the high speed data capturing option)	
Capt. Count	Infinite
Control Settings	
U/I Measuring Mode	
Setting	Each
U1 to I6	rms
HS Filter	Off
Cutoff	100Hz
Trigger Settings	Same as those listed under FORM (Wave)
External Sync	Off
Record to File	Off
File Settings	
Auto CSV Conversion	On
Item Settings	U1, I1, P1
Auto Naming	Numbering
ITEM (High speed data capturing; displayed on models with the high speed data capturing option)	
Column Num	4
Column No.	1
Element/Σ	Element1
Display Peak Over Status	Off
Display Frame	Same as those listed under ITEM (Numeric)
CURSOR (Wave)	
Wave Cursor	Off
Wave C1+ Trace	U1
Wave C2x Trace	I1
Cursor Path	Max
Wave C1+ Position	160
Wave C2x Position	640
Linkage	Off
CURSOR (Trend)	
Trend Cursor	Off
Trend C1+ Trace	T1
Trend C2x Trace	T2
Trend C1+ Position	160
Trend C2x Position	1440
Linkage	Off
CURSOR (Bar; displayed on models with the harmonic measurement option or simultaneous dual harmonic measurement option)	
Bar Cursor	Off
Bar C1+	1 order
Bar C2x	15 order
Linkage	Off

Item	Setting
CURSOR (Wave)	
Wave Cursor	Off
Wave C1+ Trace	U1
Wave C2x Trace	I1
Cursor Path	Max
Wave C1+ Position	160
Wave C2x Position	640
Linkage	Off
CURSOR (Trend)	
Trend Cursor	Off
Trend C1+ Trace	T1
Trend C2x Trace	T2
Trend C1+ Position	160
Trend C2x Position	1440
Linkage	Off
CURSOR (Bar; displayed on models with the harmonic measurement option or simultaneous dual harmonic measurement option)	
Bar Cursor	Off
Bar C1+	1 order
Bar C2x	15 order
Linkage	Off
STORE START/STOP/RESET	
Store Status	Off
STORE SET	
Control Settings	
Store Mode	Manual
Store Count	100
Interval	00:00:00
Item Settings	
Store Items	Selected Items
Items	Element1 Urms, Irms, P, S, Q, λ, Φ, FreqU, FreqI
File Settings	
Auto CSV Conversion	On
Auto Naming	Numbering
FILE	
Auto Naming	Numbering
IMAGE SAVE	
Format	BMP
Color	Off
Auto Naming	Numbering
PRINT MENU (Available on models with the printer option)	
Format	Screen
Auto Print Settings	
Print Mode	Interval
Print Count	Infinite
Print Interval	00:00:10
Print at Start	On
NULL	
Null	Off
NULL SET	
Target Element	All
Selected Items	U1 to U6, I1 to I6, Speed,[1] Torque,[1] Aux1,[2] Aux2[2]
KEY LOCK[3]	Off

1 Available on models with the motor evaluation function (option)
2 Available on models with the auxiliary input option
3 This setting is initialized when an RST command is received through the communication interface.

Item	Setting			
UTILITY				
Remote Control				
GP-IB				
Address[1,2]	1			
Network				
Time Out[1,2]	900s			
System Config				
Date/Time				
Display[1,2]	On			
Type[1,2]	Manual			
Language				
Menu Language[1]	ENG			
Message Language[1]	ENG			
LCD				
Auto Off[1,2]	Off			
Auto Off Time[1,2]	5min			
Brightness	7			
Color Settings				
Graph Color	Default			
Grid Intensity	4			
Base Color	Blue			
USB Keyboard[1,2]	English			
Preference				
Resolution[1,2]	5digits			
Freq Display at Frequency Low[1,2]	Error			
Motor Display at Pulse Freq Low[1,2]	Error			
Decimal Point for CSV File[1,2]	Period			
Menu Font Size[1,2]	Large			
Crest Factor	CF3			
Network				
TCP/IP				
DHCP[1,2]	On			
DNS[1,2]	Auto			
FTP Server				
User Name[1,2]	anonymous			
Time Out (seconds)[1,2]	900			
Net Drive				
Login Name[1,2]	anonymous			
FTP Passive[1,2]	Off			
Time Out (seconds)[1,2]	15			
SNTP				
Time Out (seconds)[1,2]	3			
Adjust at Power On[1,2]	Off			
Time Difference From GMT[1,2]	Hour: 9, Minute: 0			
D/A Output (Available on models with the D/A output option)				
Ch.	Function	Element/Σ	Order	Range Mode
1	Urms	Element 1	-	Fixed
2	Irms	Element 1	-	Fixed
3	P	Element 1	-	Fixed
4	S	Element 1	-	Fixed
5	Q	Element 1	-	Fixed
6	λ	Element 1	-	Fixed
7	Φ	Element 1	-	Fixed
8	fU	Element 1	-	Fixed
9	fI	Element 1	-	Fixed
10 to 20	None	Element 1	-	Fixed
Selftest				
Test Item	Memory			

1 This setting is not affected when the WT1800 is initialized (when you press UTILITY and then the Initialize Settings soft key).

2 Items that are not loaded when a setup parameter file is loaded (FILE-Load Setup)

App

Appendix

Numeric Data Display Order (Example for a Model with Six Input Elements Installed)

If you reset the order of the numeric data using the Element Origin setting, the data of each measurement function is displayed in the order indicated in the table below.

4 Items Display

Page											
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Urms1	Urms2	Urms3	Urms4	Urms5	Urms6	UrmsΣA	UrmsΣB	WP1	WP5	η1	Speed[1]
Irms1	Irms2	Irms3	Irms4	Irms5	Irms6	IrmsΣA	IrmsΣB	WP2	WP6	η2	Torque[1]
P1	P2	P3	P4	P5	P6	PΣA	PΣB	WP3	WPΣA	η3	Slip[1]
λ1	λ2	λ3	λ4	λ5	λ6	λΣA	λΣB	WP4	WPΣB	η4	Pm[1]

8 Items Display

Page											
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Urms1	Urms2	Urms3	Urms4	Urms5	Urms6	UrmsΣA	UrmsΣB	WP1	WP5	P1	Speed[1]
Irms1	Irms2	Irms3	Irms4	Irms5	Irms6	IrmsΣA	IrmsΣB	q1	q5	P2	Torque[1]
P1	P2	P3	P4	P5	P6	PΣA	PΣB	WP2	WP6	P3	SyncSp[1]
S1	S2	S3	S4	S5	S6	SΣA	SΣB	q2	q6	P4	Slip[1]
Q1	Q2	Q3	Q4	Q5	Q6	QΣA	QΣB	WP3	WPΣA	η1	Pm[1]
λ1	λ2	λ3	λ4	λ5	λ6	λΣA	λΣB	q3	qΣA	η2	—
Φ1	Φ2	Φ3	Φ4	Φ5	Φ6	ΦΣA	ΦΣB	WP4	WPΣB	η3	—
fU1	fU2	fU3	fU4	fU5	fU6	—	—	q4	qΣB	η4	—

16 Items Display

Page											
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Urms1	Urms2	Urms3	Urms4	Urms5	Urms6	UrmsΣA	P1	P5	P1	F1	Speed[1]
Irms1	Irms2	Irms3	Irms4	Irms5	Irms6	IrmsΣA	WP1	WP5	P2	F2	Torque[1]
P1	P2	P3	P4	P5	P6	PΣA	Irms1	Irms5	P3	F3	SyncSp[1]
S1	S2	S3	S4	S5	S6	SΣA	q1	q5	P4	F4	Slip[1]
Q1	Q2	Q3	Q4	Q5	Q6	QΣA	P2	P6	P5	F5	Pm[1]
λ1	λ2	λ3	λ4	λ5	λ6	λΣA	WP2	WP6	P6	F6	—
Φ1	Φ2	Φ3	Φ4	Φ5	Φ6	ΦΣA	Irms2	Irms6	PΣA	F7	—
Pc1	Pc2	Pc3	Pc4	Pc5	Pc6	PcΣA	q2	q6	PΣB	F8	—
fU1	fU2	fU3	fU4	fU5	fU6	UrmsΣB	P3	PΣA	η1	F9	—
fI1	fI2	fI3	fI4	fI5	fI6	IrmsΣB	WP3	WPΣA	η2	F10	—
U+pk1	U+pk2	U+pk3	U+pk4	U+pk5	U+pk6	PΣB	Irms3	IrmsΣA	η3	F11	—
U-pk1	U-pk2	U-pk3	U-pk4	U-pk5	U-pk6	SΣB	q3	qΣA	η4	F12	—
I+pk1	I+pk2	I+pk3	I+pk4	I+pk5	I+pk6	QΣB	P4	PΣB	—	F13	—
I-pk1	I-pk2	I-pk3	I-pk4	I-pk5	I-pk6	λΣB	WP4	WPΣB	—	F14	—
CfU1	CfU2	CfU3	CfU4	CfU5	CfU6	ΦΣB	Irms4	IrmsΣB	—	F15	—
CfI1	CfI2	CfI3	CfI4	CfI5	CfI6	PcΣB	q4	qΣB	—	F16	—

Matrix Display

Page								
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Urms	Urms	Irms	Time	—	—	—	—	—
Irms	Umn	Imn	WP	—	—	—	—	—
P	Udc	Idc	WP+	—	—	—	—	—
S	Urmn	Irmn	WP-	—	—	—	—	—
Q	Uac	Iac	q	—	—	—	—	—
λ	U+pk	I+pk	q+	—	—	—	—	—
Φ	U-pk	I-pk	q-	—	—	—	—	—
fU	CfU	CfI	WS	—	—	—	—	—
fI	fU	fI	WQ	—	—	—	—	—

All Items Display

Page											
1	2	3	4	5	6	7	8[2]	9[3]	10[3]	11[3]	12[3]
Urms	Urms	Irms	Time	F1	Ev1	η1	ΔU1	U(k)	Uhdf(k)	Uthd	K-factor
rmsI	Umn	Imn	Wp	F2	Ev2	η2	ΔU2	I(k)	Ihdf(k)	Ithd	EaU[1]
P	Udc	Idc	WP+	F3	Ev3	η3	ΔU3	P(k)	Phdf(k)	Pthd	EaI[1]
S	Urmn	Irmn	WP-	F4	Ev4	η4	ΔUΣ	S(k)	Z(k)	Uthf	ΦUi-Uj
Q	Uac	Iac	q	F5	Ev5	Speed[1, 4]	ΔI	Q(k)	Rs(k)	Ithf	ΦUi-Uk
λ	U+pk	I+pk	q+	F6	Ev6	Torque[1, 4]	ΔP1	λ(k)	Xs(k)	Utif	ΦUi-Ii
Φ	U-pk	I-pk	q-	F7	Ev7	SyncSp[1]	ΔP2	Φ(k)	Rp(k)	Itif	ΦUj-Ij
fU	CfU	CfI	WS	F8	Ev8	Slip[1]	ΔP3	ΦU(k)	Xp(k)	hvf	ΦUk-Ik
fI	Pc		WQ	F9		Pm[1]	ΔPΣ	ΦI(k)		hcf	
	P+pk[5]			F10							
	P-pk[5]			F11							
				F12							
				F13							
				F14							
				F15							
				F16							
				F17							
				F18							
				F19							
				F20							

Left Side of the Single List Screen[3] and Dual List Screen[3]

Page										
1	2	3	4	5	6	7	8	9	10	11
Urms1	Urms2	Urms3	Urms4	Urms5	Urms6	UrmsΣA	UrmsΣB	UrmsΣC	F1	F17
Irms1	Irms2	Irms3	Irms4	Irms5	Irms6	IrmsΣA	IrmsΣB	IrmsΣC	F2	F18
P1	P2	P3	P4	P5	P6	PΣA	PΣB	PΣC	F3	F19
S1	S2	S3	S4	S5	S6	SΣA	SΣB	SΣC	F4	F20
Q1	Q2	Q3	Q4	Q5	Q6	QΣA	QΣB	QΣC	F5	
λ1	λ2	λ3	λ4	λ5	λ6	λΣA	λΣB	λΣC	F6	
Φ1	Φ2	Φ3	Φ4	Φ5	Φ6	ΦUi-Uj	ΦUi-Uj	ΦUi-Uj	F7	
Uthd1	Uthd2	Uthd3	Uthd4	Uthd5	Uthd6	ΦUi-Uk	ΦUi-Uk	ΦUi-Uk	F8	
Ithd1	Ithd2	Ithd3	Ithd4	Ithd5	Ithd6	ΦUi-Ii	ΦUi-Ii	ΦUi-Ii	F9	
Pthd1	Pthd2	Pthd3	Pthd4	Pthd5	Pthd6	ΦUj-Ij	ΦUj-Ij	ΦUj-Ij	F10	
Uthf1	Uthf2	Uthf3	Uthf4	Uthf5	Uthf6	ΦUk-Ik	ΦUk-Ik	ΦUk-Ik	F11	
Ithf1	Ithf2	Ithf3	Ithf4	Ithf5	Ithf6				F12	
Utif1	Utif2	Utif3	Utif4	Utif5	Utif6				F13	
Itif1	Itif2	Itif3	Itif4	Itif5	Itif6				F14	
hvf1	hvf2	hvf3	hvf4	hvf5	hvf6				F15	
hcf1	hcf2	hcf3	hcf4	hcf5	hcf6				F16	
K-factor1	K-factor2	K-factor3	K-factor4	K-factor	K-factor6					

1 Displayed on models with the motor evaluation function (option)
2 Displayed on models with the delta computation option
3 Displayed on models with the harmonic measurement option or the simultaneous dual harmonic measurement option
4 On models with the auxiliary input option, Aux1 is displayed instead of Speed, and Aux2 is displayed instead of Torque.
5 Not displayed when the split display is in use.

Appendix 9 Limitations on Modifying Settings and Operations

During integration, storage, and auto printing, there are measurement conditions and computations whose settings you cannot change and features that you cannot execute.

Operation (Changing settings or executing features)		Integration Status		Storage State			Auto Print
		Start or Ready	Stop, Timeup, or Error	Start or Ready	Stop	Comp or Error	On
Basic Measurement Conditions	Wiring	No	No	No	No	No	No
	η Formula	No	Yes	No	No	No	Yes
	Element Independent	No	No	No	No	No	No
	ΔMeasure Type	No	No	No	No	No	Yes
	ΔMeasure Mode	No	Yes	No	No	No	Yes
	Element ALL	No	No	No	No	No	Yes
	Voltage or current range	No	No	Yes	Yes	Yes	Yes
	Voltage or current Auto Range	No	No	Yes	Yes	Yes	Yes
	Direct Current Input or External Current Sensor	No	No	No	No	No	Yes
	Sensor Ratio	No	No	No	No	No	Yes
	VT/CT/SF Scaling	No	No	No	No	No	Yes
	Config(V)/Config(A)	No	No	No	No	No	Yes
	Crest Factor	No	No	No	No	No	No
	Sync Source	No	No	No	No	No	Yes
	Line Filter	No	No	No	No	No	Yes
	Freq Filter	No	No	No	No	No	Yes
	Update Rate	No	No	No	No	No	No
	Average	No	No	No	No	No	Yes
Harmonics	PLL Source	No	No	No	No	No	Yes
	Min/Max Order	No	No	No	No	No	Yes
	Thd Formula	No	No	No	No	No	Yes
	Element Settings	No	No	No	No	No	Yes
Motor	Scaling	No	No	No	No	No	Yes
	Sense Type	No	No	No	No	No	Yes
	Auto Range	No	No	Yes	Yes	Yes	Yes
	Range	No	No	Yes	Yes	Yes	Yes
	Linear Scale A/B	No	No	No	No	No	Yes
	Linear Scale Calculate Execute	No	No	No	No	No	Yes
	Line Filter	No	No	No	No	No	Yes
	Motor	No	No	No	No	No	Yes
	Pulse Range Upper/Lower	No	No	No	No	No	Yes
	Torque Pulse	No	No	No	No	No	Yes
	Torque Pulse Rated Freq	No	No	No	No	No	Yes
	Pulse N	No	No	No	No	No	Yes
	Pole	No	No	No	No	No	Yes
	Sync Speed Source	No	No	No	No	No	Yes
	Electrical Angle Measurement ON/OFF	No	No	No	No	No	Yes
	Electrical Angle Correction	No	No	No	No	No	Yes
External Signal	Scaling	No	No	No	No	No	Yes
	Auto Range	No	No	Yes	Yes	Yes	Yes
	Range	No	No	Yes	Yes	Yes	Yes
	Linear Scale A/B	No	No	No	No	No	Yes
	Linear Scale Calculate Execute	No	No	No	No	No	Yes
	Line Filter	No	No	No	No	No	Yes
Computation	User-Defined Function Conditions	No	Yes	No	No	No	Yes
	Max Hold ON/OFF	No	No	Yes	Yes	Yes	Yes
	User-Defined Event Conditions	No	Yes	No	No	No	Yes

Operation (Changing settings or executing features)		Integration Status		Storage State			Auto Print
		Start or Ready	Stop, Timeup, or Error	Start or Ready	Stop	Comp or Error	On
Computation	S Formula	No	No	No	No	No	Yes
	S, Q Formula	No	No	No	No	No	Yes
	Pc Formula	No	No	No	No	No	Yes
	Sampling Frequency	No	No	No	No	No	Yes
	Phase	No	No	No	No	No	Yes
	Sync Measure	No	No	No	No	No	No
	Freq Measure	No	No	No	No	No	Yes
Integration	Independent Control	No	No	No[1]	No[1]	No[1]	No[1]
	D/A Rated Time	No	No	Yes	Yes	Yes	Yes
Waveform Display	Time/Div	No	No	No	No	No	Yes
	Trigger Mode	No	No	Yes	Yes	Yes	Yes
	Trigger Source	No	No	No	No	No	Yes
	Trigger Slope	No	No	No	No	No	Yes
	Trigger Level	No	No	No	No	No	Yes
Storage	STORE CSV Conversion	Yes	Yes	No	No	Yes	Yes
	STORE START	Yes	Yes	No[2]	Yes	No	No
	STORE STOP	Yes	Yes	Yes	Yes	Yes	No
	STORE RESET	Yes	Yes	Yes	Yes	Yes	No
Files	File Auto Naming	Yes	Yes	No	No	Yes	Yes
	File Name	Yes	Yes	No	No	Yes	Yes
	Comment	Yes	Yes	No	No	Yes	Yes
	Setup File Save	No	No	No	No	No	Yes
	Setup File Load	No	No	No	No	No	No
	Numeric Save	No	Yes	No	No	Yes	Yes
	Numeric Save Item Settings	Yes	Yes	No	No	Yes	Yes
	Wave Save	No	Yes	No	No	Yes	Yes
	Custom File Save	No	Yes	No	No	Yes	Yes
	Custom File Load	No	No	No	No	No	No
	Change Drive	Yes	Yes	No	No	No	Yes
	Change Directory	Yes	Yes	No	No	No	Yes
	Delete	No	No	No	No	No	Yes
	Rename	No	No	No	No	No	Yes
	Make Directory	No	No	No	No	No	Yes
	Copy	No	No	No	No	No	Yes
	Move	No	No	No	No	No	Yes
	Save Images	No	Yes	No	No	Yes	Yes
Printing	Auto Print ON	Yes	Yes	No	No	No	No
	Auto Print OFF	Yes	Yes	No	No	No	Yes
	Print images	Yes	Yes	No	No	No	Yes
	Print the numeric data list	Yes	Yes	No	No	No	Yes
	Print Abort	Yes	Yes	No	No	No	Yes
	Paper Feed	Yes	Yes	No	No	No	Yes
Utilities	Initialize Settings	Yes	Yes	No	No	No	Yes
	Date/Time	No	No	No	No	No	No
	Date/Time Type	No	No	No	No	No	No
	Menu Language	No	No	Yes	Yes	Yes	Yes
	Message Language	No	No	Yes	Yes	Yes	Yes
	Menu Font Size	No	No	Yes	Yes	Yes	Yes
	Freq Display at Frequency Low	No	No	No	No	No	Yes
	Motor Display at Pulse Freq Low	No	No	No	No	No	Yes
	SelfTest	No	No	No	No	No	No
Other Features	Manual Cal	No	No	Yes	Yes	Yes	Yes
	NULL	No	No	No	No	No	Yes

Yes: The setting can be changed, or the feature can be performed.

No: The setting cannot be changed, or the feature cannot be performed.

1 Only in Integ Sync mode

2 Storage can be started in Single Shot mode.

Appendix 10 Limitations on the Features during High Speed Data Capturing

During high speed data capturing, there are measurement conditions and computations whose settings you cannot change and features that you cannot execute.

Item			Operation
High Speed Data Capturing	Capture Count		Yes[1, 2]
	Optimize Count		Yes[1, 2]
	Control Settings	Voltage/Current Measuring Mode	Yes[1, 2]
		HS Filter	Yes[1, 2]
		Trigger	Yes[1]
		External Sync	Yes[1, 2]
	Record to File		Yes[1, 2]
	Save Conditions		Yes[2]
	Start		Yes[1, 2]
	Stop		Yes

Item		Operation
Switching the Display	Numeric Data Display	No[1]
	Waveform Display	No[1]
	Trend Display	No[1]
	Bar Graph Display	No[1]
	Vector Display	No[1]
	High Speed Data Capturing	Yes
	Setup Parameter List Display	No
Fundamental Measurement Conditions	Wiring System[3, 4]	Yes[1]
	Efficiency Equation	No
	Independent Input Element Configuration[4]	Yes[1]
	Delta Computation	No
	Selecting All Input Elements[4]	Yes[1]
	Voltage or Current Auto Range	No
	Direct Current Input or External Current Sensor[5]	No
	Measurement Period	No
	Line Filter[6]	Yes[1]
	Frequency Filter	No
	Data Update Interval	No
	Averaging	No
	Fundamental measurement conditions other than those listed above	Yes[1]
Harmonic Measurement	Harmonic Measurement Conditions	No
Motor Evaluation	Input Signal Type[7]	No[1]
	Analog Auto Range	No
	Synchronization Source	No
	Synchronous Speed	No
	Electrical Angle Measurement	No
Auxiliary Input	Analog Auto Range	No
	Synchronization Source	No
Computation	User-Defined Functions	No
	MAX Hold	No
	User-Defined Events	No
	Equation for Apparent Power (S Formula)	No
	Apparent Power and Reactive Power Computation Types (S,Q Formula)	No
	Corrected Power Equation (Pc Formula)	No
	Sampling Frequency[8]	Yes[7]
	Phase Difference Display Format	No
	Master/Slave Synchronization Measurement	No
Integrated Power	Integration Conditions, Integration Execution	No
Data Storage	Storage Conditions, Storage Execution	No

Item		Operation
Saving and Loading Data	Saving Setup Data	Yes[1, 2]
	Saving Waveform Display Data	No
	Saving Numeric Data	No
Saving Screen Images	Saving a Screen Image	Yes[2]
Printing	Printing[9]	Yes[2]
	Automatic Printing	No
Utility	D/A Output	No
Other Features	NULL Feature[10]	No
	Zero-Level Compensation	Yes[1]

Yes: The setting can be changed, or the feature can be performed.

No: The setting cannot be changed, or the feature cannot be performed.

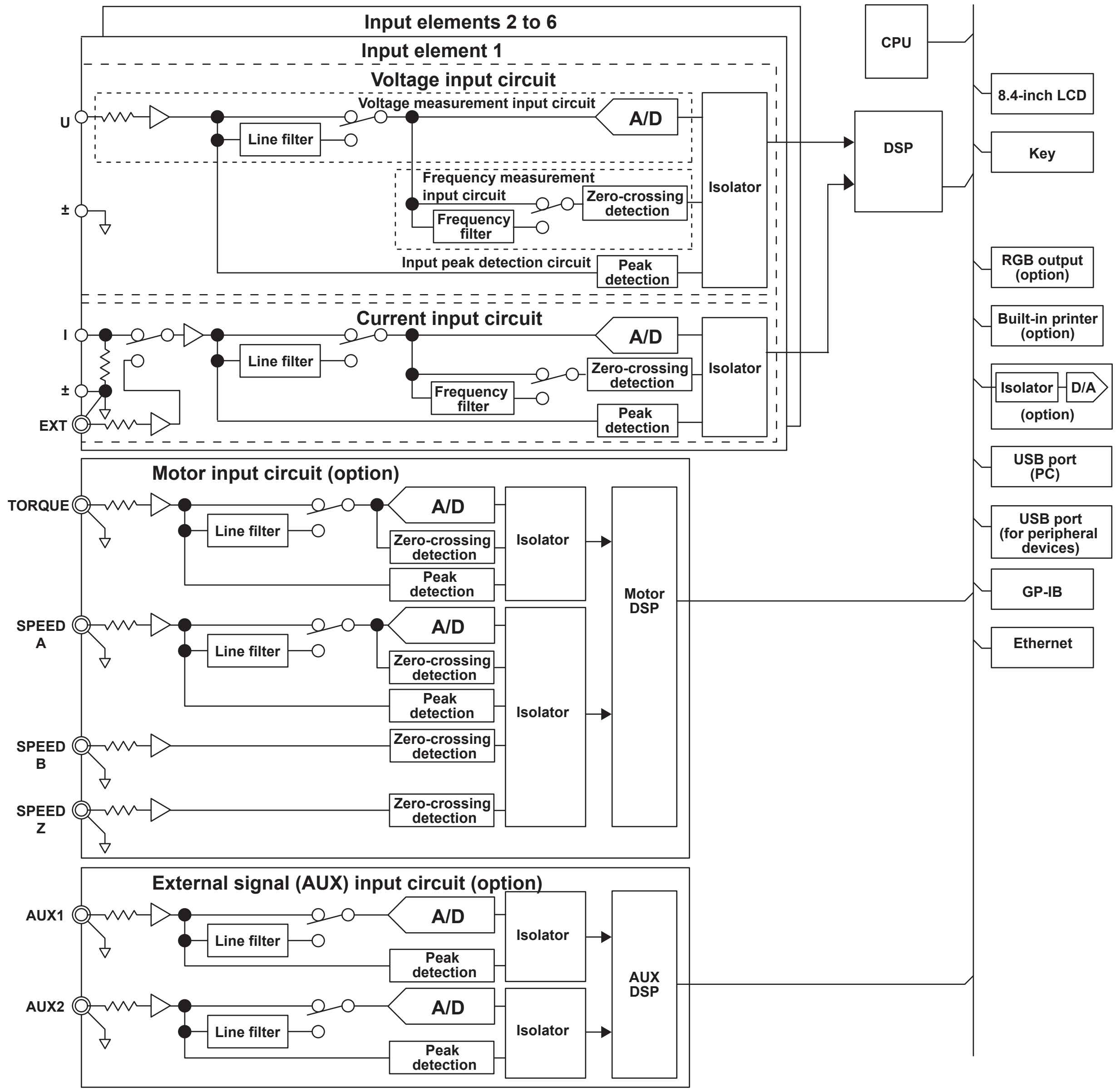
1 This setting or operation is unavailable when high speed data capturing has been started (Start).
2 This setting or operation is unavailable when a high speed data capturing file is being recorded to (Rec).
3 When the wiring system of a wiring unit has been set to a single-phase, three-wire system (1P3W) or a three-phase, three-wire system (3P3W), the voltage (UΣ), current (IΣ), and power (PΣ) of that wiring unit are not measured and are displayed as "-------" (no data).
4 When the NULL feature is enabled and this setting or operation would cause a current input switch between direct input and external current sensor input, this setting or operation is unavailable. Perform this setting or operation in the normal measurement mode.
5 When the NULL feature is enabled, you cannot switch between direct input and external current sensor input using the current input setting. Perform this setting in the normal measurement mode.
6 The line filter is always on. The line filter setting range is different than the setting range for normal measurement. The line filter setting for high speed data capturing is not the same as the line filter setting for normal measurement. The WT1800 saves both settings.
7 When the NULL feature is enabled, you cannot change the motor input signal type. Perform this setting in the normal measurement mode.
8 You cannot select Auto. When the sampling frequency has been set to Auto for normal measurement and you switch to high speed data capturing, the WT1800 operates under the Clock C setting.
9 You can print a screen image. You cannot print numeric data lists.
10 During high speed data capturing, the setting for the NULL feature remains the same as the setting specified during normal measurement (ON or OFF). You cannot change the setting for the NULL feature. Perform this setting in the normal measurement mode.

Note

When the same setting is used for both normal measurement and high speed data capturing, that setting cannot be specified when high speed data capturing has been started (Start).

Appendix 11 Block Diagram

Block Diagram



Input Signal Flow and Process

Input elements 1 through 6 consist of a voltage input circuit and a current input circuit. The input circuits are mutually isolated. They are also isolated from the case.
The voltage signal that is applied to the voltage input terminal (U, ±) is normalized using the voltage divider and the operational amplifier (op-amp) of the voltage input circuit. It is then sent to a voltage A/D converter.
The current input circuit is equipped with two types of input terminals, a current input terminal (I, ±) and an external current sensor input connector (EXT). Only one can be used at any given time. The voltage signal from the current sensor that is received at the external current sensor input connector is normalized using the voltage divider and the operational amplifier (op-amp). It is then sent to a current A/D converter.
The current signal that is applied to the current input terminal is converted to a voltage signal by a shunt. Then, it is sent to the current A/D converter in the same fashion as the voltage signal from the current sensor.

The voltage signal that is applied to the voltage A/D converter and current A/D converter is converted to digital values at an interval of approximately 0.5 μs. These digital values are isolated by the isolator and passed to the DSP. In the DSP, the measured values are derived based on the digital values. The measured values are then transmitted to the CPU. Various computed values are determined from the measured values. The measured values and computed values are displayed and transmitted (as D/A and communication output) as measurement functions of normal measurement.
The harmonic measurement functions (option) are derived in the following manner. The voltage signal sent to the A/D converter is converted to digital values at a sampling frequency that is determined by the PLL source signal. The DSP derives the measured value of each harmonic measurement item by performing an FFT on the converted digital values.