WT1801R, WT1802R, WT1803R, WT1804R, WT1805R, WT1806R
Precision Power Analyzer

USER'S MANUAL

Features Guide

YOKOGAWA
Yokogawa Test & Measurement Corporation

IM WT1801R-01EN
1st Edition

Thank you for purchasing the WT1801R, WT1802R, WT1803R, WT1804R, WT1805R, or WT1806R Precision Power Analyzer. This features guide contains useful information about the features of this instrument. To ensure correct use, please read this manual thoroughly before beginning operation.
After reading this manual, keep it in a safe place. The manuals for this instrument are listed on the next page. Please read all manuals.

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 improvements to the product's performance and functionality. Refer to our website to view our latest manuals.
- The figures given in this manual may differ from those that actually appear on your screen.
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Revisions

- 1st Edition: October 2024

1st Edition: October 2024 (YMI)

Manuals

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

Manuals included with the product

Manual Title	Manual No.	Description
WT1801R, WT1802R, WT1803R, WT1804R, WT1805R, WT1806R Precision Power Analyzer Getting Started Guide	IM WT1801R-03EN	This guide explains the handling precautions, basic operations, and specifications of this instrument.
WT1801R, WT1802R, WT1803R, WT1804R, WT1805R, WT1806R Precision Power Analyzer Request to Download Manuals	IM WT1801R-73Z2	Describes the manuals provided on the website.
WT1801R, WT1802R, WT1803R, WT1804R, WT1805R, WT1806R Precision Power Analyzer	IM WT1801R-92Z1	Document for China
Safety Instruction Manual	IM 00C01C01-01Z1	Safety manual (European languages)

Manuals provided on the website

Download the following manuals from our website.

Manual Title	Manual No.	Description
WT1801R, WT1802R, WT1803R, WT1804R, WT1805R, WT1806R Precision Power Analyzer Features Guide	IM WT1801R-01EN	This document. Explains all the instrument's features other than the communication interface features.
WT1801R, WT1802R, WT1803R, WT1804R, WT1805R, WT1806R Precision Power Analyzer User's Manual	IM WT1801R-02EN	Explains how to operate this instrument.
WT1801R, WT1802R, WT1803R, WT1804R, WT1805R, WT1806R Precision Power Analyzer Communication Interface User's Manual	IM WT1801R-17EN	Explains the functions of this instrument's communication interface, how to configure it, and the commands used to control this instrument from a PC through the interface.

For details on downloading manuals, see Request to Download Manuals (IM WT1801R-73Z2). To view the PDF data, you need Adobe Acrobat Reader or a software application that can open PDF data.

The “EN,” “E,” “Z1,” and “Z2” in the manual numbers are the language codes.

Online help

The content similar to the Features Guide, IM WT1801R-01EN, is included in this instrument as a help file (some of the content may be omitted). For instructions on how to use the help, see section 1.7 in the User's Manual, IM WT1801R-02EN.

Contents

14 Split Display

15 Cursor Measurement

16 High Speed Data Capturing

17 Data Storage

18 Saving and Loading Data

19 Saving Screen Images

20 Ethernet Communication (Network)

21 Utility

22 Other Features

Appendix

Index

1 Items That This Instrument Can Measure

The items that this instrument can measure are as follows. For details on how measurement function values are obtained, see appendix 1. For descriptions of the terms measurement function, input element, and wiring unit, see “What is a measurement function?”

▶ Click here.

The input elements and wiring units referred to in each measurement function table are listed below. However, the input elements and wiring units that can be measured vary depending on how many input elements are installed in this instrument.

- Input elements: Element1, Element2, Element3, Element4, Element5, Element6
- Wiring units: ΣA, ΣB, ΣC

Measurement functions used in normal measurement

Voltage

Function	Description	Input Element	Wiring Units
Urms	True rms voltage	Yes	Yes
Umn	Rectified mean voltage calibrated to the rms value	Yes	Yes
Udc	Simple voltage average	Yes	Yes
Urmn	Rectified mean voltage	Yes	Yes
Uac	AC voltage component	Yes	Yes
U+pk	Maximum voltage	Yes	No
U−pk	Minimum voltage	Yes	No
CfU	Voltage crest factor	Yes	No

Current

Function	Description	Input Element	Wiring Units
Irms	True rms current	Yes	Yes
Imn	Rectified mean current calibrated to the rms value	Yes	Yes
Idc	Simple current average	Yes	Yes
Irmn	Rectified mean current	Yes	Yes
Iac	AC current component	Yes	Yes
I+pk	Maximum current	Yes	No
I−pk	Minimum current	Yes	No
CfI	Current crest factor	Yes	No

Power

Function	Description	Input Element	Wiring Units
P	Active power	Yes	Yes
S	Apparent power	Yes	Yes
Q	Reactive power	Yes	Yes
λ	Power factor	Yes	Yes
Φ	Phase difference	Yes	Yes
Pc	Corrected Power	Yes	Yes
P+pk	Maximum power	Yes	No
P−pk	Minimum power	Yes	No

Frequency

Function	Description	Input Element	Wiring Units
fU	Voltage frequency	Yes	No
fI	Current frequency	Yes	No
fPLL1	PLL1 frequency[1]	No	No
fPLL2	PLL2 frequency[2]	No	No

1 Models with the harmonic measurement option or simultaneous dual harmonic measurement option

2 Models with the simultaneous dual harmonic measurement option

Integrated power (watt hours)

Function	Description	Input Element	Wiring Units
Time	Integration time	Yes	No
WP	Sum of positive and negative watt hours	Yes	Yes
WP+	Sum of positive P values	Yes	Yes
WP−	Sum of negative P values	Yes	Yes
q	Sum of positive and negative ampere hours	Yes	Yes
q+	Sum of positive I values	Yes	Yes
q−	Sum of negative I values	Yes	Yes
WS	Volt-ampere hours	Yes	Yes
WQ	Var hours	Yes	Yes

Efficiency

Function	Description
η1 to η4	Efficiency

User-defined functions

Function	Description
F1 to F20	User-defined functions

User-defined events

Function	Description
Ev1 to Ev8	User-defined events

Harmonic measurement functions (option)

Function	Description	Input Element	Wiring Units
U(k)	Rms voltage of harmonic order k	Yes	Yes
I(k)	Rms current of harmonic order k	Yes	Yes
P(k)	Active power of harmonic order k	Yes	Yes
S(k)	Apparent power of harmonic order k	Yes	Yes
Q(k)	Reactive power of harmonic order k	Yes	Yes
λ(k)	Power factor of harmonic order k	Yes	Yes
Φ(k)	Phase difference between the voltage and current of harmonic order k	Yes	No
ΦU(k)	Phase difference between the fundamental signal, U(1), and harmonic voltage U(k)	Yes	No
ΦI(k)	Phase difference between the fundamental signal, I(1), and harmonic current I(k)	Yes	No
Z(k)	Impedance of the load circuit	Yes	No
Rs(k)	Series resistance of the load circuit	Yes	No
Xs(k)	Series reactance of the load circuit	Yes	No
Rp(k)	Parallel resistance of the load circuit	Yes	No
Xp(k)	Parallel reactance of the load circuit	Yes	No
Uhdf(k)	Harmonic voltage distortion factor	Yes	No
Ihdf(k)	Harmonic current distortion factor	Yes	No
Phdf(k)	Harmonic active power distortion factor	Yes	No
Uthd	Total harmonic voltage distortion	Yes	No
Ithd	Total harmonic current distortion	Yes	No
Pthd	Total harmonic active power distortion	Yes	No
Uthf	Telephone harmonic factor of the voltage	Yes	No
Ithf	Telephone harmonic factor of the current	Yes	No
Utif	Telephone influence factor of the voltage	Yes	No
Itif	Telephone influence factor of the current	Yes	No
hvf	Harmonic voltage factor	Yes	No
hcf	Harmonic current factor	Yes	No
K−factor	K factor	Yes	No
ΦUi−Uj[1]	Phase difference between the fundamental voltage of element i, Ui(1), and the fundamental voltage of element j, Uj(1)	No	Yes
ΦUi−Uk[1]	Phase difference between Ui(1) and the fundamental voltage of element k, Uk(1)	No	Yes
ΦUi−Ii[1]	Phase difference between Ui(1) and the fundamental current of element i, Ii(1)	Yes[2]	Yes
ΦUj−Ij[1]	Phase difference between Uj(1) and the fundamental current of element j, Ij(1)	No	Yes
ΦUk−Ik[1]	Phase difference between Uk(1) and the fundamental current of element k, Ik(1)	No	Yes

1 i, j, and k are input element numbers. For example, when the number of input elements in wiring unit ΣA is six and the wiring system of elements 1, 2, and 3 is three-phase four-wire, i is 1, j is 2, and k is 3. ΦUi − Uj represents ΦU1 − U2, the phase difference between the fundamental voltage signal of element 1, U1(1), and the fundamental voltage signal of element 2, U2(1). Likewise, ΦUi – Uk, ΦUi – Ii, ΦUj – Ij, and ΦUk−Ik represent ΦU1 – U3, ΦU1 – I1, ΦU2 – I2, and ΦU3 – I3, respectively.

2 Setting i to an input element is the same as setting k to 1 in Φ(k).

Harmonic measurement function orders

The harmonic orders that you can specify are indicated below.

Input element harmonic measurement functions

Measurement Function	Characters or Numbers in Parentheses			
	Total	0(DC)	1	k
U( )	Yes	Yes	Yes	2 to 500
I( )	Yes	Yes	Yes	2 to 500
P( )	Yes	Yes	Yes	2 to 500
S( )	Yes	Yes	Yes	2 to 500
Q( )	Yes	Always zero	Yes	2 to 500
λ( )	Yes	Yes	Yes	2 to 500
Φ( )	Yes	No	Yes	2 to 500
ΦU( )	No	No	No	2 to 500
ΦI( )	No	No	No	2 to 500
Z( )	No	Yes	Yes	2 to 100
Rs( )	No	Yes	Yes	2 to 100
Xs( )	No	Yes	Yes	2 to 100
Rp( )	No	Yes	Yes	2 to 100
Xp( )	No	Yes	Yes	2 to 100
Uhdf( )	No	Yes	Yes	2 to 500
Ihdf( )	No	Yes	Yes	2 to 500
Phdf( )	No	Yes	Yes	2 to 500
Uthd	Yes	No	No	No
Ithd	Yes	No	No	No
Pthd	Yes	No	No	No
Uthf	Yes	No	No	No
Ithf	Yes	No	No	No
Utif	Yes	No	No	No
Itif	Yes	No	No	No
hvf	Yes	No	No	No
hcf	Yes	No	No	No
K-factor	Yes	No	No	No

Functions with parentheses will produce different values depending on which of the following is contained in their parentheses.

- Total: Total value (The total value of all harmonic components from the minimum order to N.* For how the value is determined, see appendix 1.)
- 0(DC): DC value
- 1: Fundamental harmonic value
- k: The value of any order from 2 to N.*

* N is the maximum measurable order. The maximum measurable harmonic order is the smallest of the following three values.
  - The specified maximum measurable harmonic order
  - The value determined automatically according to the PLL source frequency (see section 5.6 in the Getting Started Guide, IM WT1801R−03EN)
  - When the data update interval is 50 ms or Auto, the maximum measurable harmonic order is 100.

Wiring unit harmonic measurement functions (Σ functions)

Measurement Function	Characters or Numbers in Parentheses	
	Total	1
UΣ( )	Yes	Yes
IΣ( )	Yes	Yes
PΣ( )	Yes	Yes
SΣ( )	Yes	Yes
QΣ( )	Yes	Yes
λΣ( )	Yes	Yes

Functions with parentheses will produce different values depending on which of the following is contained in their parentheses.

- Total: Total value
- 1: Fundamental harmonic value

Delta calculation functions

Function	Description
ΔU1	The values returned by the delta calculation functions vary depending on the specified delta calculation type.
ΔU2	
ΔU3	
ΔUΣ	
ΔI	
ΔP1	
ΔP2	
ΔP3	
ΔPΣ	

For details on delta calculation functions, see “Delta Calculation (Δ Measure).”

▶ Click here.

Motor evaluation functions (option)

Function	Description
Speed	Motor rotating speed
Torque	Motor torque
SyncSp	Sync speed
Slip	Slip (%)
Pm	Mechanical output of the motor (mechanical power)
EaU1 to 6*, EaI1 to 6*	Electrical angle: Phase angles of U1 to I6 with the falling edge of the signal received through the Z terminal of the motor evaluation function as the reference.

* Models with the harmonic measurement option or simultaneous dual harmonic measurement option

Auxiliary input measurement functions (option)

Function	Description
Aux1	Auxiliary input 1
Aux2	Auxiliary input 2

High speed data capturing measurement functions

- U and I of each input element and wiring unit: Select rms, mean, dc, or r-mean.
- P of each input element and wiring unit
- Motor evaluation function (option) speed, torque, and Pm
- Auxiliary inputs (option) Aux1 and Aux2
- The maximum and minimum values of the above measurement functions

What is a measurement function?

Measurement function

The various physical quantities such as rms voltage, average current, power, and phase difference that the instrument measures and displays are called measurement functions. Each physical quantity is displayed with a corresponding symbol. For example, “Urms” corresponds to the true rms voltage.

Element

Element refers to a set of input terminals that can receive a single phase of voltage and current to be measured. This instrument can be equipped with up to six elements, numbered from 1 to 6. An element number is appended to the measurement function symbol for the measured data that this instrument displays, so that you can tell which data belongs to which element. For example, “Urms1” corresponds to the true rms voltage of element 1.

Wiring system

You can specify five wiring systems on this instrument to measure the power of various single-phase and three-phase power transmission systems: single-phase two-wire, single-phase three-wire, three-phase three-wire, three-phase four-wire, and three-phase three-wire with three-voltage three-current method.

Wiring unit

The wiring unit is a set of two or three input elements of the same wiring system that are grouped to measure three-phase power. There can be up to three wiring units: ΣA, ΣB, and ΣC.

▶ Click here.

Σ functions

The measurement function of a wiring unit is called a Σ function.
For example, “UrmsΣA” corresponds to the average of the voltages of the input elements that are assigned to the wiring unit ΣA. The average value represents the true rms value.

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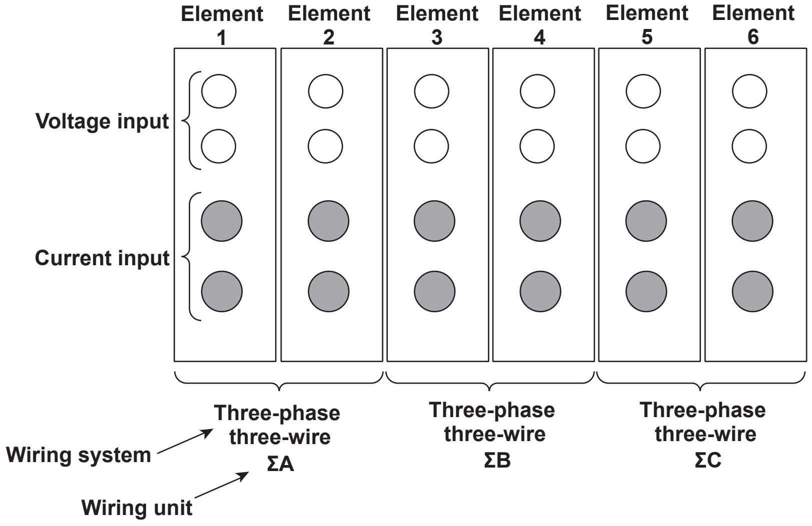


Measurement period

For the measurement period for calculating measurement functions, see “Measurement period (SYNC SOURCE).”

▶ Click here.

2 Fundamental Measurement Conditions

Wiring system settings (WIRING)

The following wiring system settings are available.

- Wiring system (Wiring)
- Efficiency formula (η Formula)
- Independent input element configuration (Element Independent)
- Delta calculation (Δ Measure)
- Settings of all elements (All Elements Setup)

Wiring system (Wiring)

The following five wiring systems are available on the instrument. The selectable wiring systems vary depending on the number of installed input elements.

- 1P2W: Single-phase two-wire system
- 1P3W: Single-phase three-wire system
- 3P3W: Three-phase three-wire system
- 3P4W: Three-phase four-wire system
- 3P3W(3V3A): Three-voltage three-current method

Wiring unit

Wiring units are sets of two or three input elements of the same wiring system that are grouped together. You can define up to three wiring units: ΣA, ΣB, and ΣC.

- When there is only one wiring unit, the wiring unit is ΣA. ΣB and ΣC cannot be assigned.
- When there are two wiring units, the wiring units are ΣA and ΣB. ΣC cannot be assigned.
- When there are three wiring units, the wiring units are ΣA, ΣB, and ΣC.
- When there are multiple wiring units, they are assigned element numbers in ascending order: ΣA, ΣB, and then ΣC.
- A wiring unit is configured with adjacent input elements. A wiring unit cannot be configured with wiring units that are not adjacent.
- A wiring unit must either be configured with only 50 A input elements or only 5 A input elements. A wiring unit cannot be configured with different types of input elements.

Σ functions

The measurement function of a wiring unit is called a Σ function.
For example, “UrmsΣA” corresponds to the average of the voltages of the input elements that are assigned to the wiring unit ΣA. The average value represents the true rms value.

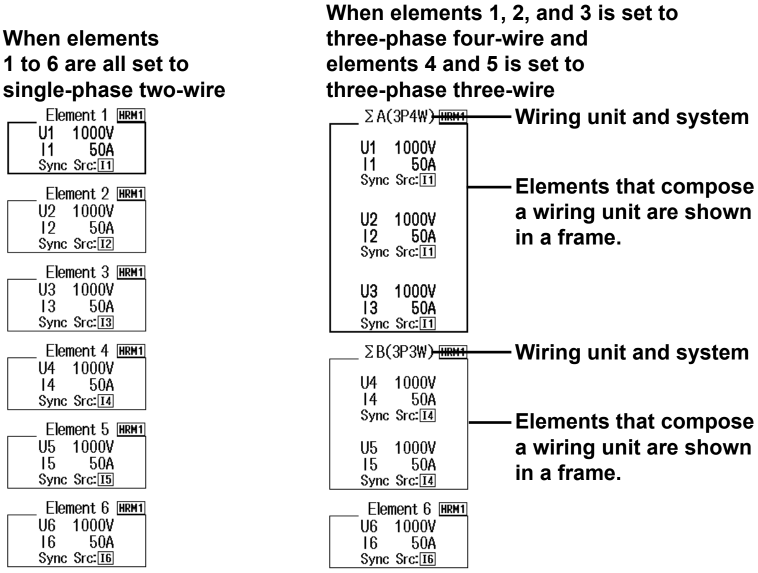
Wiring system combinations

You can configure any combination that meets the conditions for wiring units described above.
For the relationship between the wiring system and how a function is determined, see appendix 1.

Select the wiring system according to the actual wiring of the circuit under measurement. The method in which the Σ functions (wiring unit measurement functions) are determined varies depending on the wiring system. If the selected wiring system does not match that of the actual circuit, measurements and calculation will not be correct.

Wiring system display

The wiring system configuration is displayed on the right side of the screen. Because it is displayed behind the menu, to view it, you need to press the ESC key to hide the menu. The following figure shows examples of wiring system displays for a model with six input elements installed.



Settings of elements grouped in a wiring unit

When the independent input element configuration is off, if a wiring system other than 1P2W is selected when the measurement range, valid measurement range, or sync source settings of each input element are different, these settings are changed in the manner described below:

- The measurement range is set to the greatest of the measurement ranges of the input elements assigned to the same wiring unit. The external current sensor input range has precedence over the direct input current range.
- The auto range on/off settings are changed to match the setting of the input element whose measurement range is highest. If multiple input elements are set to a common highest measurement range, the setting of the input element with the smallest input element number takes precedence.
- In the valid measurement range settings, all measurement ranges are enabled (selected).
- The sync source and the group of the harmonic measurement input element are set to the settings of the input element with the smallest input element number among the input elements assigned to the same wiring unit.

At the same time that you press an ELEMENT key to select the element that you want to set the voltage or current range of, the indicators of the input elements that have been assigned to the same wiring unit lights.

Wiring system during high speed data capturing

▶ Click here.

Efficiency formula (η Formula)

You can create an efficiency formula by combining measurement function symbols. This instrument can determine the energy conversion efficiency of the device using the numeric values of the measurement functions.

η1 to η4

You can create four efficiency formulas (η1 to η4), using the following measurement functions as operands.

- The active powers of each element (P1 to P6)
- The active powers of the Σ functions (PΣA to PΣC)
- The motor output (Pm; on models with the motor evaluation option)
- Udef1, Udef2

Udef1, Udef2

To add active powers and motor output and set them in η1 to η4, define Udef1 and Udef2. You can add up to four operands consisting of the measurement functions listed above.

Formula examples

- **Efficiency of a single-phase two-wire input/single-phase two-wire output device**
  Input: Power of element 1 (P1)
  Output: Power of element 2 (P2)
  -> Efficiency formula: P2/P1 × 100 (%)

- **Efficiency of a single-phase two-wire input/three-phase three-wire output device**
  Input: Power of element 1 (P1)
  Output: Σ power of elements 2 and 3 (PΣB)
  Efficiency formula: PΣA/P1 × 100 (%)

- **Efficiency of a three-phase three-wire input/three-phase three-wire output device**
  Input: Σ power of elements 1 and 2 (PΣA)
  Output: Σ power of elements 3 and 4 (PΣB)
  Efficiency formula: PΣB/PΣA × 100 (%)

- **Efficiency of motor 1 with a single-phase two-wire input**
  Input: Power of element 1 (P1)
  Output: Motor output (Pm)
  Efficiency formula: Pm/P1 × 100 (%)

- **Efficiency of motor 1 with a three-phase three-wire input**
  Input: Σ power of elements 1 and 2 (PΣA)
  Output: Motor output (Pm)
  Efficiency formula: Pm/PΣA × 100 (%)

To correctly calculate the efficiency, set the power coefficients of all elements so that all power units used in the calculation are the same. For example, the efficiency cannot be calculated correctly if elements or wiring units used in the calculation have different power units, such as W (watt) and J (joule).

Independent input element configuration (Element Independent)

You can select whether to collectively or independently set the measurement ranges and sync sources of input elements assigned to the same wiring unit in the wiring system settings.

Turning independent input element configuration on and off

For example, assume that the wiring system on a model with three input elements is set as follows:
Input elements 1 to 3: Three-phase four-wire system (3P4W). Input elements 1 to 3 are assigned to a single wiring unit ΣA.

- ON
  The measurement range and sync source can be set independently for each input element included in a wiring unit.
- OFF
  The measurement range and sync source of input elements 1 to 3 are set to the same settings. This is convenient because when you are measuring a three-phase device, you can set the measurement range and sync source settings of all input elements included in a wiring unit simultaneously.

Settings that are shared between input elements when independent input element configuration is turned off

- Measurement range (including auto range on or off)
- Direct current input or external current sensor input
- Valid measurement range
- Sync source
- Input element group for harmonic measurement (applies to models with the simultaneous dual harmonic measurement option)

Settings that can be configured independently even when independent input element configuration is turned off

- External current sensor conversion ratio (option)
- Scaling values (VT ratio, CT ratio, and power coefficient)
- Input filters (line filter and frequency filter)

These settings can be configured independently for each input element regardless of whether independent input element configuration is turned on or off.

How settings are aligned when independent input element configuration is changed from on to off

When independent input element configuration is changed from on to off, the measurement range, valid measurement range, and sync source settings of each input element in a wiring unit (ΣA, ΣB, or ΣC) are changed as follows:

- The measurement range is set to the greatest of the measurement ranges of the input elements assigned to the same wiring unit. The external current sensor input range has precedence over the direct input current range.
- The auto range on/off settings are changed to match the setting of the input element whose measurement range is highest. If multiple input elements are set to a common highest measurement range, the setting of the input element with the smallest input element number takes precedence.
- In the valid measurement range settings, all measurement ranges are enabled (selected).
- The sync source and the group of the harmonic measurement input element are set to the settings of the input element with the smallest input element number among the input elements assigned to the same wiring unit.

Delta calculation (Δ Measure)

The sum or difference of the instantaneous voltage or current values (sampled data) between the elements in a wiring unit can be used to determine various types of data such as the differential voltage and phase voltage. This operation is called *delta math*.

Types of delta calculation (ΔMeasure Type)

The following types of delta calculation are available:
- Differential voltage and differential current (Difference)
- Line voltage and phase current (3P3W > 3V3A)
- Star-delta transformation (Star>Delta)
- Delta-star transformation (Delta>Star)

The delta calculation types that you can select vary according to the wiring system as follows:

Wiring System	Delta Calculation Type
1P3W	Difference, 3P3W>3V3A
3P3W	Difference, 3P3W>3V3A
3P4W	Star>Delta
3P3W(3V3A)	Delta>Star

- **Differential voltage and differential current (Difference)**

  The differential voltage and differential current between two elements can be calculated from data of a single-phase three-wire system or a three-phase three-wire system.

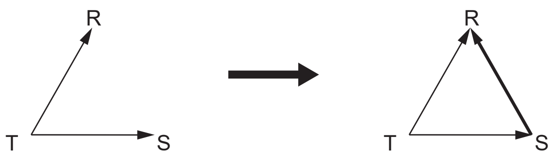
  When you perform delta calculation on wiring unit ΣA, the available measurement functions are as follows.
  ΔU1rms[UdiffA], ΔU1mn[UdiffA], ΔU1dc[UdiffA], ΔU1rmn[UdiffA], ΔU1ac[UdiffA]
  ΔIrms[IdiffA], ΔImn[IdiffA], ΔIdc[IdiffA], ΔIrmn[IdiffA], ΔIac[IdiffA]

  * In the measurement functions, *rms*, *mn(mean)*, *dc*, *rmn(r-mean)*, and *ac* are the delta calculation modes. *A* indicates the wiring unit.

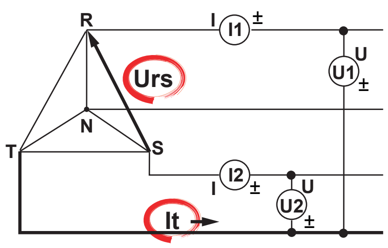
  ▶ Click here.

- **Line voltage and phase current (3P3W>3V3A)**

  You can calculate unmeasured line voltages and phase currents by converting the data of a three-phase three-wire system to the data of the three-voltage three-current method (3V3A).



  When you perform delta calculation on wiring unit ΣA, the available measurement functions are as follows.
  ΔU1rms[UrsA], ΔU1mn[UrsA], ΔU1dc[UrsA], ΔU1rmn[UrsA], ΔU1ac[UrsA]
  ΔIrms[ItA], ΔImn[ItA], ΔIdc[ItA], ΔIrmn[ItA], ΔIac[ItA]



  * In the measurement functions, *rms*, *mn(mean)*, *dc*, *rmn(r-mean)*, and *ac* are the delta calculation modes. *A* indicates the wiring unit.

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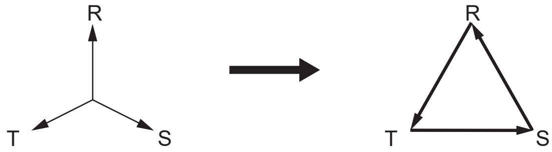
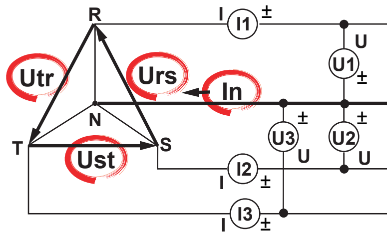
- **Star-delta transformation (Star>Delta)**

You can use the data from a three-phase four-wire system to calculate the data of a delta connection from the data of a star connection.



When you perform delta calculation on wiring unit ΣA, the available measurement functions are as follows.
ΔU1rms[UrsA], ΔU1mn[UrsA], ΔU1dc[UrsA], ΔU1rmn[UrsA], ΔU1ac[UrsA]
ΔU2rms[UstA], ΔU2mn[UstA], ΔU2dc[UstA], ΔU2rmn[UstA], ΔU2ac[UstA]
ΔU3rms[UtrA], ΔU3mn[UtrA], ΔU3dc[UtrA], ΔU3rmn[UtrA], ΔU3ac[UtrA]
ΔUΣrms[UΣA], ΔUΣmn[UΣA], ΔUΣdc[UΣA], ΔUΣrmn[UΣA], ΔUΣac[UΣA]
ΔIrms[InA], ΔImn[InA], ΔIdc[InA], ΔIrmn[InA], ΔIac[InA]

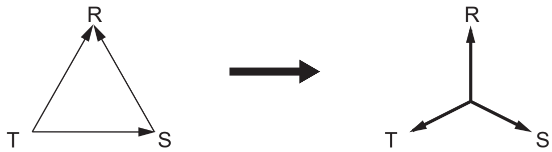


* In the measurement functions, *rms*, *mn(mean)*, *dc*, *rmn(r-mean)*, and *ac* are the delta calculation modes. *A* indicates the wiring unit.

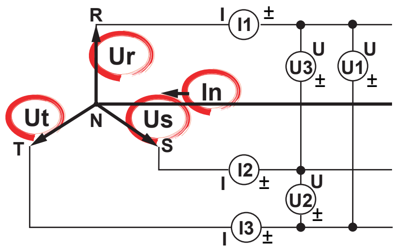
▶ Click here.

- **Delta-star transformation (Delta>Star)**

Using the data from a three-phase three-wire system that uses a three-voltage three-current method, you can calculate the data of a star connection from the data of a delta connection. This function is useful when you wish to observe the phase voltage of an object that has no neutral line, such as a motor. Neutral point N of the delta connection is assumed to be the center of gravity of the star connection. If the actual neutral point is not aligned to the center of gravity, an error results.



When you perform delta calculation on wiring unit ΣA, the available measurement functions are as follows.
ΔU1rms[UrA], ΔU1mn[UrA], ΔU1dc[UrA], ΔU1rmn[UrA], ΔU1ac[UrA]
ΔU2rms[UsA], ΔU2mn[UsA], ΔU2dc[UsA], ΔU2rmn[UsA], ΔU2ac[UsA]
ΔU3rms[UtA], ΔU3mn[UtA], ΔU3dc[UtA], ΔU3rmn[UtA], ΔU3ac[UtA]
ΔUΣrms[UΣA], ΔUΣmn[UΣA], ΔUΣdc[UΣA], ΔUΣrmn[UΣA], ΔUΣac[UΣA]
ΔIrms[InA], ΔImn[InA], ΔIdc[InA], ΔIrmn[InA], ΔIac[InA]
ΔP1[PrA]
ΔP2[PsA]
ΔP3[PtA]
ΔPΣ[PΣA]



* In the measurement functions, *rms*, *mn(mean)*, *dc*, *rmn(r-mean)*, and *ac* are the delta calculation modes. *A* indicates the wiring unit.

▶ Click here.

For the formulas, see appendix 1.
For the measurement period, see "Measurement period."

▶ Click here.

Delta calculation modes (ΔMeasure Mode)

You can select the voltage or current mode to be displayed as delta calculation values from the following: rms, mean, dc, r-mean, ac

- We recommend that you set the measurement range and scaling (VT/CT ratio and coefficients) of the elements that are undergoing delta calculation as identical as possible. Using different measurement ranges or scaling causes the measurement resolutions of the sampled data to be different. This results in errors.
- The numbers (1, 2, and 3) that are attached to delta calculation measurement function symbols have no relation to the element numbers. The calculation of all delta measurement functions, from ΔU1 to ΔPΣ, varies depending on the wiring system and the delta calculation type. For details, see appendix 1.
- When only one element is installed in this instrument, this feature cannot be used, and the setup menu does not appear.
- Delta calculation cannot be performed on a single-phase two-wire (1P2W) system.

Settings of all elements (All Elements Setup)

You can configure the settings of all elements while viewing them in a list. By selecting the left most cell, you can collectively set all elements.

Sensor conversion ratio preset (Sensor Preset)

When using the dedicated shunt box, preset the external current sensor conversion ratio. Select a preset name from the following:

Preset Name	External Current Sensor Conversion Ratio (Sensor Ratio)
Shunt20 (20 Ω)	20000.0000 mV/A(mΩ)
Shunt10 (10 Ω)	10000.0000 mV/A(mΩ)
Shunt5 (5 Ω)	5000.0000 mV/A(mΩ)
CT1000S	2.0000 mV/A

If you set this item, the external current sensor input ON/OFF (Ext Sensor) is set to ON. If you change the external current sensor conversion ratio (Sensor Ratio) after setting this item, an asterisk will be added to the preset name. To use other sensors, select Others. If you select Others, the external current sensor input ON/OFF and external current sensor conversion ratio do not change.

CT ratio preset (CT Preset)

When using the dedicated CT, preset the CT ratio. Select the preset name (CT) from one of the settings below.

Preset Name	CT Ratio (CT Scaling)	Model Name
CT2000A	2000.0000	CT2000A
CT1000	1500.0000	CT1000, CT1000A
CT200	1000.0000	CT200
CT60	600.0000	CT60

If you set this item, the scaling ON/OFF (Scaling) is set to ON. If you change the CT ratio (CT Scaling) after setting this item, an asterisk will be added to the preset name. To use other CTs, select Others. If you select Others, the scaling ON/OFF and CT ratio do not change.

Element to set the measurement range of (ELEMENT)

Select the element to set the measurement range of. Each time you press ELEMENT, only the indicators for the equipped elements light up sequentially. When independent input element configuration is off, the selected elements will switch by wiring unit, according to the wiring system.

Selecting all input elements (ALL)

You can select at once the selected input elements and the input elements that meet all the following conditions. You can set the voltage and current ranges at once.

Conditions for input elements to be selected at once

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

Default values of input elements selected at once

The voltage range, current range, and auto range on/off settings of the input element that are selected before you select all input elements are copied to all the other selected elements.

After you select all input elements, changes that you make to the voltage range, current range, and auto range on/off settings affect all the selected input elements.

To release the selection of all input elements and specify independent input element settings, press ELEMENT.

Voltage range (RANGE UP/DOWN (V))

There are two voltage range modes: fixed range (when auto range is off) and auto range (when auto range is on).

Fixed range

In fixed range mode, you can select a voltage range from the available options. The selected voltage range does not change even if the amplitude of the input signal changes. Set the range based on the rms value of the input signal.

When the crest factor is set to CF3

Select from 1.5V, 3V, 6V, 10V, 15V, 30V, 60V, 100V, 150V, 300V, 600V, and 1000V.

When the crest factor is set to CF6 or CF6A

Select from 0.75V, 1.5V, 3V, 5V, 7.5V, 15V, 30V, 50V, 75V, 150V, 300V, and 500V.

Auto range

▶ Click here.

- Set the range based on the rms value of the input signal. For example, if you are applying a 100-Vrms sinusoidal signal, set the range to 100 V.
- When measuring a signal other than a sine wave (such as a distorted wave), you can obtain accurate measurements by selecting the smallest measurement range that does not produce any of the conditions below.
  - Input peak over indicator at the top center of the screen lights red or blinks.
  - The measured values of the voltage and current are indicated as being overloaded (“-OL-”).
- The peak over-range indicator may not light or blink in the following cases.
  - If the pulse width is narrow, and the peak value of the waveform cannot be acquired at the sampling rate of this instrument (approximately 2 MS/s).
  - If the high frequency components of the pulse waveform attenuate due to the bandwidth limitations of this instrument’s measurement circuit, causing the waveform peak value to be less than the peak over-range detection level.
- If a signal with a peak that is greater than about 10 times the range is applied, it takes about 1 second to change the range.
- When applying the secondary output of a VT (voltage transformer) to the voltage input terminal, set the voltage range according to the maximum value of the VT output. Then, use the scaling feature to set the VT ratio.
- To display a list of the range settings of all input elements, see “Displaying the setup parameter list.” You can change measurement ranges from the list.

  ▶ Click here.

Auto voltage range (AUTO (V))

When you press AUTO, the AUTO key lights, and the mode changes to auto range. The range changes automatically according to the amplitude of the input signal as follows. The different ranges used in auto range mode are the same as those available for the fixed range.

Range increase

The measurement range is increased when any of the following conditions is met.

- The crest factor is set to CF3 or CF6 and the data of measurement function Urms or Irms exceeds 110 % of the measurement range.
- The crest factor is set to CF6A and the data of measurement function Urms or Irms exceeds 220 % of the measurement range.
- The crest factor is set to CF3 and the data of Upk* or Ipk* exceeds approximately 330 % of the measurement range.
- The crest factor is set to CF6 or CF6A and the data of Upk* or Ipk* exceeds approximately 660 % of the measurement range.

- If all the installed input elements are selected (all element indicators are lit), the measurement range is increased on all input elements when any of the elements meets the range-increase conditions described above.
- When a wiring unit is configured, the measurement range is increased on all input elements in the wiring unit when any of the elements in the unit meets the range-increase conditions described above.

Range decrease

The measurement range is decreased when all the following conditions are met.

- The data of Urms or Irms is less than or equal to 30 % of the measurement range.
- The data of Urms or Irms is less than or equal to 105 % of the next lower range.
- The crest factor is set to CF3 and the data of Upk* or Ipk* is less than or equal to 300 % of the next lower range.
- The crest factor is set to CF6 or CF6A and the data of Upk* or Ipk* is less than or equal to 600 % of the next lower range.

* Even if the NULL feature is on, the values are determined as if it were off.

- If all the installed input elements are selected (all element indicators are lit), the measurement range is decreased on all input elements when all the elements meet the range-decrease conditions described above.
- When a wiring unit is configured, the measurement range is decreased on all input elements in the wiring unit when all the elements in the unit meet the range-decrease conditions described above.

- If you disable a measurement range in the valid measurement range settings, that measurement range is skipped, and the auto range feature operates using only the valid measurement ranges.
- When non-periodic pulse waveforms are applied, the range may not remain constant. If this happens, use the fixed range setting.

Current range (RANGE UP/DOWN (A))

There are two current range modes: fixed range (when auto range is off) and auto range (when auto range is on).

Fixed range

In fixed range mode, you can select a current range from the available options. The selected current range does not change even if the amplitude of the input signal changes. Set the range based on the rms value of the input signal.

5 A input element

- **When the crest factor is set to CF3**
  Select from 10mA, 20mA, 50mA, 100mA, 200mA, 500mA, 1A, 2A, and 5A.
- **When the crest factor is set to CF6 or CF6A**
  Select from 5mA, 10mA, 25mA, 50mA, 100mA, 250mA, 500mA, 1A, and 2.5A.

50 A input element

- **When the crest factor is set to CF3**
  Select from 1A, 2A, 5A, 10A, 20A, and 50A.
- **When the crest factor is set to CF6 or CF6A**
  Select from 500mA, 1A, 2.5A, 5A, 10A, and 25A.

Auto range

This feature is similar to auto range for voltage.

▶ Click here.

- When the secondary output of a CT (current transformer) or a clamp-type current sensor that outputs current is being applied to the current input terminal, set the current range according to the maximum value of the CT or current sensor output. Then, use the scaling feature to set the CT ratio or the conversion ratio of the clamp-type current sensor that outputs current.

Auto current range (AUTO (A))

This feature is similar to auto range for voltage.

▶ Click here.

Power range

The measurement ranges (power ranges) of active power (P), apparent power (S), and reactive power (Q) are as follows:

Wiring System	Power Range
1P2W (single-phase two-wire)	Current range × voltage range
1P3W (single-phase three-wire) 3P3W (three-phase three-wire) 3P3W (3V3A, three-voltage three-current method)	Voltage range × current range × 2 (when the voltage and current ranges on the elements in the wiring unit are set to the same ranges)
3P4W (three-phase four-wire)	Voltage range × current range × 3 (when the voltage and current ranges on the elements in the wiring unit are set to the same ranges)

- When the result of voltage range × current range exceeds 1000 W (VA or var), the displayed unit changes to kW (kVA or kvar).
- Number of displayed digits (display resolution)

  ▶ Click here.

For a detailed table of the available voltage and current range combinations and power ranges when the voltage range and current range are the same across all elements, see appendix 3.

In auto range mode, because the voltage and current ranges switch independently according to range increase and decrease conditions, different power ranges may be set for the same power value.

External current sensor range (EXT SENSOR, option)

The output of voltage-output current sensors, such as shunts and clamps, can be measured by connecting the output to an element's external current sensor input terminal (EXT). Press EXT SENSOR to select it (the EXT SENSOR key lights), and set the external current sensor range.
There are two external current sensor range modes: fixed range (when auto range is off) and auto range (when auto range is on).

Fixed range

In fixed range mode, you can select a current range from the available options. The selected current range does not change even if the amplitude of the input signal changes. Set the range based on the rms value of the input signal.

- **When the crest factor is set to CF3**
  Select from 50mV, 100mV, 200mV, 500mV, 1V, 2V, 5V, and 10V.
- **When the crest factor is set to CF6 or CF6A**
  Select from 25mV, 50mV, 100mV, 250mV, 500mV, 1V, 2.5V, and 5V.

Auto range

This feature is similar to auto range for voltage.

▶ Click here.

External current sensor conversion ratio (SENSOR RATIO, option)

Set the conversion ratio used when applying the output from a voltage-output current probe to the external current sensor input terminal (EXT) and measuring it. Set how many millivolts the current probe generates when 1 A of current is applied (conversion ratio). Then, the input signal can be made to correspond to the numeric data or waveform display data that is obtained when the current is directly applied to the current input terminals. When using a current-output current sensor, set the conversion ratio as the CT ratio.

▶ Click here.

Measurement Function	Conversion Ratio	Data before Conversion	Conversion Result
Current I	E	I_S (current sensor output)	I_S/E
Active power P	E	P_S	P_S/E
Apparent power S	E	S_S	S_S/E
Reactive power Q	E	Q_S	Q_S/E
Max./min. current Ipk	E	Ipk_S (current sensor output)	Ipk_S/E

Element1 to Element6

Use the soft keys to select an element, and then set the element's external current sensor conversion ratio in the following range.
0.0001 to 99999.9999

Copying the external current sensor conversion ratio (Exec Copy Σ)

You can copy the external current sensor conversion ratio of the selected input element to other input elements in the same wiring unit.

External current sensor range and conversion ratio configuration example

When measuring a current with a maximum value of 100 A using a current sensor that generates 10 mV when 1 A of current is flowing, the maximum voltage that the current sensor generates is 10 mV/A × 100 A = 1 V. Therefore, configure the settings as indicated below.

- External current sensor range: 1 V
- External current sensor conversion ratio: 10 mV/A

- When using the dedicated shunt box, you can select an external current sensor conversion ratio preset in the settings of all elements (All Elements Setup).
  ▶ Click here.
- When you want to divide the external current sensor output by the conversion ratio and read the current of the circuit under measurement directly, turn the external VT/CT scaling feature off. If the feature is turned on, the value will be further multiplied by the CT ratio.
- When measuring a signal other than a sine wave (such as a distorted wave), you can obtain accurate measurements by selecting the smallest measurement range that does not produce any of the conditions below.
  - Input peak over indicator at the top center of the screen lights red or blinks.
  - The measured values of the voltage and current are indicated as being overloaded ("-OL-").

External current sensor range display format (DIRECT/ MEASURE, option)

You can select the external current sensor range display format from the following options.

- DIRECT (direct input value display)
  Values are displayed within the external current sensor range (voltage). This setting is useful when you want to set the external current sensor range based on an external current sensor's output voltage applied to the instrument.
- MEASURE (measurement range display)
  The external current sensor range is divided by the external current sensor conversion ratio, and the resulting (current) range is displayed. This setting is useful when you want to set the external current sensor range based on the current measured by the external current sensor. For example, if you are using a current sensor that generates 10 mV when it receives 1 A (external current sensor conversion ratio: 10 mV/A) and you set the external current sensor range to 1 V, the displayed current range is 100 A.

Scaling feature (SCALING)

You can set coefficients for when you apply a voltage or current signal from an external VT (voltage transformer) or CT (current transformer).

Turning scaling on and off (Scaling)

You can select whether to apply the VT ratio, CT ratio, and power coefficient to applicable measurement functions.

To read measured values directly by using a VT or CT (or current sensor), select ON. When ON is selected, the SCALING key lights, and the Scaling indicator turns on at the top of the screen.

Applicable measurement functions

Voltage U, current I, power (P, S, and Q), maximum and minimum voltages (U+pk and U-pk), and maximum and minimum currents (I+pk and I-pk)

- ON: The measurement functions above are multiplied by the VT ratio, CT ratio, or power coefficient.
- OFF: The measurement functions above are not multiplied by the VT ratio, CT ratio, or power coefficient. The output values of the VT and CT are displayed directly as numeric data.

VT ratio (VT Scaling)

Set the VT ratio when applying the secondary output of a VT to the voltage input terminal. Then, set the voltage range according to the maximum VT output.

Element1 to Element6

Use the soft keys to select an element, and then set the VT ratio in the following range.
0.0001 to 99999.9999

Copying the VT ratio (Exec Copy Σ)

You can copy the VT ratio of the selected input element to the other input elements in the same wiring unit.

CT ratio (CT Scaling)

Set the CT ratio (or the conversion ratio of the current-output current sensor) when applying the secondary output of a CT or clamp-type current-output current sensor to the current input terminal. Then, set the current range according to the maximum CT or current sensor output.

Element1 to Element6

Use the soft keys to select an element, and then set the CT ratio in the following range.
0.0001 to 99999.9999

Copying the CT ratio (Exec Copy Σ)

You can copy the CT ratio of the selected input element to the other input elements in the same wiring unit.

When using the CT, you can select a CT ratio preset in the settings of all elements (All Elements Setup).

▶ Click here.

Power coefficient (SF Scaling, scaling factor)

By setting the power coefficient (SF), you can display the measured active power, apparent power, and reactive power after they have been multiplied by a coefficient.

measurement function	Data before Conversion	Conversion Result	
Voltage U	U_2(VT's secondary output)	$U_2 \times V$	V: VT ratio
Current I	I_2(CT's secondary output)	$I_2 \times C$	C: CT ratio
Active power P	P_2	$P_2 \times V \times C \times SF$	SF: Power coefficient
Apparent power S	S_2	$S_2 \times V \times C \times SF$	
Reactive power Q	Q_2	$Q_2 \times V \times C \times SF$	
Max./min. voltage Upk	Upk_2(VT's secondary output)	$Upk_2 \times V$	
Max./min. current Ipk	Ipk_2(CT's secondary output)	$Ipk_2 \times C$	

Element1 to Element6

Use the soft keys to select an element, and then set the power coefficient in the following range.
0.0001 to 99999.9999

Copying the power coefficient (Exec Copy Σ)

You can copy the power coefficient of the selected input element to the other input elements in the same wiring unit.

- If the value of the result of multiplying the measured value by the VT ratio, CT ratio, or power coefficient (scaling factor) exceeds 9999.99 M, "-OF-" will appear in the numeric data display frame.
- You can view the VT and CT ratios and the power coefficients of all input elements in the setup parameter list.

  ▶ Click here.
- To correctly calculate the power and efficiency of Σ functions, set the power coefficients of all elements so that all power units used in the calculation are the same. For example, the efficiency cannot be calculated correctly if elements or wiring units used in the calculation have different power units, such as W (watt) and J (joule). To calculate the efficiency correctly, make all the power units the same (either all W or all J).

Valid measurement range (CONFIG (V)/CONFIG (A))

You can enable or disable a measurement range by selecting or clearing its check box. This instrument switches between enabled measurement ranges, skipping disabled measurement ranges. For example, when using auto range to measure the current of a device that produces 2 A in operation mode and 100 mA in standby mode, disable the 200 mA, 500 mA, and 1 A ranges. If the instrument is measuring at the 200 mV range setting in standby mode and changes to operation mode, it will skip the intermediate 200 mA, 500 mA, and 1 A ranges and switch directly to the 2 A range.

Element1 to Element6

For each input element or wiring unit, you can set all ranges as valid measurement ranges (All ON).

Measurement range box (Left column of the list)

For each range, you can set whether the range is a valid measurement range for all input elements (All ON) or not (All OFF).

Measurement range to switch to when a peak over-range occurs (Peak Over Jump)

You can specify which measurement range to switch to when the auto range feature is enabled and a peak over-range occurs. The background of the selected measurement range turns yellow. The background of the selected measurement range turns yellow. If a peak over-range occurs when this feature is disabled, this instrument increases the measurement range, switching between valid measurement ranges (measurement ranges whose check boxes have been selected).

You can specify valid current measurement ranges for each input element type.

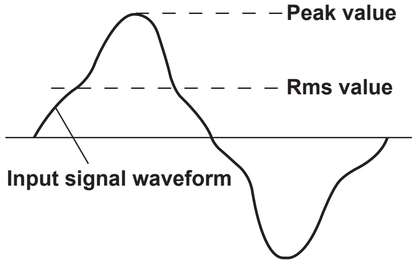
- **50A Input Element**
  Set the valid direct input measurement ranges of 50 A input elements.
- **5A Input Element**
  Set the valid direct input measurement ranges of 5 A input elements.
- **Ext Sensor Input Element (option)**
  Select the valid external current sensor input measurement range.

- You cannot set all measurement ranges to off. There must be at least one valid range.
- The settings for the valid range and for the measurement range to switch to when peak over-range occurs are shared by all the input elements in a wiring unit.
- When independent input element configuration is off and you change the wiring system, all measurement ranges are enabled (set to their initial setting).
- When you change independent input element configuration from on to off, all measurement ranges are enabled (set to their initial setting).
- If you set the valid range setting for the current measurement range to off, this instrument switches to the next higher measurement range. If there is no measurement range above the current one, this instrument switches to the next lower measurement range.

Crest factor (Crest Factor)

The crest factor is defined as the ratio of the peak value of the waveform to the rms value.

$$\text{Crest factor (CF)} = \frac{\text{Peak value}}{\text{Rms value}}$$



On this instrument, the crest factor is the ratio of the maximum applicable peak value to the measurement range.

$$\text{Crest factor (CF)} = \frac{\text{Peak value that can be input}}{\text{Measurement range}}$$

Set the crest factor to CF3 or CF6.

- CF3: The crest factor is 3.
- CF6: The crest factor is 6.
- CF6A: The input range of the measurement range is expanded as follows as compared to when the crest factor is set to 6. This is used to suppress frequent range changes when measuring a distorted waveform in auto range mode.
  - Condition for increasing the range in auto range mode
    The voltage or current exceeds 220 % of the measurement range.
  - Condition that cause an overload indication (“- - O L - -”) (for details, see section 1.3 in the Getting Started Guide, IM WT1801R-03EN)
    The measured voltage or current exceeds 280 % of the measurement range.

The measurable crest factor is as follows:

$$\text{Crest factor (CF)} = \frac{\{\text{measurement range} \times \text{CF setting (3 or 6)}\}}{\text{Measured value (rms value)}}$$

* However, the peak value of the input signal must be less than or equal to the maximum allowable input.

If the crest factor of the input signal is greater than the specifications of this instrument (the crest factor defined at the rated input), you can measure the signal by setting a greater measurement range. For example, even if CF is set to 3, measurement is possible for signals with a crest factor greater than or equal to 5 when the measured value (rms value) is less than 60 % of the measurement range. If the minimum effective input (1 % of the measurement range) is being applied when CF is set to 3, measurement for CF = 300 is possible.
The voltage range, current range, effective input range, and measurement accuracy vary depending on the crest factor setting. For details, see section 5 in the Getting Started Guide (IM WT1801R-03EN).

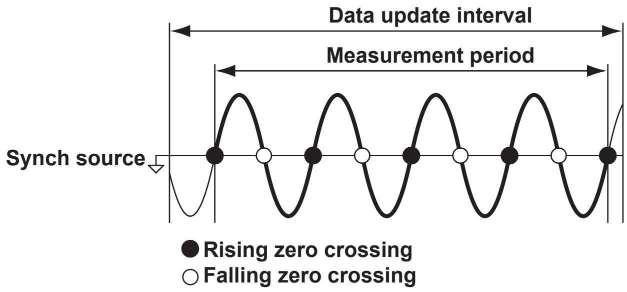
- When you change the crest factor, the following settings change for all elements.
  - All elements are automatically set to their maximum voltage and current ranges.
  - In the valid measurement range settings, all measurement ranges are enabled (selected).
- If the crest factor is set to CF6 or CF6A, the measurement conditions of crest factor 5 and higher required by IEC 62018 are met.
- When measuring waveforms whose crest factor is less than or equal to CF3, you can achieve more accurate measurements by setting the crest factor to 3.

Measurement period (SYNC SOURCE)

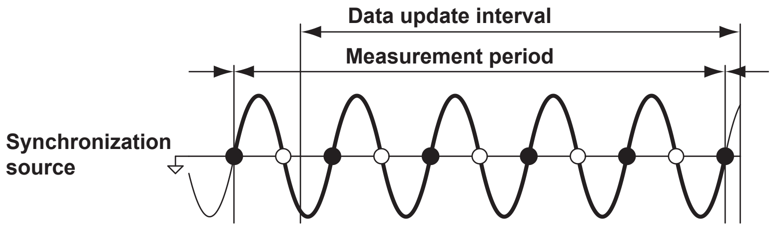
Measurement period of normal measurement functions

The measurement period is determined by the input signal that is used as the reference (sync source). The measurement period is set within the data update interval between the first point where the sync source crosses level zero (center of the amplitude) on a rising slope (or falling slope) and the last point where the sync source crosses the specified level on a rising slope (or falling slope).

- When the data update interval is not Auto

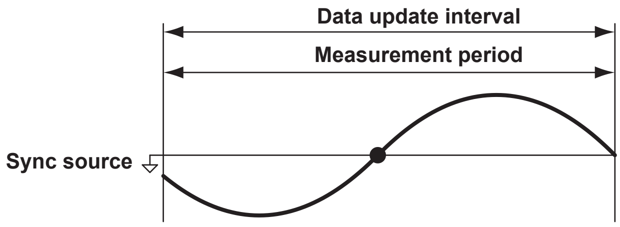


- When the data update interval is Auto

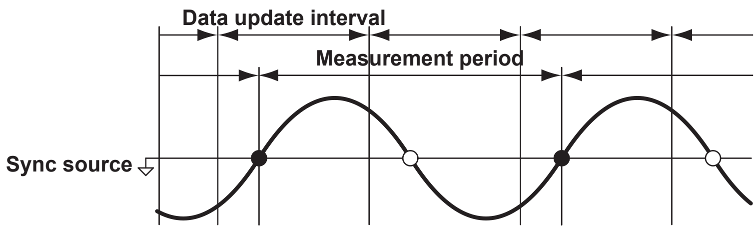


When the data update interval is not Auto, if there is no more than one zero-crossing within the data update interval, the measurement period is the entire data update interval.

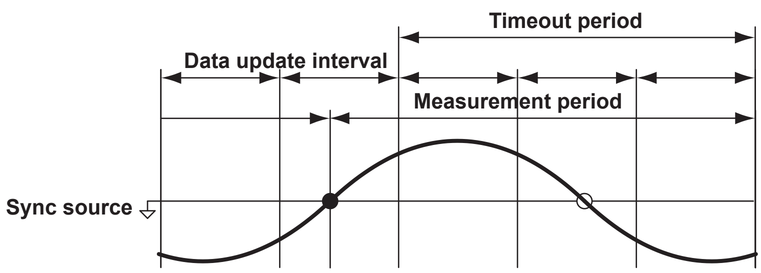
- When the data update interval is not Auto



- When the data update interval is Auto



- When the data update interval is Auto and timeout occurs



When the data update interval is not Auto, the measurement period for determining the numeric data of the peak voltage or peak current is always the entire span of the data update interval. Therefore, the measurement period for the measurement functions that are determined on the basis of the maximum voltage or current value (U+pk, U-pk, I+pk, I-pk, CfU, P+pk, P-pk, and CfI) is also the entire span of the data update interval.
For details, see appendix 4.
When the data update interval is Auto, the numeric data of the peak voltage or peak current is the data within the measurement period.

Measurement period of harmonic measurement functions

The measurement period is from the first sampled data in the data update interval to the following number of points counted at the sampling frequency for harmonics.

- When the data update interval is 50 ms, 100 ms, or 200 ms: 1024 points
- When the data update interval is 500 ms, 1 s, 2 s, 5 s, 10 s, 20 s: 8192 points
- When the data update interval is Auto: Select 1024 or 8192 points

This instrument determines the harmonic sampling frequency automatically based on the period of the signal that is set as the PLL source. The sampling data and measurement period that are used to determine the values of harmonic measurement functions may be different from those used to determine the values of normal measurement functions.
When the data update interval is Auto, the number of times harmonic measurement data is updated may be different from normal measurement.

Element1 to Element6

Use the soft keys to select an element, and select the sync source signal from the following options. The available options vary depending on the installed elements. When independent element configuration is off, elements in the same wiring unit have the same sync source.
U1, I1, U2, I2, U3, I3, U4, I4, U5, I5, U6, I6, Ext Clk (external clock),* and None

* When you select Ext Clk, the external signal applied to the external clock input terminal (EXT CLK) on the rear panel is used as the sync source. For the specifications of the EXT CLK terminal, see section 3.3 in the *Getting Started Guide*, IM WT1801R-03EN.

Setting the sync source for when the data update interval is Auto (Sync Source Setting)

Turning on and off the sync source rectifier for when the data update interval is Auto (Voltage/Current/Ext Sensor Rectifier)

When the data update interval is Auto, select whether to rectify the sync source that determines the measurement period (ON/OFF).

Sync source level for when the data update interval is Auto (Voltage/Current/Ext Sensor Level)

Set the sync source signal level for when the data update interval is Auto.
Set the signal level in the following range.

- When the sync source rectifier is off: −100.0 % to 100.0 %
- When the sync source rectifier is on: 0.0 % to 100.0 % (absolute value)

- If sync source is set to None
  - When the data update interval is not Auto, all the sampled data within the data update interval are used to determine the numeric data.
  - When the data update interval is Auto, all the sampling data up to the timeout time are used to determine numeric data.

  When you are measuring DC signals, this method can be used to prevent noise from causing errors in the detection of the measurement period.
- If the sync source is not set appropriately, the measured values may fluctuate or they may not be correct. Set the sync source by referring to appendix 4.

Line filter (LINE FILTER)

There are two types of input filters: line filters and frequency filters.
Because the line filter is inserted into the voltage and current measurement input circuits, it directly affects voltage, current, and power measurements (see the block diagram in appendix 12). When the line filter is turned on, measured values will not contain high frequency components. Thus, the voltage, current, and power of inverter waveforms, strain waveforms, and so on, can be measured with their high frequency components removed.

Element1 to Element6

Select the soft key for the element you want to set. Then, set the line filter to ON or OFF, and set the cutoff frequency.
Set the cutoff frequency in the following range.
0.1 kHz to 100.0 kHz (0.1 kHz steps), 300 kHz, 1 MHz

- If the filter of any of the elements is not set to OFF, the LINE FILTER key lights, and the Line Filter indicator turns on at the top of the screen.
- Turning it off disables the line filter.

Copying line filter settings (Exec Copy Σ)

You can copy the line filter on/off state and cutoff frequency setting of the selected input element to other input elements in the same wiring unit.

Line filter during high speed data capturing

▶ Click here.

Frequency filter (FREQ FILTER)

The frequency filter is inserted into the frequency measurement input circuit and affects frequency measurements. It also affects the detection of the measurement period for measuring voltage, current, and power (see appendix 4). In this case, the frequency filter functions as a filter for detecting the zero-crossing of the sync source signal more accurately. The frequency filter is not inserted into the voltage and current measurement input circuits. Therefore, the measured values include high frequency components even when the frequency filter is turned on.

- This instrument detects the zero-crossing with a hysteresis of approximately 5 % of the measurement range.
- If the filter of any of the elements is not set to OFF, the Freq Filter indicator turns on at the top of the screen.
- Even when the frequency filter is set to OFF, if the line filter described earlier is set to ON, the line filter will affect frequency measurements.
- We recommend that you set the frequency filter to ON when the input signal frequency is 1 kHz or less.

The following two types of frequency filters are available. When you press FREQ FILTER, either one appears depending on the data update interval setting.

- Element1 to Element6 (when the data update interval is not Auto)
- Element1 to Element6 (when the data update interval is Auto)

Element1 to Element6
(When the data update interval is not Auto)

Set the frequency filter used when the data update interval is not auto.
Use the soft keys to select an element, and select the cutoff frequency from the following options.
OFF, 100Hz, 1kHz

Freq Filter at Update Rate Auto

The frequency filter setup menu is displayed for when the data update interval is Auto.

Element1 to Element6

(When the data update interval is Auto)

Select the soft key for the element you want to set. Then, set the frequency filter (used when the data update interval is Auto) to ON or OFF, and set the cutoff frequency.
Set the cutoff frequency in the following range.
100Hz, 200Hz, 400Hz, 800Hz, 1.6kHz, 3.2kHz, 6.4kHz, 12.8kHz, 25.6kHz

Freq Filter

The frequency filter setup menu is displayed for when the data update interval is not Auto.

- When the data update interval is not Auto (50 ms to 20 s), the frequency filter is used for data update interval extraction and frequency measurement noise filter.
- When the data update interval is Auto, the frequency filter (used when the auto update interval is Auto) is used for data update interval extraction and frequency measurement noise filter.

Data update interval (UPDATE RATE)

The data update interval is the interval at which the data that is used in measurement functions is sampled.

- When the data update interval is not Auto
  - Select the data update interval from the following options.
    50ms, 100ms, 200ms, 500ms, 1s, 2s, 5s, 10s, 20s
  - At each data update interval, the numeric data is updated, stored, transmitted through a communication interface, and converted and output as analog signals.
  - 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.
- When the data update interval is Auto
  - Every time a period* of the input waveform specified as the sync source is detected, measured data is updated, output as analog signals, and transmitted through the communication interface.
    * 50 ms or more
  - The trigger mode is set to OFF on the waveform display.

To capture relatively fast load fluctuations in a power system, select a fast data update rate. To capture low frequency signals, select a slow data update rate.
If the fluctuation in the input signal period is large, select Auto.

Turning auto data update interval on and off

Select whether to set the data update interval to Auto (ON/OFF).

- When set to ON
  - The Fast/Slow soft key is disabled.
  - The measurement mode display at the upper left of the screen shows Normal Mode (Auto).
  - Set the following items.
    - Timeout period for when the data update interval is Auto
    - Element1 to Element6 (for when the data update interval is Auto)
    - On/Off of the sync source rectifier for when the data update interval is Auto
    - Sync source level for when the data update interval is Auto

- When set to OFF, use the Fast/Slow soft key to set the data update interval.

Fast

The data update interval is increased to the next faster setting in the above steps.

Slow

The data update interval is increased to the next slower setting in the above steps.

Current Rate

The current data update interval is displayed. Press the soft key to select the data update interval from the above options.

Timeout period when data update interval is Auto (Time Out at Update Rate Auto)

Timeout is the time limit for detecting the period of the input waveform.
Select 1s, 5s, 10s, or 20s.
If the input signal frequency is low and the sync source period cannot be detected within the timeout period, the frequency data will be outside the measurement range and will result in error. The measurement functions of normal measurement determine measured values using the entire period up to the timeout as the measurement period.

- The display update interval of numeric data and waveform data shown on the screen may become longer than a data update period.
- The lower frequency limit for measuring AC signals is different for each data update period. Measurements may not be stable if AC signals with frequencies lower than the lower measurement frequency limit (see section 5.4 in the Getting Started Guide, IM WT1801R−03EN) are measured.
- When the data update interval is Auto, fPLL2, WS, and WQ are not measured and displayed as "-------" (no data).

Averaging (AVG)

You can take exponential or moving averages of the numeric data. The averaging function is effective when the numeric display is difficult to read due to fluctuations. This occurs when the fluctuation of the power supply or the load is large or when the input signal frequency is low.

Turning averaging on and off (Averaging)

Measurement Functions of Normal Measurement

You can select whether to average values. When you enable averaging (ON), the AVG key lights, and the AVG indicator turns on at the top of the screen.

Measurement functions of harmonic measurement (option)

- If averaging is turned on, and the averaging type is set to Exp (exponential averaging), averaging is performed on harmonic measurement functions.
- Even if averaging is turned on, if the averaging type is set to Lin (moving average), averaging is not performed on harmonic measurement functions.

Averaging Type (Type)

You can use exponential (Exp) or moving averages (Lin).

Exponential average (Exp)

With the specified attenuation constant, numeric data is exponentially averaged according to the formula below.

$$D_n = D_{n-1} + \frac{(M_n - D_{n-1})}{K}$$

D_n: Displayed value that has been exponentially averaged n times. (The first displayed value, D_1, is equal to M_1.)
D_{n-1}: Displayed value that has been exponentially averaged n – 1 times
M_n: Measured data at the n^{th} time.
K: Attenuation constant (select from 2 to 64)

Moving average (Lin)

Moving average is applied to numeric data according to the following formula with the specified average count.

$$D_n = \frac{M_{n-(m-1)} + \cdots M_{n-2} + M_{n-1} + M_n}{m}$$

D_n: Simple average of m numeric data values from $n-(m-1)^{th}$ to n^{th} time
$M_{n-(m-1)}$: Numeric data at the $n-(m-1)^{th}$ time
……………………………………………
……………………………………………
M_{n-2}: Numeric data at the $n-2^{th}$ time.
M_{n-1}: Numeric data at the $n-1^{th}$ time.
M_n: Measured data at the n^{th} time.
m: Average count (select from 8 to 64)

Attenuation constant or average count (Count)

- If the averaging type is set to Exp (exponential average), set the attenuation constant to a value within the following range.
  2 to 64
- If the averaging type is set to Lin (moving average), set the average count to a value within the following range.
  8 to 64

Measurement functions that are averaged

The measurement functions that are directly averaged are shown below. Other functions that use these functions in their calculation are also affected by averaging. For details on how measurement function values are obtained, see appendix 1.

Measurement functions of normal measurement

- Urms, Umn, Udc, Urmn, Uac, Irms, Imn, Idc, Irmn, Iac, P, S, Q
- ΔU1 to ΔPΣ (delta math)
- Torque, Speed, Pm (models with the motor evaluation option)
- Aux1, Aux2 (model with the auxiliary input option)
- λ, Φ, CfU, CfI, Pc, q, q+, q−, and η1 to η4 are calculated from averaged Urms, Irms, P, S, and Q.
- Slip is calculated from averaged speed (models with the motor evaluation option).

Measurement functions of harmonic measurement (option)

- U(k), I(k), P(k), S(k), Q(k)
- λ(k), and Φ(k) are calculated from averaged P(k) and Q(k).
- Z, Rs, Xs, Rp, Xp, Uhdf, Ihdf, Phdf, Uthd, Ithd, Pthd, Uthf, Ithf, Utif, Itif, hvf, hcf, and K-factor are calculated from averaged U(k), I(k), and P(k).

  * k: The harmonic order

Measurement functions that do not perform averaging

The following measurement functions do not perform averaging.

Measurement functions of normal measurement

fU, fI, U+pk, U−pk, I+pk, I−pk, P+pk, P−pk, Time, WP, WP+, WP−, WPΣ, WP+Σ, WP−Σ, WS, WQ, SyncSp (models with the motor evaluation option)

Measurement functions of harmonic measurement (option)

ΦU (k), ΦI (k), ΦUi−Uj, ΦUi−Uk, ΦUi−Ii, ΦUj−Ij, ΦUk−Ik, fPLL1, fPLL2, EaU, EaI

* k: The harmonic order

Measurement functions common to normal and harmonic measurement (option)

F1 to F20, Event1 to Event8

- When averaging is turned on, the average value of multiple measurements is determined and displayed. If the input signal changes drastically, it will take longer for the change to be reflected in the measured values when averaging is used.
- A larger attenuation constant (for exponential average) or average count (for moving average) will result in more stable (and less responsive) measured values.
- When the data update interval is Auto, averaging is performed every 50 ms.

Setup parameter list (INPUT INFO)

A setup parameter list is displayed in the top half of the screen.

Display format (FORM)

Input element settings list (Power Element Settings)

The wiring system, measurement range, scaling coefficient, sync source, line filter, and frequency filter settings are displayed for each element.

Measurement range settings list (Range Settings)

The measurement range setting is displayed for each element. In the valid measurement range settings, disabled measurement ranges appear dimmed.

Display items (ITEM)

Turning the display frame on and off (Display Frame)

▶ Click here.

- The setup parameter list displays the settings applied when the measurement was performed. If you change the measurement range while the hold function is on, for example, the change is not reflected in the list.
- When the setup parameter list is displayed, the FORM menu of the setup parameter list and the FORM menu displayed in the bottom half of the screen toggle each time you press FORM. The same holds true for the ITEM key.

3 Harmonic Measurement Conditions (option)

Harmonic measurement conditions (HRM SET)

Using harmonic measurement, you can measure functions that are based on the voltage, current, and power harmonics and their distortion factors; on the phase angle of each harmonic relative to the fundamental, and so on. You can also calculate the harmonic distortion factors for voltage and current.
For a list of the measurement functions that can be measured with harmonic measurement and their descriptions, see “Harmonic measurement functions” under “Items That This Instrument Can Measure.”

▶ Click here.

Models with the harmonic measurement option

The following menu appears.

- PLL source (PLL Source)
- Measured harmonic orders (Min Order/Max Order)
- Distortion factor formula (Thd Formula)
- Number of FFT points (FFT Points)

Models with the simultaneous dual harmonic measurement option

The following menu appears.

- Input element groups (Element Settings)
- Hrm1 group’s PLL (Hrm1 PLL Source)
- Hrm1 group’s measured harmonic orders (Min Order/Max Order)
- Hrm1 group’s distortion factor formula (Thd Formula)
- Number of FFT points (FFT Points)
- Hrm2 group’s PLL (Hrm2 PLL Source)
- Hrm2 group’s measured harmonic orders (Min Order/Max Order)
- Hrm2 group’s distortion factor formula (Thd Formula)

PLL source (PLL Source)

For harmonics to be measured, the fundamental period (the period of the fundamental signal) that will be used to analyze the harmonics must be determined. The signal for determining the fundamental period is the PLL (phase locked loop) source.

Select the PLL source from the following options. The available options vary depending on the installed elements.
U1, I1, U2, I2, U3, I3, U4, I4, U5, I5, U6, I6, Ext Clk*

* If you select Ext Clk, the frequency of the signal applied to the rear panel’s external clock input terminal (EXT CLK) is used as the fundamental frequency for harmonic measurement. For the EXT CLK terminal specifications, see section 4.3 in the *Getting Started Guide*, IM WT1801R-03EN.

- Select a signal that has the same period as the signal that you want to measure the harmonics of. For stable harmonic measurement, choose an input signal for the PLL source that has as little distortion and fluctuation as possible. If the fundamental frequency of the PLL source fluctuates or if the fundamental frequency cannot be measured due to waveform distortion, correct measurements will not be obtained. When the measured item is a switching power supply and in other cases where the distortion of the voltage signal is smaller than that of the current signal, we recommend that the PLL source be set to the voltage.
- If all of the input signals are distorted or the amplitude level is small relative to the measurement range, the specifications may not be met. To achieve stable, accurate measurements on high harmonics, set the PLL source to an external clock signal and apply a signal with the same period as the input signal to the external clock input connector.
- If the fundamental frequency is 1 kHz or less and high frequency components are present, we suggest you turn on the frequency filter. This filter applies only to the frequency measurement circuit.
- If the amplitude level of the signal applied to the element that is specified as the PLL source is small relative to the measurement range, PLL synchronization may not be achieved. If the crest factor is set to CF3, set the measurement range so that the amplitude level of the PLL source is at least 50 %. If the crest factor is set to CF6 or CF6A, set the measurement range so that the amplitude level of the PLL source is at least 100 %.
- If the frequency of the PLL source changes, correct measured values are displayed four data updates after the change. Correct measured values may not be obtained immediately after the PLL source or its frequency changes, because the PLL circuit inside this instrument needs time to redetect the frequency.

Measured harmonic orders (Min Order/Max Order)

You can set the harmonic measurement range. The harmonic orders specified here are used to determine the numeric data of the distortion factor.

▶ Click here.

Minimum harmonic order to be measured (Min Order)

Select from the following options.

- 0: The 0th order (DC) component is included when numeric harmonic waveform data is determined.
- 1: The 0th order (DC) component is not included when numeric harmonic waveform data is determined. Harmonic measurement data (harmonic waveform data) is determined from the 1st harmonic (the fundamental wave).

Maximum harmonic order to be measured (Max Order)

You can select a value between 1 and 500.

However, the maximum measurable harmonic order is the smallest of the following three values.

- The specified maximum harmonic order to be measured
- The value determined automatically according to the PLL source frequency (see section 6.6 in the Getting Started Guide, IM WT1801R−03EN)
- When the data update interval is 50 ms or Auto, the maximum measurable harmonic order is 100.

Columns for harmonic numeric data that exceeds the maximum measurable order show no data [−−−−−−−].

- If the minimum harmonic order to be measured is set to 1, the data of the DC component is not included when the distortion factor is determined.
- There is no overload indication (“-OL-”) or zero indication (rounding to zero) for the numeric data of harmonic orders 0 (DC) to 500. For details on the overload indication (“-OL-”) of normal measurement functions, see section 1.3 in the Getting Started Guide, IM WT1801R-03EN. For details on the zero indication (rounding to zero), section 5.4 in the Getting Started Guide, IM WT1801R−03EN.

Distortion factor formula (Thd Formula)

When determining the harmonic measurement functions Uhdf, Ihdf, Phdf, Uthd, Ithd, and Pthd, you can select to use one of the denominators described below as the denominator for the formula. For the formula, see appendix 1.

1/Total

The denominator is the measured data of all orders from the minimum measured order (0 or 1st) to the maximum measured order (within the upper limit of harmonic analysis).

1/Fundamental

The denominator is the data of the fundamental signal component (1st order).

Number of FFT points (FFT Points)

When the data update interval is Auto, set the number of FFT points to 1024 or 8192.

Input element groups (Element Settings)

Input element groups are displayed on models with the harmonic measurement option or the simultaneous dual harmonic measurement option. You can divide the input elements into two groups: Hrm1 and Hrm2, and measure harmonics using two PLL sources with different frequencies. You can measure the input and output harmonics of an AC−AC converter whose input and output frequencies are different.
Input element groups are not displayed on models without the harmonic measurement option or the simultaneous dual harmonic measurement option.
When the data update interval is Auto, harmonics of the Hrm2 group are not measured.

Element1 to Element6

Use the soft keys to select an element, and set the group to Hrm1 or Hrm2. Input elements that are assigned to the same wiring unit are set to the same group.

Hrm1 group’s PLL (Hrm1 PLL Source)
Hrm2 group’s PLL (Hrm2 PLL Source)

This is the same as the PLL source (PLL Source).

▶ Click here.

Hrm1 group’s measured harmonic orders (Min Order/Max Order)
Hrm2 group’s measured harmonic orders (Min Order/Max Order)

This is the same as the measured harmonic orders (Min Order/Max Order).

▶ Click here.

Hrm1 group’s distortion factor formula (Thd Formula)
Hrm2 group’s distortion factor formula (Thd Formula)

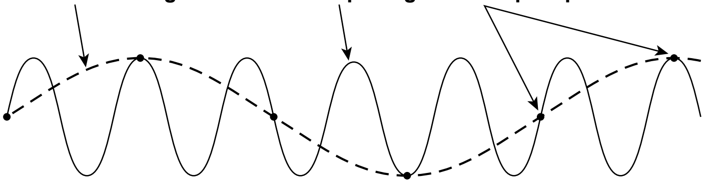
This is the same as the distortion factor formula (Thd Formula).

▶ Click here.

* When the data update interval is Auto, these menus do not appear.

Anti-aliasing filter

When an FFT is taken by performing A/D conversion on a repetitive waveform, a phenomenon occurs in which frequency components that exceed half the frequency of the sampling frequency are detected as low frequency components. This phenomenon is called *aliasing*.



Aliasing causes problems such as increased errors in measured values and incorrect measurements of the phase angles on each harmonic. An anti-aliasing filter is used to prevent aliasing and eliminate high frequency components that are irrelevant to the harmonic measurement.
For example, when an input signal with a fundamental frequency of 50 Hz is measured up to the 50^{th} order, the frequency of the 50^{th} order is 2.5 kHz. Thus, a 5-kHz anti-aliasing filter is used to eliminate high frequency components that are greater than or equal to approximately 5 kHz, which are irrelevant to harmonic measurement.

This instrument uses the line filter as an anti-aliasing filter for harmonic measurements. For the setup procedure, see “Line filter (LINE FILTER).”

▶ **Click here.**

The accuracy and the upper limit of the measurement bandwidth change when the anti-aliasing filter (line filter) is turned on. For details, see section 6.6 in the Getting Started Guide (IM WT1801R-03EN).

4 Motor Evaluation Conditions (option)

Motor evaluation and auxiliary input conditions (MOTOR/AUX SET)

Press MOTOR/AUX SET to display a setup dialog box for the installed option.

Models with the motor evaluation function option

A MOTOR Settings dialog box appears.

This instrument can determine the motor rotating speed, torque, and output using the revolution sensor signal, which is proportional to the motor rotating speed, and the torque meter signal, which is proportional to the motor torque. You can configure this instrument to receive analog (DC voltage) signals or pulse signals from the revolution sensor and torque meter. You can also set the number of motor poles and determine the motor's sync speed and slip. Furthermore, you can use the active power, frequency, and motor output measured by this instrument to calculate the motor efficiency and total efficiency.

For a list of the measurement functions that can be measured with the motor evaluation feature and their descriptions, see "Motor evaluation functions" under "Items That This Instrument Can Measure."

▶ Click here.

Model with the auxiliary input option

An Aux Settings dialog box appears.

▶ Click here.

Motor evaluation conditions

You can set the following motor evaluation conditions.

- Scaling factor (Scaling)
- Unit (Unit)
- Input signal type (Sense Type)
- Analog input range
- Linear scaling of analog input
- Line filter (Line Filter)
- Sync source (Sync Source)
- Pulse input range
- Torque signal pulse rating
- Revolution signal pulses per revolution (Pulse N)
- Motor poles (Pole)
- Frequency measurement source (Source)
- Electrical angle measurement (Electrical Angle Measurement)
- Calculating the motor efficiency and total efficiency

* Available on models with the harmonic measurement option or simultaneous dual harmonic measurement option

Scaling factor (Scaling)

Setting the scaling factor for scaling the revolution signal

You can set the factor for scaling the revolution signal in the range of 0.0001 to 99999.9999.

- **When the revolution signal type is analog**

  This setting is used as the scaling factor in the formula for the linear scaling of analog input.

- **When the revolution signal type is pulse**
  This setting is used as the scaling factor in the formula for the number of revolution signal pulses per revolution.

Setting the scaling factor for scaling the torque signal

You can set the factor for scaling the torque signal to motor torque in the range of 0.0001 to 99999.9999.

- **When the torque signal type is analog**
  This setting is used as the scaling factor in the formula for the linear scaling of analog input.

- **When the torque signal type is pulse**
  This setting is used as the scaling factor in the formula for the torque signal pulse rating.

Setting the scaling factor for calculating the motor output

You can specify the scaling factor for calculating the motor output (mechanical power) from the rotating speed and torque. Set the factor in the range of 0.0001 to 99999.9999.
The formula is indicated below. The scaling factors of the rotating speed and torque are set so that the unit of the rotating speed is min^{-1} (or rpm) and the unit of torque is N·m. When the scaling factor of the motor output specified here is 1, the unit of the motor output Pm is W. Because the efficiency calculation uses W as the unit of Pm, we recommend that you set the scaling factor of each item so that the unit of Pm is W.

$$\text{Motor output Pm} = \frac{2\pi}{60} \times \text{Speed} \times \text{Torque} \times S$$

Speed: The rotating speed, determined from the number of pulses per revolution
Torque: The torque, determined from the torque signal pulse rating
S: Scaling factor

Unit (Unit)

- Number of characters: Up to 8
- Types of characters: Spaces and all characters that are displayed on the keyboard

Input signal type (Sense Type)

You can select one of the following two types of signals to be input to this instrument from the rotation sensor or torque meter.
- Analog: Select this option when this instrument will receive DC voltage (analog) signals.
- Pulse: Select this option when this instrument will receive pulse signals.

Single type and settings

The required settings vary depending on the revolution signal and torque signal type as follows:

Signal Type Settings

Setting	Signal Type	
	Analog	Pulse
Analog auto range	Yes	No
Analog range	Yes	No
Linear scale A, B	Yes	No
Line filter	Yes	No
Sync source	Δ	Δ
Pulse range	No	Yes
Number of pulses per rotation	No	Yes

Yes: Setting required
No: Setting not required
Δ: Measurement can be performed when the sync source is set to None (the default setting), but you can improve simultaneity with power measurements by specifying a sync source.

Common settings unrelated to the signal type

- Scaling coefficient
- Unit
- Motor poles
- Sync speed frequency measurement source

Analog input range

Set the analog input range for input signals whose type has been set to analog. For input signals whose type has been set to pulse, there is no need to set the analog input range.

Turning auto range on and off (Analog Auto Range)

Select whether to turn auto range on or off. When auto range is on, this instrument automatically switches between the following ranges according to the size of the input signal.
20V, 10V, 5V, 2V, 1V

Range increase

- The measurement range is increased when the rotating speed or torque input signal exceeds 110 % of the measurement range.
- The measurement range is increased when the peak value of the input signal exceeds approximately150 % of the measurement range.

Range decrease

The measurement range is decreased when the rotating speed or torque input signal falls below 30 % of the measurement range and the peak value of the input signal is less than 125 % of the lower range.

When non-periodic pulse waveforms are applied during auto range, the range may not remain constant. If this happens, use the fixed range setting.

Fixed range (Analog Range)

You can select one of the following input ranges.
20V, 10V, 5V, 2V, 1V

Linear scaling of analog input

Set the input signal slope and offset. There are two ways to set them.

- Set the values manually.
- Specify two points, and use those points to calculate the values.

Setting the input signal slope and offset manually (Linear Scale A, B)

You can set the slope (A) and offset (B) of the rotating speed and torque input signals to values within the following ranges.
A: 1.000m to 1.000M
B: −1.000M to 1.000M
The following formula is used to calculate the rotating speed and torque.
Rotating speed and torque = S(AX + B) − NULL

S: scaling factor
A: slope of the input signal
X: input voltage from the rotating sensor and torque meter
B: offset
NULL: null value

When there is no offset in the input voltage from the revolution sensor or torque meter

If you set A to 1 and B to 0, the linear scaling settings do not affect calculation, and the previous formula becomes:

Rotating speed and torque = SX − NULL

The rotational speed and torque are scaled when you set the scaling factor to the rotational speed and torque per 1 V of input voltage.

When there is offset in the input voltage from the revolution sensor or torque meter

If you set S to 1, the scaling factor does not affect the calculation, and the previous formula becomes

Rotating speed and torque = AX + B − NULL

The rotating speed and torque are scaled when you set the input signal slope (A) to the rotating speed and torque per 1 V of input voltage and offset (B) to the offset value.

If you enable the NULL function and then change the input signal slope (A) or offset value (B), NULL correction will be offset. Reset the NULL value.

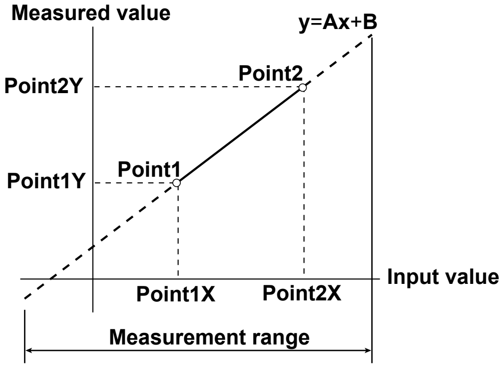
Calculating the input signal slope and offset from two points (Calculation)

On the input characteristic graphs of the rotating speed and torque, you can specify two measured rpm or N·m values (Point1Y and Point2Y) in relation to two input voltage values (Point1X and Point2X).

Input values (Point1X, Point2X): −1.000T to 1.000T

Measured values (Point1Y, Point2Y): −1.000T to 1.000T

Select Execute to use these four values to determine and set the input signal slope (A) and offset (B).



Line filter (Line Filter)

You can insert a line filter in the circuit that measures the revolution and torque signals to remove high-frequency noise.

You can select the cutoff frequency from the following options.

OFF, 100Hz, 1kHz

Selecting OFF disables the filter.

The line filter setting applies to input signals whose type has been set to analog. For input signals whose type has been set to pulse, there is no need to configure this setting.

Sync source (Sync Source)

- When you are measuring analog revolution and torque signals, you can select the element's input signal to use as the sync source from the following options. The available options vary depending on the installed elements.
  U1, I1, U2, I2, U3, I3, U4, I4, U5, I5, U6, I6, Ext Clk (external clock),* and None
  * For the specifications of the EXT CLK terminal, see section 3.3 in the *Getting Started Guide*, IM WT1801R-03EN.
- The measurement period is determined according to the zero-crossing of the selected sync source. This instrument uses the measurement period to measure the analog revolution and torque signals.
- If sync source is set to None
  - When the data update interval is not Auto, all the sampling data within the data update interval are used to determine rotating speed (Speed) and torque (Torque).
  - When the data update interval is Auto, all the sampling data up to the timeout period are used to determine rotating speed (Speed) and torque (Torque).
- When the revolution or torque signal is a pulse signal, the value averaged over the measurement period or pulse signal period determined by the sync source selected here becomes the measured value of the revolution or torque signal. If the pulse signal period does not fit within the measurement period, the previous period is used to determine the measured value.
- To achieve stable motor efficiency measurements, we recommend that you set the sync source for motor efficiency measurement to the same sync source that is set in the basic measurement conditions. This ensures that the measurement period is in sync with the measurement functions, such as those for voltage, current, and active power.

Pulse input range

Set an appropriate range for the maximum and minimum input signal values. For example, when you are measuring signals for rotating speeds of 120 rpm to 180 rpm and torques of −18 N·m to +18 N·m, set the rotating speed pulse input range to 100 rpm to 200 rpm and the torque pulse input range to −20 N·m to +20 N·m.

Upper limit and lower limit(Pulse Range Upper, Pulse Range Lower)

You can set the pulse range for each input signal within the following range.

- Revolution signal: 0.0000 to 99999.9999 [rpm]
- Torque signal: −10000.0000 to 10000.0000 [N·m]

When the input signal type is pulse, the lower and upper waveform display limits are the values that you set here.

On models with the D/A output option, the rated D/A output values are as follows.

Revolution and torque input signals	D/A output
Pulse Range Upper setting	+5 V
Pulse Range Upper setting × (–1)	−5 V

Torque signal pulse rating

When the torque signal type is pulse, refer to the torque meter's specifications to set its rated positive and negative values.

Positive and negative rated torque signal values (Rated Upper, Rated Lower)

Range: −10000.0000 to -10000.0000 (N m)

Positive and negative rated torque signal pulse frequencies (Rated Freq Upper, Rated Freq Lower)

Range: 1 to 100000000 (Hz)

The following formula is used to calculate the torque.
Torque = S(AX + B) − NULL

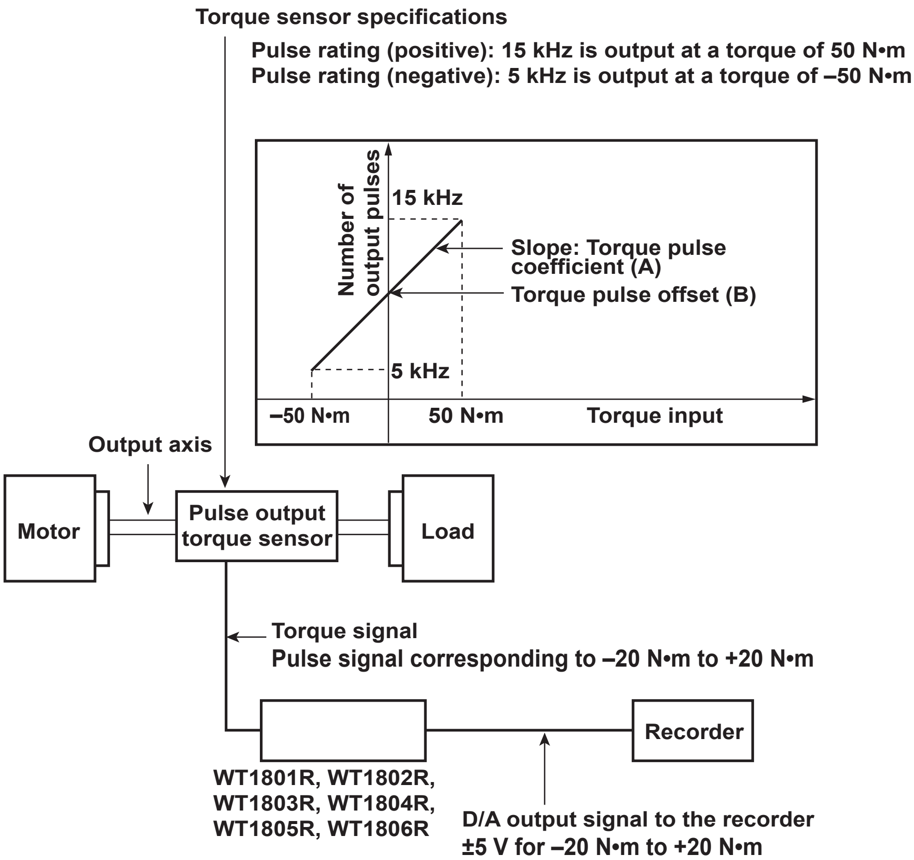
S: scaling factor[1]
A: torque pulse coefficient[2]
X: pulse frequency
B: torque pulse offset[2]
NULL: null value

1 If the torque signal is a modulated signal, you can set the scaling factor to determine the torque before the modulation.
2 The torque pulse coefficient and torque pulse offset are determined from the torque signal pulse rating as shown in the next figure.

Relationship between the torque signal pulse input range and pulse rating

To measure a torque of −20 N·m to +20 N·m using a torque meter with specifications in the figure below, configure the pulse input range and pulse rating settings as indicated below.

- Upper limit of the pulse input range (Pulse Range Upper): 20.0000
- Lower limit of the pulse input range (Pulse Range Lower): −20.0000
- Positive rated torque signal value (Rated Upper): 50.0000
- Negative rated torque signal value (Rated Lower): −50.0000
- Positive rated torque signal pulse frequency (Rated Freq Upper): 15000
- Negative rated torque signal pulse frequency (Rated Freq Lower): 5000



The pulse input range setting applies to input signals whose type has been set to pulse. For input signals whose type has been set to pulse, there is no need to configure this setting.

Revolution signal pulses per revolution (Pulse N)

Set the number of pulses per revolution in the range of 1 to 9999.
The following formula is used to calculate the rotating speed.

$$\text{Rotating speed} = S\frac{X}{N} - \text{NULL}$$

S: scaling factor*
X: number of input pulses from the revolution sensor per minute
N: number of pulses per revolution
NULL: null value

* When the scaling factor is 1, the rotating speed is the number of revolutions per minute (min^{-1} or rpm). If the revolution signal is a modulated signal, you can set the scaling factor to determine the rotating speed before the modulation.

The setting specifying the number of revolution signal pulses per revolution applies to input signals whose type has been set to pulse. For input signals whose type has been set to pulse, there is no need to configure this setting.

Sync speed(Sync Speed)

Motor poles (Pole)

Set the number of motor poles in the range of 1 to 99. This number is used to calculate the sync speed.

Frequency measurement source (Source)

- Select the frequency measurement source to use to calculate the sync speed from the following options. This number is used to calculate the sync speed. The available options vary depending on the installed elements.
  U1, I1, U2, I2, U3, I3, U4, I4, U5, I5, U6, I6
- Normally, you should select the voltage or current that is being applied to the motor. If you select the frequency of a voltage or current that is not being applied to the motor, the sync speed may not be determined properly.

Sync speed formula

The unit of sync speed is fixed to min^{-1} or rpm.

$$\text{Sync speed } (min^{-1}) = \frac{120 \times Fs}{Pole}$$

Fs: frequency of the frequency measurement source (Hz)
Pole: number of motor poles

Slip formula

The unit of sync speed is fixed to min^{-1} or rpm. To determine the slip, configure the rotating speed scaling factor so that the unit of the rotating speed is also min^{-1} (or rpm).

$$\text{Slip (\%)} = \frac{\text{SyncSp} - \text{Speed}}{\text{SyncSp}} \times 100$$

SyncSp: sync speed (min^{-1})
Speed: rotating speed (min^{-1})

Set the frequency measurement source to a stable voltage or current signal that is being applied to the motor and that has low distortion and noise.

Electrical angle measurement (Electrical Angle Measurement)

Electrical angle measurement is displayed on models with the harmonic measurement option or simultaneous dual harmonic measurement option.

Turning electrical angle measurement on and off

Select whether to measure the electrical angle.

Electrical angle correction value (Electrical Angle Correction)

You can set the electrical angle correction value.

Correction value (Correction Value)

Set the correction value in the range of −180.00° to -180.00°.

Clear correction value (Clear Correction)

Sets the correction value to 0.00.

Automatic correction value calculation (Auto Enter Correction)

This instrument automatically sets the correction value to the difference between the phase of the voltage or current whose correction value is being automatically calculated and the current electrical angle phase.

Voltage or current for automatically calculating the correction value (Auto Enter Target)

Select the voltage or current for automatically calculating the correction value. The available options vary depending on the installed elements.
U1, I1, U2, I2, U3, I3, U4, I4, U5, I5, U6, I6

Calculating the motor efficiency and total efficiency

This instrument can calculate the motor efficiency (the ratio of power consumption to motor output) and total efficiency from the active power and motor output that it measures.* Set the formula using the efficiency formula (η Formula).

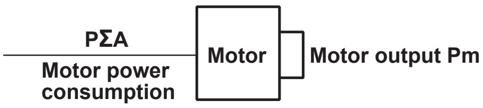
▶ Click here.

* The total efficiency is the ratio of total power consumption—not just the power consumption of the motor but also the power consumption of the converter that supplies the motor with power—to motor output.

The following is an example of how the values are calculated.

When the motor input is wired to ΣA

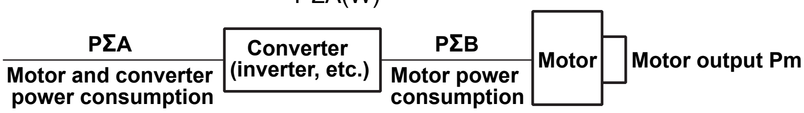
$$\text{Motor efficiency (\%)} = \frac{\text{Motor output Pm (W)}}{\text{P}\Sigma\text{A(W)}} \times 100$$



When the converter and motor inputs are wired to ΣA and ΣB, respectively

$$\text{Motor efficiency (\%)} = \frac{\text{Motor output Pm (W)}}{\text{P}\Sigma\text{B(W)}} \times 100$$

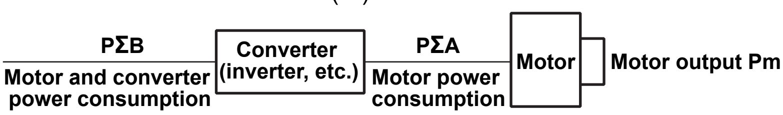
$$\text{Total efficiency (\%)} = \frac{\text{Motor output Pm (W)}}{\text{P}\Sigma\text{A(W)}} \times 100$$



When the converter and motor inputs are wired to ΣB and ΣA, respectively

$$\text{Motor efficiency (\%)} = \frac{\text{Motor output Pm (W)}}{\text{P}\Sigma\text{A(W)}} \times 100$$

$$\text{Total efficiency (\%)} = \frac{\text{Motor output Pm (W)}}{\text{P}\Sigma\text{B(W)}} \times 100$$



If ΣA or ΣB is a three-phase three-wire (3P3W) system, you can use delta calculation to perform 3P3W>3V3A transformation on ΣA and ΣB. From the 3P3W>3V3A transformation, you can determine one unmeasured line voltage and one unmeasured common mode current.

5 Auxiliary Input Conditions (option)

Auxiliary input conditions (MOTOR/AUX SET)

You can apply signals from illuminance sensors, wind sensors, temperature sensors, and the like to the AUX1 and AUX2 terminals and display these physical quantities. You can set the following auxiliary input conditions.

- Input signal name (Aux Name)
- Scaling factor (Scaling)
- Unit (Unit)
- Analog input range
- Linear scaling of analog input
- Line filter (Line Filter)

Input signal name (Aux Name)

- Number of characters: Up to 8
- Types of characters: Spaces and all characters that are displayed on the keyboard

Scaling factor (Scaling)

You can set the factor for scaling the auxiliary signal. Set the factor in the range of 0.0001 to 99999.9999. This setting is used as the scaling factor in the formula for the linear scaling of analog input.

Unit (Unit)

This is the same as the input signal name (Aux Name).

▶ **Click here.**

Analog input range

Set the auxiliary signal (analog input) range.

Turning auto range on and off (Analog Auto Range)

Select whether to turn auto range on or off. When auto range is on, this instrument automatically switches between the following ranges according to the size of the auxiliary signal.

20V, 10V, 5V, 2V, 1V, 500mV, 200mV, 100mV, 50mV

Range increase

- The measurement range is increased when the auxiliary signal exceeds 110 % of the measurement range.
- The measurement range is increased when the peak value of the auxiliary signal exceeds approximately150 % of the measurement range.

Range decrease

The measurement range is decreased when the auxiliary signal falls below 30 % of the measurement range and the peak value of the auxiliary signal is less than 125 % of the lower range.

When non-periodic pulse waveforms are applied during auto range, the range may not remain constant. If this happens, use the fixed range setting.

Fixed range (Analog Range)

You can select one of the following input ranges.

20V, 10V, 5V, 2V, 1V, 500mV, 200mV, 100mV, 50mV

Linear scaling of analog input

Set the auxiliary signal slope and offset. There are two ways to set them.

- Set the values manually.
- Specify two points, and use those points to calculate the values.

Setting the auxiliary signal slope and offset manually (Linear Scale A, B)

You can set the slope (A) and offset (B) of the auxiliary signal to values within the following ranges.

A: 1.000m to 1.000M

B: –1.000M to 1.000M

The following formula is used to calculate the measured values of an auxiliary signal.

Measured values of an auxiliary signal = S(AX + B − NULL)

S: scaling factor
A: slope of the external signal
X: auxiliary signal's input voltage
B: offset
NULL: null value

When there is no offset in the auxiliary signal input voltage

If you set A to 1 and B to 0, the linear scaling settings do not affect calculation, and the previous formula becomes:

Measured values of an auxiliary signal = SX − NULL)

The auxiliary signal is scaled when you set the scaling factor to the auxiliary signal per 1 V of input voltage.

When there is offset in the auxiliary signal input voltage

If you set S to 1, the scaling factor does not affect the calculation, and the previous formula becomes

Measured values of an auxiliary signal = AX + B − NULL

The auxiliary signal is scaled when you set the auxiliary signal slope (A) to the auxiliary signal per 1 V of input voltage and offset (B) to the offset value.

If you enable the NULL function and then change the auxiliary signal slope (A) or offset value (B), NULL correction will be offset. Reset the NULL value.

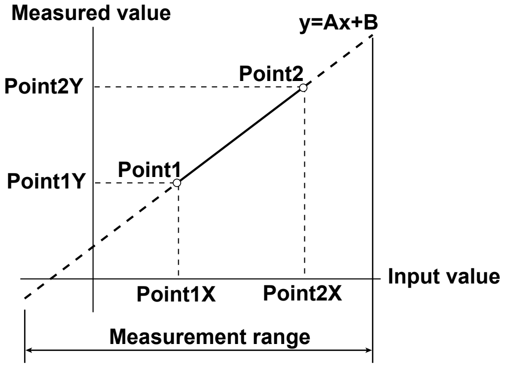
Calculating the auxiliary signal slope and offset from two points (Calculation)

On the input characteristic graphs of the auxiliary signal, you can specify two measured values (Point1Y and Point2Y) (Unit) corresponding to two input voltage values (Point1X and Point2X) (V). Select Execute to use these four values to determine and set the auxiliary signal slope (A) and offset (B).

Input values (Point1X, Point2X): –1.000T to 1.000T

Measured values (Point1Y, Point2Y): –1.000T to 1.000T

Select Execute to use these four values to determine and set the auxiliary signal slope (A) and offset (B).



Line filter (Line Filter)

You can insert a line filter in the circuit that measures auxiliary signals Aux1 and Aux2. High-frequency noise will be rejected.

You can select the cutoff frequency from the following options.

OFF, 100Hz, 1kHz

Selecting OFF disables the filter.

6 Holding Measured Values and Performing Single Measurements

Holding measured values (HOLD)

You can hold the data measurement and display operations that occur every data update interval and hold the display of all measurement function data. Values such as D/A output and communication output also reflect numeric data that are being held.

During integration and high speed data capturing, the display is held, but measurement continues without stopping.
For details on how holding works during integration, see the sections on holding and releasing integration.

▶ Click here.

Single measurement (SINGLE)

- While the display is held when the data update interval is not Auto, the signal is measured once at the data update interval, and then the display is re-held. If you press SINGLE when the measurement is not being held, measurement is performed again from that point.
- When the data update interval is set to Auto, single measurement is not possible.

Using an auxiliary signal to hold measured values and control single measurements (option)

On models with the 20-channel D/A output option, you can use the remote control feature to hold measured values and perform single measurements using an external signal. For details about the remote control feature, see appendix 3.6 in the Getting Started Guide, IM WT1801R-03EN.

7 Numeric Data Display

Numeric data display (NUMERIC)

You can press NUMERIC to make the numeric data display appear.
Each time that you press NUMERIC, the display format switches, in order, between 4 Items, 8 Items, 16 Items, Matrix, All Items, Hrm List Single, Hrm List Dual, and Custom.

Display format (FORM)

The display format settings vary depending on the screen that is being displayed.

- Numeric data display format
- Waveform display format
- Trend display format
- Bar graph display format
- Vector display format
- Setup parameter list display format
- High-speed data capturing settings

Numeric data display format

You can select the number of numeric data items that are displayed simultaneously from the choices below or choose to display a list of items.

4-Value Display (4 Items)

Four numeric data values are displayed in a single column.

8-Value Display (8 Items)

- When the display mode is set to numeric, eight numeric data values are displayed in a single column.
- When the display mode is set to split display, eight numeric data values are displayed in two columns.

16-Value Display (16 Items)

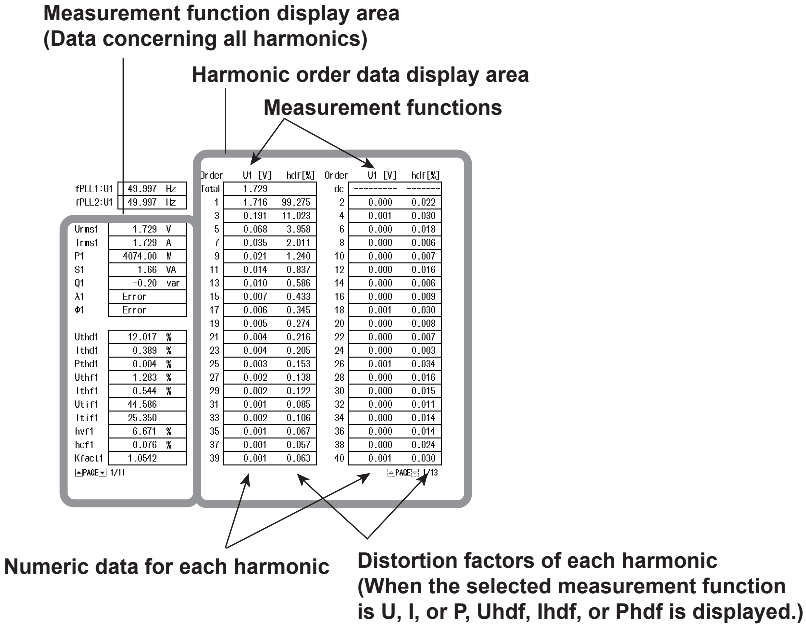
16 numeric data values are displayed in two columns.

Matrix display (Matrix)/All (All Items)

A table of numeric data is displayed with measurement functions listed vertically and symbols indicating elements and wiring units listed horizontally. The number of displayed items varies depending on the number of elements that are installed in this instrument.

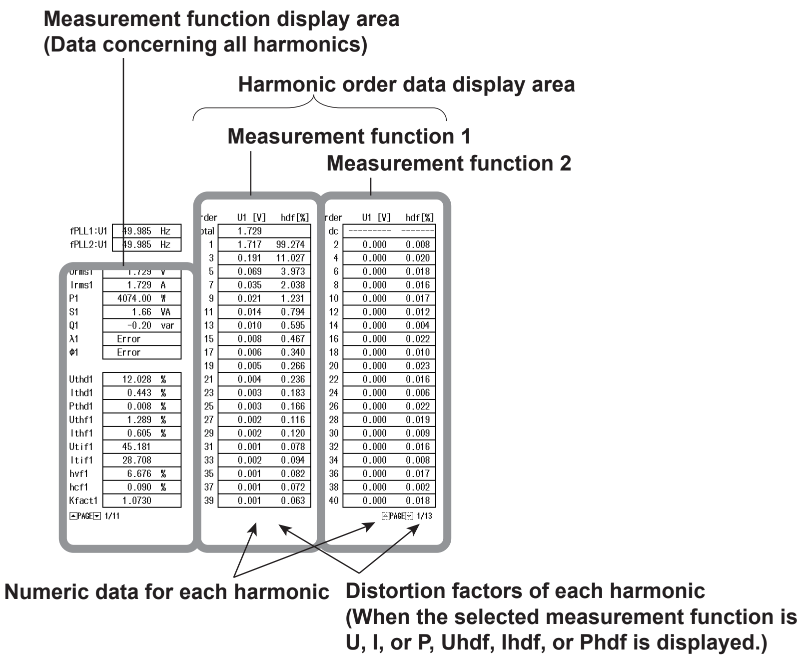
Hrm List Single display (Hrm List Single, option)

- When the display mode is set to numeric, 42 harmonic order data items of a single measurement function are displayed in two columns.
- When the display mode is split display, 22 harmonic order data items of a single measurement function are displayed in two columns.



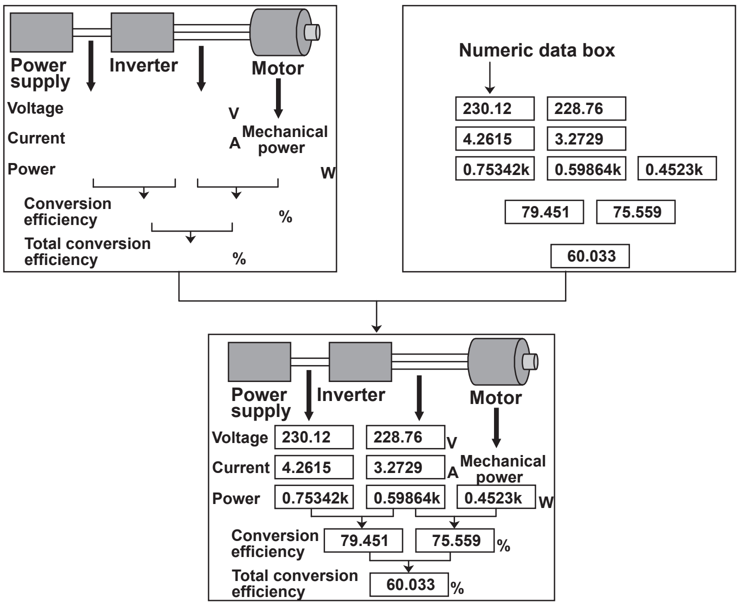
Dual harmonics list display (Hrm List Dual, option)

- When the display mode is set to numeric, 22 harmonic order data items of the two measurement functions are displayed in two columns (the items of each measurement function in its own column).
- When the display mode is split display, 12 harmonic order data items of two measurement function are displayed in two columns (the items of each measurement function in its own column).



Custom display (Custom)

Illustrations (.BMP) or photos (.BMP) created on a PC or other devices can be displayed as the screen background. On top of this background, numerical data boxes can be placed to configure the screen. Numeric data will be displayed on this screen.



Display

Switching the displayed page (PAGE UP/PAGE DOWN)

You can change the displayed items collectively by switching the displayed page.

- PAGE▼: The next page is displayed.
- PAGE▲: The previous page is displayed.

4-, 8-, and 16-value displays

Displayed pages are pages 1 to 12.

Matrix display

Displayed pages are pages 1 to 9.

All Items display

The first page is pinned to the top half of the screen. You can switch between other pages in the bottom half of the screen. When the display is split and the All Items display is shown, no part of the screen is pinned.

Hrm List Single and Hrm List Dual displays

You can switch the measurement function display pages (on the left edge of the screen) and the harmonic order data display pages, separately. Use the left and right cursor keys to select which pages you want to change.

Custom display

When the display configuration is set so that the displayed contents span over multiple pages, you can switch between those pages.

Displaying the first or last page (PAGE TOP/PAGE END)

- ⯯: The last page is displayed.
- ⯭: The first page is displayed.

Number of displayed digits (Display Resolution)

The number of displayed digits (display resolution) for voltage, current, active power, apparent power, reactive power, and so on is as follows:

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

For details, see appendix 3. When the range rating (rated value of the specified measurement range) is specified, the decimal place and unit applied to the Σ functions of the voltage, current, active power, apparent power, reactive power, and so on, are set to those of the element with the lowest number of displayed digits (display resolution) in the wiring unit. For details on the display resolution during integration, see “Number of displayed digits (Display Resolution)” under “Integrated power (Watt hours).”

▶ **Click here.**

Display items (ITEM)

The display item settings vary depending on the screen that is being displayed.

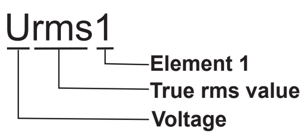
- Numeric data display items
  - 4-, 8-, and 16-value displays (4 Items/8 Items/16Items)
  - Matrix display (Matrix)
  - All display (All Items)
  - Single and dual harmonic list displays (Hrm List)
  - Custom display (Custom)
- Waveform display items
- Trend display items
- Bar graph display items
- Vector display items
- High-speed data capturing display items

For a list of the measurement functions and their descriptions, see “Items That This Instrument Can Measure.”

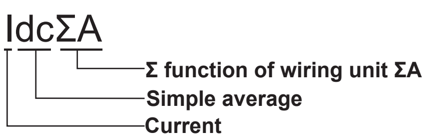
▶ **Click here.**

Example of how measurement functions are displayed in the numeric data display

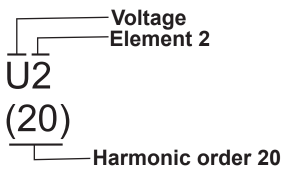
True rms voltage of element 1



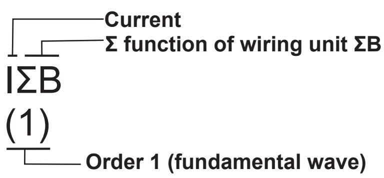
Simple average of the currents of the elements in wiring unit ΣA



20th harmonic voltage of element 2



Simple average of the fundamental currents of the elements in wiring unit ΣB



Notes about the numeric data display

- “-------” is displayed if a measurement function is not selected or if there is no numeric data.
- If Urms, Umn, Udc, Urmn, Uac, Irms, Imn, Idc, Irmn, or Iac exceeds 140 % of the measurement range, overload [-OL-] is indicated.
- For P, if the voltage or current exceeds 140 % of the measurement range, overload [-OL-] is indicated.
- If the measured or calculated result cannot be displayed using the specified decimal place or unit, overflow [-OF-] is indicated.
- If rounding to zero is on, when the voltage or current measurement meets the following conditions relative to the measurement range, Urms, Umn, Urmn, Irms, Imn, Irmn, and other measurement functions based on these measurement functions are displayed as zero. For λ or Φ, an error is indicated.
  - When the crest factor is set to CF3
    Urms, Uac, Irms, or Iac is 0.3 % or less. Umn, Urmn, Imn, or Irmn is 2 % or less.
  - When the crest factor is set to CF6 or CF6A
    Urms, Uac, Irms, or Iac is 0.6 % or less. Umn, Urmn, Imn, or Irmn is 4 % or less.
- When the data update interval is not Auto, if the data update interval is shorter than the analysis window width (number of cycles of the fundamental signal) that is determined by the fundamental frequency, harmonic data is not measured, and “-------” (no data) is displayed. If this happens, increase the data update interval. For example, if the data update interval is 50 ms and the fundamental frequency is 10 Hz (period: 100 ms), the analysis window width is one cycle (see section 5.6 in the Getting Started Guide, IM WT1801R-03EN), and the data measurement period is 100 ms. In this case, the time required for harmonic measurement is approximately 150 ms or greater (data measurement period + data processing time). To measure and display harmonic data, set the data update interval to a value greater than or equal to 200 ms.
- When the data update interval is Auto, fPLL2, WS, and WQ are not measured and displayed as “-------” (no data).
- There is no overload indication (“-OL-”) or zero indication (rounding to zero) for the numeric data of harmonic orders 0 (DC) to 500.
- If the measured frequency is outside the measurement range, an error is indicated for fU and fI.
- If λ is greater than 1 or less than -1, λ and Φ are displayed as follows.

	λ	Φ
$1<\lambda\leq2$	1	0.0
$-2\leq\lambda<-1$	−1	180.0
$\lambda < -2$ or $2 < \lambda$	Error	Error

4-, 8-, and 16-value displays (4 Items/8 Items/16 Items)

Item number to edit (Item No.)

Select the number of the item that you want to edit.

Function (Function)

You can select any of the measurement function types listed under “Items That This Instrument Can Measure.”

▶ **Click here.**

If you select None, no measurement function is displayed for the selected item.

Selecting functions directly (U/I/P, S/Q/λ/Φ, WP/q/TIME, FU/FI/η, U/I MODE)

When a menu is not displayed, you can change the selected measurement function display using one of the function select keys (U/I/P, S/Q/λ/Φ, WP/q/TIME, FU/FI/η, U/I MODE).

U/I/P, S/Q/λ/Φ, WP/q/TIME, FU/FI/η

Each time you press U/I/P, the function changes in the following order: U, I, P, original display. The same holds true for S/Q/λ/Φ, WP/q/TIME, FU/FI/η.

U/I MODE

Each time you press the key, measurement function U or I changes in the following order: rms, mean, dc, rmean, ac, rms.

Element (Element/Σ)

- You can select the element/wiring unit from the following options. The available options vary depending on the installed elements.
  Element1, Element2, Element3, Element4, Element5, Element6, ΣA, ΣB, ΣC
- If the selected wiring unit does not have any elements assigned to it, "-------" (no data) is displayed as there is no numeric data. For example, if elements are assigned to ΣA but not to ΣB, the measurement function for ΣB is displayed as "-------" (no data).

Selecting elements directly (ELEMENT)

When a menu is not displayed, you can change the element number of the selected measurement function using the ELEMENT key.

Changing elements collectively (ALL)

You can collectively change the element/wiring units of all display items on display. The ALL indicator lights.

Harmonic order (Order, option)

When you select a function that has harmonic data, you can set the displayed harmonic order within the following range.
Total (Total value) or 0 (dc) to 500

The harmonic orders that can be specified vary depending on the measurement function. For details, see "Harmonic Measurement Function Orders."

▶ **Click here.**

Columns for harmonic numeric data that exceeds the maximum measurable order show no data [−−−−−−−]. For information about the maximum measurable harmonic order, see "Maximum harmonic order to be measured (Max Order)."

▶ **Click here.**

Resetting the display items (Reset Items)

Reset patterns (Reset Pattern)

You can select the reset method from the following options.

- Element Origin: The numeric data for each element is displayed on each page. The arrangement pattern varies depending on the number of installed elements.
- Function Origin: The numeric data for each function is displayed on each page. The arrangement pattern varies depending on the number of installed elements.
- Clear Current Page: All the display items on the current page are set to None.
- Clear All Pages: All the display items on every page are set to None.

Resetting items (Reset Items Exec)

You can reset items.

Turning the display frame on and off (Display Frame)

Select whether to show the display frame (on or off).

Matrix display (Matrix)

Item number to edit (Item No.)

This is the same as setting the item number in the 4-, 8-, and 16-value displays.

▶ Click here.

Function (Function)

This is the same as setting the function in the 4-, 8-, and 16-value displays.

▶ Click here.

In the matrix display, if you choose a measurement function that does not require an element or wiring unit (such as η1 to η4, F1 to F20, Ev1 to Ev8, etc.), data is displayed in the first column.

Selecting functions directly (U/I/P, S/Q/λ/Φ, WP/q/TIME, FU/FI/η, U/I MODE)

This is the same as selecting functions directly in the 4-, 8-, and 16-value displays.

▶ Click here.

Harmonic order (Order, option)

This is the same as setting the harmonic order in the 4-, 8-, and 16-value displays.

▶ Click here.

Resetting the display items (Reset Items)

This is the same as resetting the display items in the 4-, 8-, and 16-value displays.

▶ Click here.

Column (Column Settings)

Number of columns (Column Num)

Set the number of columns to 4 or 6.

Column number (Column No.)

Select the number of the column that you want to edit.

Element (Element/Σ)

- You can select the element/wiring unit from the following options. The available options vary depending on the installed elements.
  None, Element1, Element2, Element3, Element4, Element5, Element6, ΣA, ΣB, ΣC
- If you select None, no measurement data is displayed in the selected column.
- If the selected wiring unit does not have any elements assigned to it, “-------” (no data) is displayed as there is no numeric data. For example, if elements are assigned to ΣA but not to ΣB, the measurement function for ΣB is displayed as “-------” (no data).

Selecting elements directly (ELEMENT)

This is the same as selecting elements directly in the 4-, 8-, and 16-value displays.

▶ Click here.

Resetting the settings (Reset Items Exec)

You can reset columns settings.

Turning the display frame on and off (Display Frame)

This is the same as turning the display frame on and off in the 4-, 8-, and 16-value displays.

▶ Click here.

All display (All Items)

You cannot change individual measurement functions. Switch to display using PAGE UP/PAGE DOWN or the up and down cursor keys.

The number of displayed pages varies according to the installed options as follows:

Harmonic measurement option or simultaneous dual harmonic measurement option	
Available	Not available
Page 12	Page 8

Harmonic order (Order(k), option)

The harmonic order applies to page 9 or 10. On pages 9 and 10, the harmonic order setting appears in the upper left of the screen. This is the same as setting the harmonic order in the 4-, 8-, and 16-value displays.

▶ Click here.

Turning the display of the numeric data for all elements and wiring units on and off (Display All Elements)

- OFF
  The numeric data is displayed in six columns. When the total number of elements and wiring units is seven or more, you can change the element/wiring unit to be displayed by horizontally scrolling the screen using the left and right cursor keys.
- ON
  When the total number of elements and wiring units is seven or more, all the numeric data for the elements and wiring units is displayed in nine columns. If you select ON when the total number of elements and wiring units is six or less, the display is the same as when OFF is selected.

Turning the display frame on and off (Display Frame)

This is the same as turning the display frame on and off in the 4-, 8-, and 16-value displays.

▶ Click here.

Single harmonics and dual harmonics lists (Hrm Single List/Hrm Dual List, option)

For each measurement function, you can display the numeric data for a harmonic order from 0 (DC) to 500 or for all harmonic orders in two columns.
Available on models with the harmonic measurement option or simultaneous dual harmonic measurement option

Item number to edit (List Item No.)

- You can specify two lists to show in the harmonic order data display area (the right side of the screen). Select the number of the list you want to edit: 1 or 2.
  - When Hrm List Single is selected, the data of List Item No1 is listed in two columns.
  - When Hrm List Dual is selected, the data of List Item No1 is listed in one column, and the data of List ItemNo2 is listed in another column.
- You cannot change individual items in the measurement function display area (the left side of the screen). Switch to display using PAGE UP/PAGE DOWN or the up and down cursor keys.

Function (Function)

Select the measurement function to show in the harmonic order data display area from the following options.
U, I, P, S, Q, λ, Φ, ΦU, ΦI, Z, Rs, Xs, Rp, Xp

Selecting functions directly (U/I/P, S/Q/λ/Φ, WP/q/TIME, FU/FI/η, U/I MODE)

You can directly select the measurement function to show in the harmonic order data display area. This is the same as selecting functions directly in the 4-, 8-, and 16-value displays.
However, for Hrm List Single and Hrm List Dual displays, you can select only the measuring functions that have harmonic order data. Use U/I/P to select U, I, or P. Use S/Q/λ/Φ to select, S, Q, λ, Φ, ΦU, or ΦI. The WP/q/TIME key, FU/FI/η key, and U/I MODE key are disabled.

Element (Element/Σ)

You can select the element or wiring unit to display in the harmonic order data display area. This is the same as setting the element in the 4-, 8-, and 16-value displays.

▶ Click here.

Selecting elements directly (ELEMENT)

You can select the element or wiring unit to display in the harmonic order data display area. This is the same as selecting elements directly in the 4-, 8-, and 16-value displays.

▶ Click here.

Harmonic order

The Total value and 0 (DC) order numeric data is always displayed at the top of the harmonic order data display area. To view the numeric data of harmonic orders 1 to 500, switch to displayed page using PAGE UP/PAGE DOWN or the up and down cursor keys.
The number of harmonic orders that switch is as follows:

	Normal display (1 screen)	Split display
Hrm List Single	40 orders	20 orders
Hrm List Dual	20 orders	10 orders

Turning the display frame on and off (Display Frame)

This is the same as turning the display frame on and off in the 4-, 8-, and 16-value displays.

▶ Click here.

Custom display (Custom)

Loading a display configuration file (Load Items)

A display configuration file specified in the file list is loaded. The extension is .TXT.
For how to configure the file list display and how to operate files and folders, see “File operations (Utility).”

▶ Click here.

Loading a background file (Load Bmp)

A background file specified in the file list is loaded. The extension is .BMP.
You can create an image that conforms to the following specifications with commercially available image creation software and load it into this instrument.

- File type: BMP
- Resolution: 800×672 pixels
- Color gradation: 16-bit high color (R: 5-bit, G: 6-bit, B: 5-bit) or 24-bit true color (R: 8-bit, G: 8-bit, B: 8-bit)
- Data size: approx. 1 MB (16 bit)/1.6 MB (24 bit)

▶ Click here.

- If you load an image that does not conform to the above specifications, the image may not be displayed correctly, and an error message may be displayed.
- After you properly load a display configuration file and a background file, if you restart the instrument and the same background file is not in the same location, the background will return to its default.

Loading display configuration and background files at the same time (Load Items & Bmp)

If you select and load a display configuration file (.txt) from the file list, a background file with the same name but with a .bmp extension will be loaded at the same time.

▶ Click here.

An error will occur if a background file that has the same name as the display configuration file is not present in the save destination folder of the display configuration file.

Display configuration (Edit Items)

Total number of items (Total Items)

Set the total number of numeric data boxes to be displayed in the range of 1 to 192.*

Number of items per page (Items Per Page)

Set the number of numeric data boxes to be displayed per page in the range of 1 to 192.*
The total number of pages will be Total Items/Items Per Page.

* The setting ranges for Total Items and Items Per Page are linked as follows:
  - Total Items: Items Per Page to Items Per Page×12
  - Items Per Page: Total Items/12 to Total Items

Customizing display items (Custom Items)

- **Item number to edit (Item No.)**
  Select the number of the item that you want to edit.

- **Function (Function)**
  This is the same as setting the function in the 4-, 8-, and 16-value displays.
  ▶ Click here.
  Select None to display text in the numeric data box. Set the text in the String menu.

- **Element (Element/Σ)**
  Element is enabled when anything other than None is selected for the function. This is the same as setting the element in the 4-, 8-, and 16-value displays.
  ▶ Click here.

- **Harmonic order (Order, option)**
  This is the same as setting the harmonic order in the 4-, 8-, and 16-value displays.
  ▶ Click here.
  When Function is set to None, a String menu is displayed instead of Order.

- **String (String)**
  This appears when you set Function two None. Set the text to display in the numeric data box. You can set up to 15 characters for the text.
  When Function is set to anything other than None, an Order menu is displayed instead of String.

- **Display position X (X Pos)**
  Set the left edge position of the numeric data box on the screen in the range of 0 (left edge of screen) to 800 (right edge of screen).

- **Display position Y (Y Pos)**
  Set the top edge position of the numeric data box on the screen in the range of 0 (top edge of screen) to 671 (bottom edge of screen).

- **Text size (Font Size)**
  Select the size of the displayed text from the following options.
  14, 16, 20, 24, 32, 48, 64, 96, 128

- **Text color (Font Color)**
  Select the color of the displayed text from the following options.
  Yellow, Green, Magenta, Cyan, Red, Orange, Light Blue, Purple, Blue, Pink, Light Green, Dark Blue, Blue Green, Salmon Pink, Mid Green, Gray, White, Dark Gray, Blue Gray, Black

Saving the display configuration (Save Custom Items)

You can save the screen configuration you customized to the specified storage device. The extension is .TXT.

- **File list display and save destination settings (File List)**
  On the file list, specify the save destination. For how to configure the file list display and how to operate files and folders, see "File operations (Utility)."
  ▶ Click here.
- **Auto naming (Auto Naming)**
  This is the same as the auto naming feature for saving and loading data.
  ▶ Click here.
- **File name (File Name)**
  This is the same as the file name setting for saving and loading data.
  ▶ Click here.
- **Saving (Save Exec)**
  The display configuration is saved.

- Note that if a file with the same name exists in the destination folder, it will be overwritten without warning.
- File names are not case-sensitive.

Turning the display frame on and off (Display Frame)

This is the same as turning the display frame on and off in the 4-, 8-, and 16-value displays.

▶ Click here.

8 Computation

Computation (MEASURE)

You can specify the following items.

- User-defined functions (User Defined Function)
- Average active power measurement
- MAX hold (Max Hold)
- User-defined events (User Defined Event)
- Apparent power, reactive power, and corrected power formulas (Formula)
- Sampling frequency (Sampling Frequency)
- Phase difference display format (Phase)
- Master/slave synchronous measurement (Sync Measure)
- Voltage or current for measuring frequency

User-defined functions (User Defined Function)

You can combine measurement function symbols to create a formula and find the numeric data of that formula.
A USB keyboard is convenient when you need to set many arithmetic formulas or input many characters.

User-defined functions allow you to combine operands to determine physical values other than those of the measurement functions. The measurement functions that you can specify for the efficiency formula are limited to power and motor output measurement functions. However, by using user-defined functions, you can create formulas consisting of measurement functions other than power and motor output measurement functions to determine ratios other than efficiency.

Selecting which user-defined function to edit

Select the number corresponding to the user-defined function that you want to edit from the following options.

- User Defined F01−F05: User-defined functions F1 to F5
- User Defined F06−F10: User-defined functions F6 to F10
- User Defined F11−F15: User-defined functions F11 to F15
- User Defined F16−F20: User-defined functions F16 to F20

Turning the calculation of user-defined functions on or off

Turn the calculation of user-defined functions on and off.

User-defined function name (Name)

- Number of characters: Up to 8
- Types of characters: Spaces and all characters that are displayed on the keyboard

Unit (Unit)

- Number of characters: Up to 8
- Types of characters: Spaces and all characters that are displayed on the keyboard

Expression (Expression)

Operation type

You can use combinations of measurement functions and element numbers (e.g., Urms1) as operands to configure up to 20 expressions (F1 to F20). There can be up to 16 operands in an expression.
The different types of operands are listed below (measurement function: operand).

- **Normal measurement**

Voltage, current, and power

Urms: URMS( )	Irms: IRMS( )	P: P( )	Pfnd: PFND( )
Umn: UMN( )	Imn: IMN( )	S: S( )	Sfnd: SFND( )
Udc: UDC( )	Idc: IDC( )	Q: Q( )	Qfnd: QFND( )
Urmn: URMN( )	Irmn: IRMN( )	λ: LAMBDA( )	λfnd: LAMBDAFND( )
Uac: UAC( )	Iac: IAC( )	Φ: PHI( )	Φfnd: PHIFND( )
Ufnd: UFND( )	Ifnd: IFND( )	Pc: PC( )	−−−
U+pk: UPPK( )	I+pk: IPPK( )	P+pk: PPPK( )	−−−
U-pk: UMPK( )	I-pk: IMPK( )	P-pk: PMPK( )	−−−
CfU: CFU( )	CfI: CFI( )	−−−	−−−
fU: FU( )	fI: FI( )	−−−	−−−

Integrated power

Wp: WH( )	q: AH( )	Time: TI( )
Wp+: WHP( )	q+: AHP( )	WS: SH( )
Wp-: WHM( )	q-: AHM( )	WQ: QH( )

Efficiency

η1: ETA1( ) to η4: ETA4( )

User-defined functions

F1: F1( ) to F20: F20( )

User-defined events

Ev1: EV1( ) to Ev8: EV8( )

- **Harmonic measurement (option)**

U(k): UK(,)	I(k): IK(,)	P(k): PK(,)
S(k): SK(,)	Q(k): QK(,)	λ(k): LAMBDAK(,)
ΦU(k): UPHI(,)	ΦI(k): IPHI(,)	Φ(k): PHIK(,)
Z(k): ZK(,)	Rs(k): RSK(,)	Xs(k): XSK(,)
−−−	Rp(k): RPK(,)	Xp(k): XPK(,)
Uhdf(k): UHDF(,)	Ihdf(k): IHDF(,)	Phdf(k): PHDF(,)
Uthd: UTHD( )	Ithd: ITHD( )	Pthd: PTHD( )
Uthf: UTHF( )	Ithf: ITHF( )	−−−
Utif: UTIF( )	Itif: ITIF( )	−−−
hvf: HVF( )	hcf: HCF( )	−−−
fPLL1: PLLFRQ1( )	fPLL2: PLLFRQ2( )	Kfactor: KFACT( )
ΦU1-U2: PHIU1U2( )	ΦU1-U3: PHIU1U3( )	ΦU1-I1: PHIU1I1( )
ΦU2-I2: PHIU2I2( )	ΦU3-I3: PHIU3I3( )	−−−

- **Delta calculation**

ΔU1( ): DELTAU1( )	ΔI( ): DELTAI( )	ΔP1( ): DELTAP1( )
ΔU2( ): DELTAU2( )	–––	ΔP2( ): DELTAP2( )
ΔU3( ): DELTAU3( )	–––	ΔP3( ): DELTAP3( )
ΔUΣ( ): DELTAUSIG( )	–––	ΔPΣ( ): DELTAPSIG( )
ΔU1rms( ): DELTAU1RMS( )	ΔU1mean( ): DELTAU1MN( )	ΔU1rmean( ): DELTAU1RMN( )
ΔU2rms( ): DELTAU2RMS( )	ΔU2mean( ): DELTAU2MN( )	ΔU2rmean( ): DELTAU2RMN( )
ΔU3rms( ): DELTAU3RMS( )	ΔU3mean( ): DELTAU3MN( )	ΔU3rmean( ): DELTAU3RMN( )
ΔUΣrms( ): DELTAUSIGRMS( )	ΔUΣmean( ): DELTAUSIGMN( )	ΔUΣrmean( ): DELTAUSIGRMN( )
ΔU1dc( ): DELTAU1DC( )	ΔU1ac( ): DELTAU1AC( )	ΔIrms( ): DELTAIRMS( )
ΔU2dc( ): DELTAU2DC( )	ΔU2ac( ): DELTAU2AC( )	ΔImean( ): DELTAIMN( )
ΔU3dc( ): DELTAU3DC( )	ΔU3ac( ): DELTAU3AC( )	ΔIrmean( ): DELTAIRMN( )
ΔUΣdc( ): DELTAUSIGDC( )	ΔUΣac( ): DELTAUSIGAC( )	ΔIdc( ): DELTAIDC( )
–––	–––	ΔIac( ): DELTAIAC( )

- **Motor evaluation (option)**

Speed: SPEED( )	Torque: TORQUE( )	Pm: PM( )
Slip: SLIP( )	SyncSp: SYNC( )	EaU: EAU( )
EaI: EAI( )	–––	–––

- **Auxiliary input (option)**

Aux1: AUX1( )	Aux2: AUX2( )

Setting the operand parameters

The parameters you need to enter depend on whether the function is followed by “(,)” or “( )”.

- **(,) Notation**
  Specify the element to the left of the comma, and specify the harmonic order to the right of the comma. For example: (E1,OR2).
  - Symbols representing elements
    E1 to E6: Elements 1 to 6
    E7 to E9: Wiring units ΣA to ΣC
  - Symbols representing harmonic orders (Order)*
    ORT: Total value
    OR0: dc
    OR1: Fundamental wave
    OR2 to OR500: Harmonic orders 2 to 500
    * Models with the harmonic measurement option or simultaneous dual harmonic measurement option

- **How to set the values inside parentheses**
  Set a symbol representing an element. You do not need to set a harmonic order. For example, set it as (E1).

For the symbols that can be used for the parameters of each operand, see appendix 5.

Values substituted in operands

- The unit of TI( ) is seconds.
- η1 to η4 are displayed as percentages (see appendix 1), but ETA1 to ETA4 calculated in this section are ratios.
  Example: When η1 is 80 %, ETA1 is 0.8
- The U1 in PHIU1U2 represents the voltage signal of the element whose element number is the smallest in the wiring unit (ΣA, ΣB, or ΣC). For example, if input elements 2, 3, and 4 are assigned to wiring unit ΣA, PHIU1U2 is the phase difference between the voltage signals of input elements 2 and 3.
- User-defined expressions can use other user-defined expressions with smaller numbers as operands. For example, the expression for user-defined function F3 can be set to F1( ) + F2( ). This allows expressions that would otherwise exceed 50 characters in length to be calculated. This can be accomplished by, for example, setting expressions in F1 and F2, and then adding or dividing those expressions in F3. This feature is also convenient when defining multiple expressions that include common operands. For example, you can set common operands in F1, and then set F4 as F3( ) divided by F1( ) and set F5 as F4( ) divided by F1( ).
  However, if you enter a user-defined expression with a number that is greater than or equal to its own number, correct results will not be obtained. For example, if you set user-defined function F3 to F1( )+F3( ) or to F1( ) +F4( ), the calculated result will be displayed as “-------” (no data) or “-OF-” (overflow).

Operators

The following operators can be used in expressions.

Operator	Example	Description
+, −, *, /	U(E1,OR1)−U(E2,OR1)	Basic arithmetic
ABS	ABS(P(E1,ORT)+P(E2,ORT))	Absolute value
SQR	SQR(I(E1,OR0))	Square
SQRT	SQRT(ABS(I(E1,OR3)))	Square root
LOG	LOG(U(E1,OR25))	Natural logarithm
LOG10	LOG10(U(E1,OR25))	Common logarithm
EXP	EXP(U(E1,OR12))	Exponent
NEG	NEG(U(E1,OR12))	Negation
SIN	SIN(EAI(E1))	Sine (sin)
COS	COS(EAI(E1))	Cosine (cos)
TAN	TAN(EAI(E1))	Tangent (tan)
ASIN	ASIN(EAI(E1))	Arc sine (arcsin)
ACOS	ACOS(EAI(E1))	Arc cosine (arccos)
ATAN	ATAN(EAI(E1))	Arc tangent (arctan)

Number and type of characters that can be used in expressions

- Number of characters: Up to 60
- Types of characters: Spaces and all characters that are displayed on the keyboard
  On the keyboard, press to enter operand and expression characters. The characters that you can select are indicated below.

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(	−−−	−−−
SIN(	COS(	TAN(	−−−

Examples of expressions

An expression to determine the rms value of the harmonic components of the voltage signal of input element 2

$$\sqrt{(\text{Total rms voltage value})^2 - (\text{Rms value of the fundamental voltage signal})^2}$$

SQRT(SQR(U(E2,ORT))−SQR(U(E2,OR1)))

If an operand in an expression is undetermined, the calculated result is displayed as "-------" (no data). This occurs when a delta calculation measurement function is in the expression, but delta calculation is turned off or when a measurement function of an element that is not installed is in the expression.

Saving a user-defined function (Save UserDef)

File list (File List)

On the file list, specify the save destination. You can perform file operations such as creating folders on the storage device, deleting and copying files, and changing file names.

▶ Click here.

Auto naming (Auto Naming)

This is the same as the auto naming feature for saving setup data.

▶ Click here.

File name (File Name)

This is the same as the file name setting for saving setup data.

▶ Click here.

Saving (Save Exec)

Saves the user-defined function to the specified save destination with the specified file name.
Measurement stops while this instrument is saving data. After this instrument finishes saving or saving is canceled, measurement resumes.

Loading a user-defined function (Save UserDef)

The user-defined function of the file specified in the file list is loaded. The extension is .TXT. For how to configure the file list display and how to operate files and folders, see "File list (File List)."

▶ Click here.

Loading (Load Exec)

Data is loaded from the specified file.

- If you change the extension of the saved data file, by using a PC or some other device, the instrument will no longer be able to load it.
- When a user-defined function is loaded from a file, the user-defined function is changed to the loaded function and cannot be changed back. We recommend that you save the current user-defined function before loading a user-defined function from a file.

Loading presets (Preset)

This instrument contains preset expressions for rotational-coordinate voltages, currents (id, iq, vd, vq), and so on used in the vector control of three-phase motors.
When calculating these parameters, load the presets, and adjust the expressions as necessary for use.

The available presets are as follows:

- **Calculation of the rotational coordinate dq-axis parameter**
  dq (3V3A): absolute transformation (3V3A)
  dq (3P4W): absolute transformation (3P4W)
  dq (3V3A): relative transformation (3V3A)
  dq (3P4W): relative transformation (3P4W)

- **Six-phase motor measurement**
  6P7W: six-phase seven-wire

dq (3V3A) preset example

FUNC_No.	STATE (ON/OFF)	NAME	EXPRESSION	UNIT
F1	ON	Pole/2	ABS(1111)	
F2	ON	Ra	ABS(2222)	Ohm
F3	ON	Psi_a	ABS(3333)	Wb
F4	ON	Omega_e	F1()*2*3.14159*Speed()/60	rad/s
F5	ON	delta	EAU(E1)-90+30	deg
F6	ON	beta	EAI(E1)-90	deg
F7	ON	vd	NEG(Ufnd(E1)*SIN(F5()))	V
F8	ON	vq	Ufnd(E1)*COS(F5())	V
F9	ON	id	SQRT(3)*NEG(Ifnd(E1)*SIN(F6()))	A
F10	ON	iq	SQRT(3)*(Ifnd(E1)*COS(F6()))	A
F11	ON	Ld	(F8()-F2()*F10()-F4()*F3())/(F4()*F9())	H
F12	ON	Lq	(F2()*F9()-F7())/(F4()*F10())	H

Average active power measurement

The average active power can be calculated for devices, such as intermittent control devices, whose power fluctuates. Use a user-defined function to specify the expression for calculating the average active power.

$$\text{Average active power} = \frac{\text{Integrated power}}{\text{Elapsed integration time}}$$

For example, to determine the average active power of element 1, set the expression of a user-defined function as follows:

WH(E1)/(TI(E1)/3600)

The unit of TI( ) is seconds.

MAX hold (Max Hold)

Set whether to hold the maximum numeric value (MAX value) (on or off). You can determine the measurement functions whose maximum values will be held using a user-defined function. The different types of operands are listed below (measurement function: operand).

Urms: URMSMAX( )	Irms: IRMSMAX( )	P: PMAX( )
Umn: UMEANMAX( )	Imn: IMEANMAX( )	S: SMAX( )
Udc: UDCMAX( )	Idc: IDCMAX( )	Q: QMAX( )
Urmn: URMEANMAX( )	Irmn: IRMEANMAX( )	---
Uac: UACMAX( )	Iac: IACMAX( )	---
U+pk: UPPEAKMAX( )	I+pk: IPPEAKMAX( )	P+pk: PPPEAKMAX( )
U-pk: UMPEAKMAX( )	I-pk: IMPEAKMAX( )	P-pk: PMPEAKMAX( )

To hold the maximum value of the Urms for element 1, enter URMSMAX(E1) in the expression for a user-defined function, and enable MAX hold.

- For the symbols that can be used for the parameters of each operand, see appendix 5.
- The maximum values of the above data are held while the MAX hold function is enabled.
- Values such as D/A output and communication output will also be the maximum values that are being held.

- When MAX hold is applied to measurement functions that have positive and negative values, this instrument compares the absolute values to determine the maximum value.
- To reset held maximum values, turn MAX hold off, and then turn it on again.

User-defined events (User Defined Event)

User-defined events can be used to trigger data storage. You can define up to eight user-defined events.

User-defined event number (Event No.)

Select the number of the user-defined event you want to edit in the range of 1 to 8.

Turning user-defined events on and off

Select whether to enable user-defined events.

User-defined event name (Name)

- Number of characters: Up to 8
- Types of characters: Spaces and all characters that are displayed on the keyboard

Indication of user-defined event occurrence (TRUE/FALSE)

Set the text to show when a user-defined event occurs and when it does not occur.

- Number of characters: Up to 6
- Types of characters: Spaces and all characters that are displayed on the keyboard

Judgment condition setup method (Expression)

You can set the method for setting judgment conditions to one of the following options.

- Range (Range): Specify judgment conditions using ranges of measurement function values or differences from a reference value.
- Condition (Condition): Specify judgment conditions using user-defined events.

Range (Range)

Set the judgment condition for when you set the judgment condition specification method to Range.

- **Function (Function)**
  You can select any of the measurement function types listed under "Items That This Instrument Can Measure."
  ▶ Click here.

- **Element (Element/Σ)**
  You can select the element/wiring unit from the following options. The available options vary depending on the installed elements.
  Element1, Element2, Element3, Element4, Element5, Element6, ΣA, ΣB, ΣC

- **Harmonic order (Order, option)**
  This is the same as the harmonic order in the 4-, 8-, and 16-value displays.
  ▶ Click here.

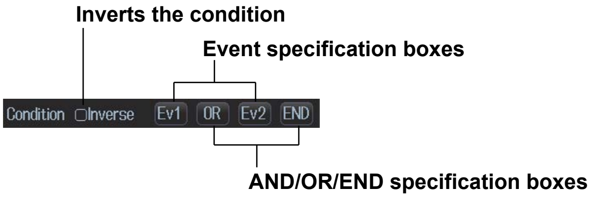
- **Judgment condition**
  Select the method for comparing the measured value and the reference value from the following options.
  OFF, <, <=, =, >, >=, != (not equal)

- **Reference value**
  Set in the range of –9.9999T to 9.9999T.

For example, a condition that is true when 150 < the measured power value of element 1 < 160 W and false otherwise would be configured as shown below.

Condition (Condition)

Set the judgment condition for when you set the judgment condition specification method to Condition.



Inversion of judgment conditions (Inverse)

You can invert the judgment of the condition (true or false) indicated to the right of the check box.

Event specification boxes

You can select the number of a user-defined event that is smaller than the number of the user-defined event that you are currently editing. For example, when you are editing the conditions of user-defined event Ev3, you can select Ev1 or Ev2.

AND/OR/END specification boxes

- **AND, OR**

  To use multiple user-defined events to configure a condition, set the method of combining the events to logical AND or logical OR. When you select AND or OR, an event specification box appears to the right of the AND/OR/END specification box. The number of user-defined events that you can combine is indicated below. When you reach the maximum number of combinable user-defined events, no more AND/OR/END specification boxes appear to the right of the last event.
  - Ev1: 0 You cannot use other user-defined events as conditions. Set the judgment condition using a range.
  - Ev2: 1 (Ev1)
  - Ev3: 2 (Ev1 and Ev2)
  - Ev4: 3 (Ev1 to Ev3)
  - Ev5: 4 (Ev1 to Ev4)
  - Ev6: 5 (Ev1 to Ev5)
  - Ev7: 6 (Ev1 to Ev6)
  - Ev8: 7 (Ev1 to Ev7)
- **END**

  Select END to end the definition of the condition. No event specification box appears to the right of an AND/OR/END specification box that has been set to END.

If you set the event judgment condition to a range and the function of the judgment condition returns a value of “-------” (no data), because judgment cannot be performed, the judgment result will be FALSE. For example, when integration is not being performed, if the function of event Ev1 is set to integrated power (WP) and the judgment condition is WH(E1)>0, the measured data is displayed as “-------” (no data), so the judgment for Ev1 is FALSE. Also, if you set the judgment condition specification method to Condition and events that cannot be judged are included in the judgment conditions, the judgment result is FALSE. For example, if you set the judgment condition of event Ev2 to NOT(EV1()), if the judgment for Ev1 is FALSE because of the reason given in the example above, the result for Ev2 is not TRUE but FALSE.

Apparent power, reactive power, and corrected power formulas (Formula)

Formula for apparent power (S Formula)

You can select the voltage and current to use to calculate the apparent power (voltage × current) from the following options.

- Urms*Irms
  The product of the true rms values of the voltage and current
- Umean*Imean
  The product of the voltage's and current's rectified mean values calibrated to the rms values
- Udc*Idc
  The product of the simple averages of the voltage and current
- Umean*Irms
  The product of the voltage's rectified mean value calibrated to the rms value and the current's true rms value
- Urmean*Irmean
  The product of the voltage's and current's rectified mean values

Apparent power and reactive power calculation types (S,Q Formula)

There are three types of power: active power, reactive power, and apparent power. In general, they are defined by the following formulas.

Active power $P = UI\cos\Phi$ (1)
Reactive power $Q = UI\sin\Phi$ (2)
Apparent power $S = UI$ (3)
U = rms voltage; I = rms current; Φ = phase difference between voltage and current
The power values are related as follows:
$(\text{Apparent power S})^2 = (\text{Active power P})^2 + (\text{Reactive power S})^2$ (4)
The three-phase power is the sum of the power of each phase.

These definitions only apply to sine waves. The measured values for apparent power and reactive power vary for distorted waveform measurement depending on which of the above definitions are combined for the calculation. Because the formulas for deriving the apparent and reactive power for distorted waveforms are not defined, none of the formulas can be said to be more correct than the other. Therefore, this instrument allows you to select the apparent power and reactive power formulas (Type1 to 3).
Unlike apparent power and reactive power, active power is derived directly from the sampled data, so errors resulting from different definitions do not occur.

Type 1 (the method used in the normal mode of conventional WT series power meters)

This instrument calculates the apparent power of each phase using formula 3, calculates the reactive power of each phase using formula 2, and sums the results to derive the power.

Active power for a three-phase four-wire system $P\Sigma = P1 + P2 + P3$
Apparent power for a three-phase four-wire system $S\Sigma = S1 + S2 + S3$ ($= U1 \times I1 + U2 \times I2 + U3 \times I3$)
Reactive power for a three-phase four-wire system $Q\Sigma = Q1 + Q2 + Q3$

$$(= s1\times\sqrt{(U1\times I1)^2 - P1^2} + s2\times\sqrt{(U2\times I2)^2 - P2^2} + s3\times\sqrt{(U3\times I3)^2 - P3^2})$$

The signs for s1, s2, and s3 are negative when the current leads the voltage and positive when the current lags the voltage.

Type 2

This instrument calculates the apparent power of each phase using formula 3 and sums the results to derive the three-phase apparent power. This instrument calculates the three-phase reactive power from the three-phase apparent power and the three-phase active power using formula 4.

Active power for a three-phase four-wire system $P\Sigma = P1 + P2 + P3$
Apparent power for a three-phase four-wire system $S\Sigma = S1 + S2 + S3$ ($= U1 \times I1 + U2 \times I2 + U3 \times I3$)
Reactive power for a three-phase four-wire system $Q\Sigma = \sqrt{S\Sigma^2 - P\Sigma^2}$

Type 3 (the method used in the harmonic measurement modes of the WT1600, WT3000 and PZ4000)

This instrument calculates the reactive power of each phase using formula 2 and calculates the three-phase apparent power using formula 4. This formula is available on models with the harmonic measurement option or simultaneous dual harmonic measurement option.

Active power for a three-phase four-wire system $P\Sigma = P1 + P2 + P3$

Apparent power for a three-phase four-wire system $S\Sigma = \sqrt{P\Sigma^2 + Q\Sigma^2}$

Reactive power for a three-phase four-wire system $Q\Sigma = Q1 + Q2 + Q3$

Formula for corrected power (Pc Formula)

Some standards require that a voltage transformer's active power be corrected when the load connected to the voltage transformer is very small. You can select a formula to use for this correction and specify the coefficient.

Applicable standard (Select standard)

Select from the following options.

- IEC76-1(1976)
- IEC76-1(2011)

Formulas for each applicable standard

IEC76-1(1976)

$$Pc = \frac{P}{P_1 + P_2\left(\frac{Urms}{Umn}\right)^2}$$

IEC76-1(2011)

$$Pc = P\left(1 + \frac{Umn - Urms}{Umn}\right)$$

Pc: Corrected power
P: Active power
Urms: True rms voltage
Umn: Voltage's rectified mean calibrated to the rms value
P1, P2: Coefficients specified by the applicable standard

Coefficients (P1 and P2)

You can set coefficients P1 and P2 to values within the range of 0.0001 to 9.9999.

The IEEE C57.12.90-2010 formula is the same as IEC76-1 (1976).

Sampling frequency (Sampling Frequency)

This instrument offers three types of sampling frequencies, each approximately 2 MHz, to prevent the input waveform from being measured as a DC signal because of aliasing. You can choose to automatically switch the sampling frequency or choose to use a fixed frequency.

- Auto:
  - This instrument automatically switches between clocks A, B, and C.
  - In the following situations, setting sampling frequency to Auto will fix the sampling frequency to Clock C.
    - When the data update interval is Auto
    - When the line filter of the input element is set to a value in the 100 Hz to 100 kHz range
    - When the line filter of motor evaluation or auxiliary signal input is not set to OFF
    - For high speed data capturing
- Clock A: 2.000000 MHz
- Clock B: 1.941176 MHz
- Clock C: 1.885714 MHz

- Set the sampling frequency to Auto to prevent the measured values from being distorted by aliasing.
- If you want to use a fixed sampling frequency, select a frequency from Clock A to Clock C.

Phase difference display format (Phase)

The phase difference Φ between the voltage and current indicates the current phase relative to the voltage of each element. Set the display format to one of the following options.

- **180 degrees**
  If the current phase is in the counterclockwise direction with respect to voltage, the current is leading (D) the voltage. If the current phase is in the clockwise direction with respect to the voltage, the current is lagging (G) the voltage. The phase difference is expressed by an angle between 0 and 180° (see appendix 2).
- **360 degrees**
  The phase difference is expressed as an angle between 0 and 360° in the clockwise direction.

- If the measured voltage or current value is zero, "Error" is displayed.
- Phase difference Φ for lead (Lead) and lag (Lag) is displayed correctly only when both the voltage and current are sine waves and the ratio of the input to the measurement range is not greatly different between the voltage and current.
- If the calculation result of power factor λ exceeds 1, Φ is displayed as follows:
  - If λ is greater than 1 and less than or equal to 2, Φ returns 0.
  - If λ is greater than 2, Φ returns an error ("Error" is displayed).
- On models with the harmonic measurement option, the phase differences ΦU and ΦI of harmonic orders 1 to 500 of the voltage and current are always displayed using an angle between 0 and 180° (no sign for lead and negative sign for lag).

Master/slave synchronous measurement (Sync Measure)

Connect the external start signal input/output connector (MEAS. START) of the master and slave instruments using a BNC cable (sold separately). You can synchronize the measurement of two instruments making one the master and the other the slave. The master outputs a measurement start signal, and the slave receives the signal.
For the specifications of the external start signal input/output terminals, see section 4.4 in the Getting Started Guide, IM WT1801R-03EN.

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.
- When the data update interval is Auto
- During real-time integration mode or real-time storage mode

Follow the procedure below to hold values during synchronized measurement.
- To hold the display, hold the display of the master first.
- To stop holding display, stop holding the display of the slave first.

Voltage or current for measuring frequency

This instrument can measure the frequencies of the voltages or currents of all elements.

9 Integrated Power (Watt hours)

This instrument can integrate the active power (watt hour), the current (ampere hour), the apparent power (volt-ampere hour), and the reactive power (var hour).
For the symbols and definitions of the measurement functions related to integrated power (watt hours), see “Items That This Instrument Can Measure.”

▶ Click here.

Set the following items.

- Enabling or disabling independent integration (Independent Control)
- Independently integrated elements (Element Object)
- Starting, stopping, and resetting integration (Start/Stop/Reset)
- Integration conditions (Integ Set)

Integration indications

Integration status

Reset

“Reset” appears when the integrated value is reset and integration can be started.

Start

“Start” and the elapsed integration time appear when integration is running.

Stop

“Stop” and the elapsed integration time appear when integration is not running.

- When you manually stop integration with the Stop soft key, “Stop” appears in yellow. You can press the Start soft key to resume integration.
- If the integration mode is real-time normal integration or real-time continuous integration and the scheduled integration stop time arrives causing the integration to automatically stop, “Stop” appears in orange. In this case, you cannot resume integration by pressing the Start soft key. To start integration, reset it first.

Ready

In real-time normal integration mode, when you press the Start soft key, before the scheduled integration start time arrives, “Ready” and the scheduled integration start time appear.

Scheduled integration start time

TimeUp

If the integration timer expires, integration stops automatically, and “TimeUp” and the elapsed integration time appear.

Error

In the following situations, integration will automatically stop and “Error” and the elapsed integration time appear.

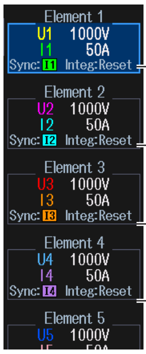
- The integration time reaches the maximum integration time (10000 hours).
- The integrated value reaches its maximum or minimum displayable value.
- A power failure occurs when integration is in progress. Even when a power failure occurs, this instrument stores and holds the integration result. When the power returns after a power failure, the integration result is displayed up to the point when the power failure occurred in the integration-stopped state.

Example of the display when the integration timer is set to a non-zero value

Elapsed integration time
Integration timer

Example of the display when independent integration is enabled

The integration status of the input element or wiring unit selected with the ELEMENT key for setting ranges.
When a wiring unit is selected, the element number at the top is the number of the smallest input element in the wiring unit.



Integration status of each element

Number of displayed digits (display resolution)

The number of displayed digits (display resolution) for an integrated value is six (the maximum value is 999999). When an integrated value reaches 1000000 counts, the decimal point shifts automatically. For example, if 0.001 mWh is added to 999.999 mWh, the display shows 1.00000 Wh.

Maximum and minimum displayable integrated values

Active power (WP): ±999999 MWh
Current (q): ±999999 MAh
Apparent power (WS): ±999999 MVAh
Reactive power (WQ): ±999999 Mvarh

Display when integration overflow occurs

If either of the conditions below is met, integration stops, and the integration time and integrated value are held.

- The integration time reaches the maximum integration time (10000 hours).
- The integrated value of WP, q, WS, or WQ reaches the maximum or minimum displayable value given above.

Display when the data update interval is Auto

WS and WQ are not measured and displayed as “-------” (no data).

Integration when the MAX hold feature is enabled

This instrument determines and displays the integrated value by summing the values measured at each data update interval, irrespective of the MAX hold feature.

Integration when the measured value exceeds the measurement limit

If a sampled instantaneous current or voltage exceeds the maximum or minimum measurement range limits of the AD circuit, the value is measured as the maximum or minimum measurement range limit value.

Integration when current input is small

If rounding to zero is on, when the current input meets the following conditions relative to the measurement range, integration is performed assuming the current to be zero.

- When the crest factor is set to CF3
  Irms or Iac is 0.3 % or less. Imn or Irmn is 2 % or less.
- When the crest factor is set to CF6 or CF6A
  Irms or Iac is 0.6 % or less. Imn or Irmn is 4 % or less.

Sample rate and valid frequency ranges for integration

The sample rate is approximately 2 MHz. The voltage/current signal frequencies that are valid for integration are as follows:

Integrated Item		Valid Frequency Range for Integration
Active power		DC to approximately 1 MHz
Current	When integrating Irms	DC or the lower frequency limit determined by the data update interval to approximately 1 MHz
	When integrating Imn	DC or the lower frequency limit determined by the data update interval to approximately 1 MHz
	When integrating Idc	DC to approximately 1 MHz
	When integrating Irmn	DC or the lower frequency limit determined by the data update interval to approximately 1 MHz
	When integrating Iac	The lower frequency limit determined by the data update interval to approximately 1 MHz

Using an external signal to control integration (option)

On models with the 20-channel D/A output option, you can use an external signal to start, stop, and reset integration using the remote control feature. For details on the remote control feature, see appendix 4.6 in the Getting Started Guide, IM WT1801R-03EN.

Limitations on modifying the settings during integration

During integration, there are some settings that you cannot change and functions that you cannot execute. For details, see appendix 8.

Limitations on waveform display during integration

- During integration, the waveform display trigger does not function. Therefore, the signal level of the waveform display at the left edge of the screen may not be stable.
- During integration, the shortest possible waveform data update interval is 1 s. If you select an update interval shorter than 1 s, the numeric data and waveform data will contain measured values for different measurement periods.

Auto range and range skipping

If you start integration in auto range mode, integration is performed with auto range mode enabled. This state is called integration auto range.

- In auto range mode, both the voltage and current measurement ranges will switch automatically according to the size of the input signal.
- For the range-increase and range-decrease conditions in auto range mode, see “Auto voltage range (AUTO (V)).

  ▶ Click here.
- In auto range mode, you can enable range skipping, which allow the range to increase or decrease within the selected measurement ranges, skipping measurement ranges that are not used. For details, see “Valid measurement range (CONFIG (V)/CONFIG (A)).”

  ▶ Click here.
- When non-periodic pulse waveforms are applied, the range may not remain constant. If this happens, use the fixed range setting.

Data correction when the range is changed by auto range

Measurement does not take place while the range is being changed by the auto range feature. The first measurement data after the measurement range is determined is added to the integrated value for the time that the measurement was not executed. Measurement also does not take place while the range is being switched for elements that are not applicable to range increasing or decreasing. Power or current value measured immediately before is added to the integrated value.

- When the range is increased
  The first measurement data after the measurement range is determined is added to the integrated value immediately before the range-increase condition is satisfied, up to a maximum of three times per range-increase.
- When the range is decreased
  The first measurement data after the measurement range is determined is added to the integrated value immediately before the range-decrease condition is satisfied, up to a maximum of two times per range-decrease.

Checking whether the range has been changed by the auto range feature

If the measurement range is changed by the auto range feature while integration is in progress, a hyphen is added to the measurement range information transmitted through communication.

Integration auto range limitations

- Integration is not possible using auto range for the following measurement ranges. The measurement ranges are fixed to those that are being used at the start of integration.
  - Voltage range, current range (when the data update interval is set to Auto)
  - Analog input range of the revolution signal for the motor evaluation option and torque signal
  - Analog input range of the auxiliary input option
- If independent input element configuration is on, integration cannot be started.
- If the Apparent power and reactive power calculation type is Type3, integration cannot be started.

We recommend that you select a short data update interval to measure integration with higher accuracy when using auto range.

Enabling or disabling independent integration (Independent Control)

You can select whether to start, stop, and reset integration on all elements simultaneously or separately.

- OFF: All elements are controlled simultaneously.
- ON: Integration works differently depending on the independent input element configuration (Element Independent) setting as follows:
  - When independent input element configuration is disabled
    Elements whose wiring system is 1P2W are controlled separately. For elements whose wiring system is not 1P2W, all elements assigned to the same wiring unit are controlled simultaneously.
  - When independent input element configuration is enabled
    The integration of each element is controlled separately.
- When the data update interval is Auto and independent integration is on, integration cannot be started.

When independent integration is enabled, independent input element configuration is enabled, and integration is controlled separately for elements in the same wiring unit, because the elements' integration periods differ, the Σ functions for those elements (the functions that deal with wiring unit integration, such as the integrated active power and apparent power functions) return errors.

Independently integrated elements (Element Object)

This setting is valid when independent integration is enabled.

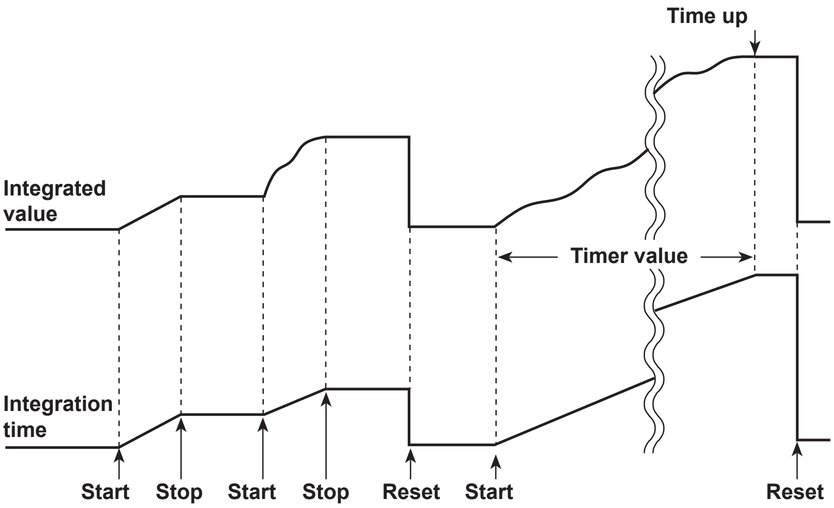
- You can select which elements to start, stop, and reset the integration of by selecting the elements' check boxes.
- All ON: All elements are controlled.
- All OFF: No elements are controlled.

Even if you enable independent integration, when independent input element configuration is disabled, the integration of elements in the same wiring unit is controlled simultaneously regardless of whether the elements' check boxes are selected.
Examples
- Elements 1, 2, and 3 are assigned to wiring unit ΣA as a three-phase four-wire system.
- Under Element Object, the check box of element 1 is selected, but the check boxes of elements 2 and 3 are not.

If you start or stop the integration of element 1 under the above conditions, the integration of elements 2 and 3, whose check boxes are not selected, also starts or stops.
To independently control the integration of input elements that are assigned to the same wiring unit, you must enable independent integration and enable independent input element configuration.

Starting, stopping, and resetting integration (Start/Stop/Reset)

You can start, stop, and reset integration using the front panel soft keys or communication commands. The relationship between the integration operation and start, stop, and reset is as follows:



Integration start (Start)

- Integration starts under each of the following conditions depending on the integration mode.
  - Manual integration mode, normal integration mode, and continuous integration mode
    Integration starts immediately.
  - Real-time normal integration mode and real-time continuous integration mode
    This instrument enters into an integration-ready state. Integration starts when the scheduled start time arrives.
- When integration starts, the START indicator to the right of the INTEG key lights, and "Start" is displayed in the integration status.
- When the instrument is ready to integrate, the START indicator blinks, and "Ready" is displayed in the integration status.

Integration stop (Stop)

- You can manually stop integration. The integration time and integrated value are held.
- When you manually stop integration, the STOP indicator blinks, and “Stop” is displayed in yellow in the integration status. You can press the Start soft key to resume integration. However, when integration stops automatically, as described below, you cannot resume integration with the Start soft key.

Automatic stopping of integration

- Integration stops automatically under each of the following conditions depending on the integration mode. The integration time and integrated value are held. If integration stops automatically, you cannot resume integration with the Start soft key. To start integration, reset it first.
  - When the integration mode is set to manual integration, normal integration, or real-time normal integration
    After the specified timer time elapses, integration stops automatically. The STOP indicator lights, and “TimeUp” is displayed in the integration status.
  - When the integration mode is set to real-time normal integration or real-time continuous integration
    When the scheduled integration stop time arrives, integration starts automatically. The STOP indicator lights, and “Stop” is displayed in orange in the integration status.

Integration reset (Reset)

The integration time and integrated value are reset. The STOP indicator turns off. The displays for integration-related functions change to “-----------” (no data).

When an integration error occurs, the START and STOP indicator blink, and “Error” is displayed in the integration status.

Holding integration and releasing the hold

Integration hold

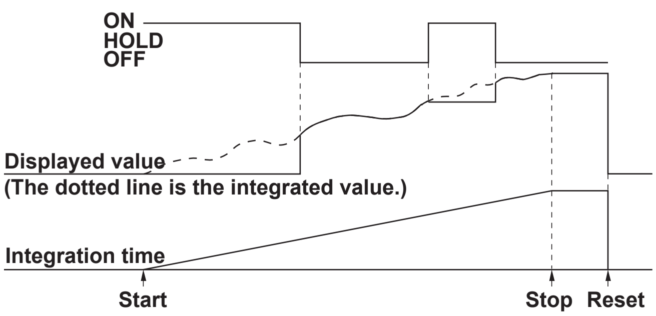
When you press HOLD, the key lights, and the integration result is held on the display and in the communication output. The integration operation continues regardless of whether the result is held.

Releasing the hold

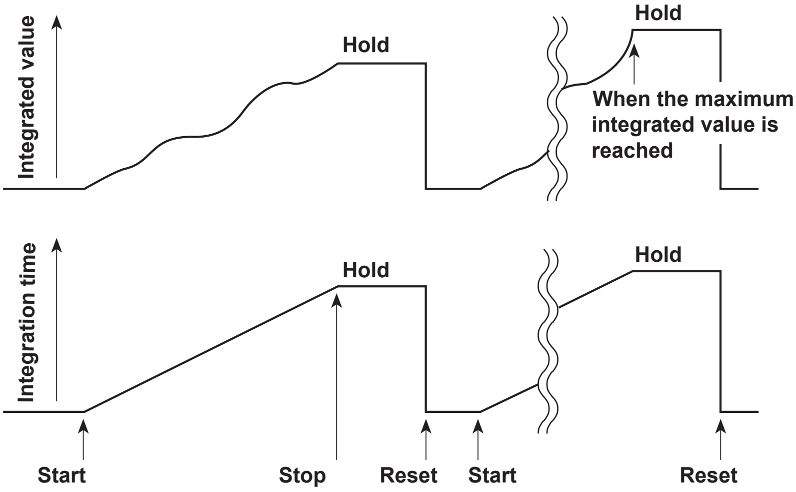
If you press HOLD when the integration result is held, the HOLD key light turns off, and the numeric data display is updated. While the integration result is held, you can update the display by executing a single measurement (by pressing SINGLE).

The relationship between the hold function and start and stop is as follows:

- If you start integration while the integration result is held, the display and communication output do not change. When you release the hold (turn it off) or make a single measurement (by pressing SINGLE), the integration result at that point is displayed and transmitted.



- If you stop integration while the integration result is held, the displayed and transmitted values do not change. When you release the hold (turn it off) or make a single measurement (by pressing SINGLE), the integration result at the point when integration was stopped is displayed and transmitted.



Integration conditions (Integ Set)

The following integration conditions are available.

- Integration mode (Mode)
- Integration timer (Integ Timer)
- Scheduled times for real-time integration (Real-time Control)
- Integration auto calibration on/off (Auto Cal)
- Watt hour integration method for each polarity (WP ± Type)
- Current mode for current integration (q Mode)
- Rated time of integrated D/A output (D/A Output Rated Time, option)

Integration mode (Mode)

The integration feature has the following five modes.

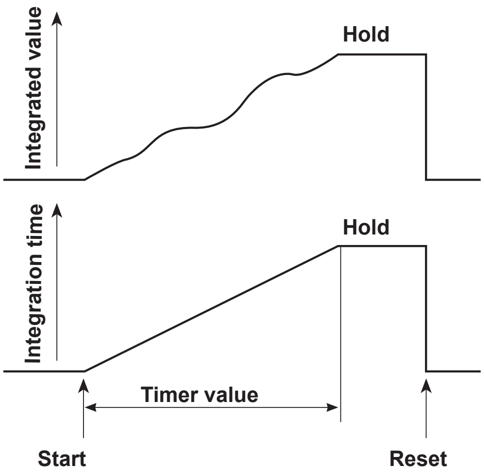
Integration mode	Start	Stop	Repetition
Manual integration mode (Normal)	Key operation	Key operation	---
Normal integration mode (Normal)	Key operation	Stopped by the timer	---
Continuous integration mode (Continuous)	Key operation	Key operation	Repeats when the timer expires
Real-time normal integration mode (R−Normal)	Date and time	Date and time	---
Real-time continuous integration mode (R−Continuous)	Date and time	Date and time	Repeats when the timer expires

When the data update interval is Auto, only manual integration mode and normal integration mode can be used.

Manual integration mode

When you select normal integration mode (Normal) and set the integration timer to 00000:00:00, this instrument performs integration in manual integration mode. After integration starts, it continues until you press the Stop soft key. However, if either of the conditions below is met, integration stops, and the integration time and integrated value are held.

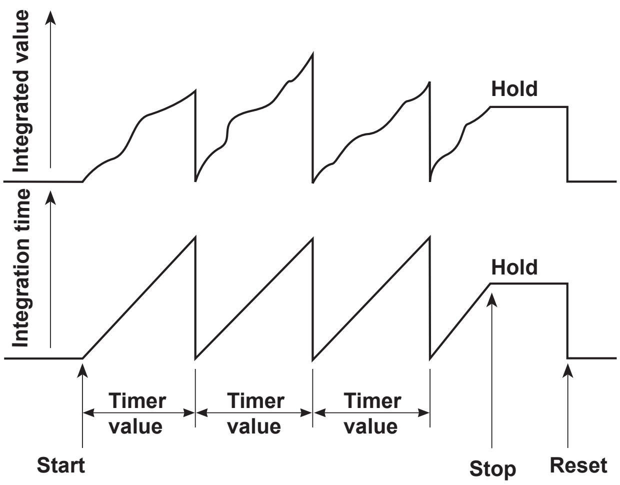
- The integration time reaches the maximum integration time (10000 hours).
- The integrated value reaches its maximum or minimum displayable value.



Normal integration mode (Normal)

You can set a relative integration time (set a timer). Integration starts when you press the Start soft key. When any of the conditions below is met, integration is stopped, and the integration time and integrated value are held.

- The specified timer time elapses.
- Press the Stop soft key.
- The integrated value reaches its maximum or minimum displayable value.



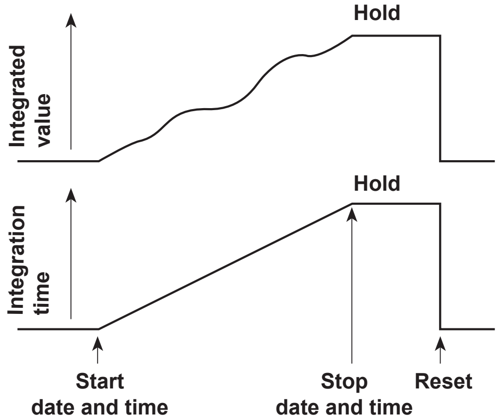
Continuous integration mode (Continuous integration, Continuous)

The integration time is set using relative time. Integration starts when you press the Start soft key. When the specified integration timer time elapses, integration automatically resets, restarts, and repeats the process. Integration repeats until you press the Stop soft key. However, if the integrated value reaches its maximum or minimum displayable value before the specified time elapses, integration stops, and the integration time and integrated value at that point are held.

Real-time normal integration mode (R−Normal)

Set the date and time when integration starts and stops and the duration of integration. Integration starts at the scheduled start time. When any of the conditions below is met, integration stops, and the integration time and integrated value are held.

- The scheduled stop time arrives.
- The specified timer time elapses.
- The integration time reaches the maximum integration time (10000 hours).
- The integrated value reaches its maximum or minimum displayable value.



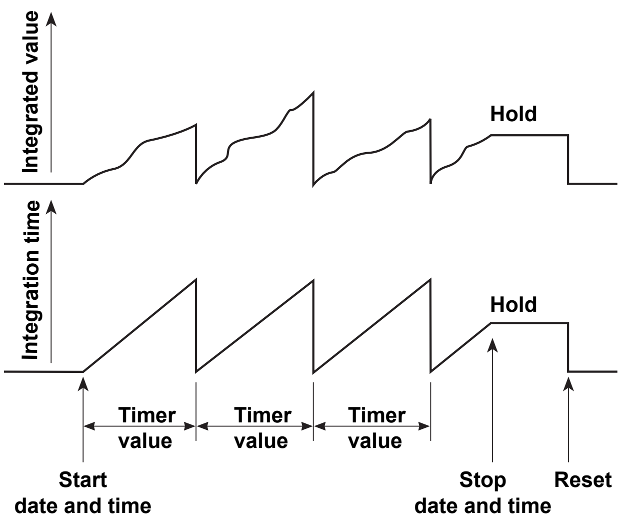
In real-time integration mode, when you set the integration time to 00000:00:00, integration starts at the scheduled start time. When any of the conditions below is met, integration stops, and the integration time and integrated value are held.

- The scheduled stop time arrives.
- The integration time reaches the maximum integration time (10000 hours).
- The integrated value reaches its maximum or minimum displayable value.

Real-time continuous integration mode (Continuous integration, R-Continuous)

Set the date and time when integration starts and stops and the duration of integration. Integration starts at the scheduled start time. When the specified timer time elapses, integration resets, restarts, and repeats the process. If either of the conditions below is met, integration stops, and the integration time and integrated value are held.

- The scheduled stop time arrives.
- The integrated value reaches its maximum or minimum displayable value.



Integration timer (Integ Timer)

You can set the value in hours:minutes:seconds format in the following range.
00000:00:00 to 10000:00:00

When independent integration is disabled

The integration timer that you specified above applies to every element.

When independent integration is enabled

- **Setting**
  You can select the method for setting the integration timer from the following options.
  - Each: The timer is set separately for each input element.
  - All: The timer is set collectively for all installed input elements.
- **Element1 to Element6**
  You can set the integration timers for each element within the above range.

Scheduled times for real-time integration (Real-time Control)

This setting is valid in real-time normal integration mode and real-time continuous integration mode.
You can set the year, month, day, hour, minute, and second of the integration start and stop times. Be sure to set the integration stop time later than the integration start time. You can set the values within the following ranges.

- Year: Four-digit Gregorian year
- Hour: Minute:Second: 00:00:00 to 23:59:59
- Now: The scheduled integration start time is set to the current time.
- Copy: The scheduled integration start time is copied to the scheduled integration stop time.

When independent integration is disabled

The scheduled times that you specified above apply to every element.

When independent integration is enabled

- **Setting**
  You can select the method for setting the scheduled times from the following options.
  - Each: The timer is set separately for each input element.
  - All: The timer is set collectively for all installed input elements.
- **Element1 to Element6**
  You can set the scheduled times for each element within the above range.

- In the scheduled time settings, February can be set up to 31 days. If you specify an inappropriate date, an error message will appear when you start integration. Set the scheduled times appropriately.
- This instrument recognizes leap years when it performs integration.
- In real-time normal integration mode and real-time continuous integration mode, after you press Start soft key and this instrument enters into an integration-ready state, the numeric data may not be updated immediately. This is because the numeric data is updated in sync with the clock of this instrument. This ensures that the numeric data is updated at the same time as the scheduled integration start time and that the integration time is accurate.

Integration auto calibration on/off (Auto Cal)

Ordinary zero-level compensation takes place when the measurement range or line filter is changed, but you can also automatically calibrate the zero level during integration.

- ON: Zero-level compensation takes place automatically approximately once every hour during integration.
- OFF: Zero-level compensation does not take place automatically during integration.

When the data update interval is Auto, integration auto calibration is set to on.

- When integration auto calibration is on and zero-level compensation is in progress, the power or current value measured immediately before is integrated.
- When integration auto range is in use, integration calibration takes the sum of the following times.
  - Zero-level compensation time: Data update interval × about 30
  - Internal processing time: About 2 s

Watt hour integration method for each polarity (WP ± Type)

Setting

You can select the method for setting the integration method from the following options.

- Each: The timer is set separately for each input element.
- All: The timer is set collectively for all installed input elements.

Element1 to Element6

Select the integration method from the following options.

- Charge/Discharge: Measure DC watt hours (for each sampled data item) by polarity.
- Sold/Bought: Measure AC watt hours (for each sampled data item) by polarity.

For the integration formulas, see appendix 1.
When the data update interval is Auto, the integration method is set to Charge/Discharge.

Current mode for current integration (q Mode)

Setting

You can select the method for setting the current mode from the following options.

- Each: The timer is set separately for each input element.
- All: The timer is set collectively for all installed input elements.

Element1 to Element6

You can select the current mode from the following options. For the current formulas, see appendix 1.

- rms: True rms value
- mean: Rectified mean value calibrated to the rms value
- dc: Simple average
- r-mean: Rectified mean value
- ac: AC component

When the current mode is dc, the polarity (+ or -) is displayed.

Rated time of integrated D/A output (D/A Output Rated Time, option)

This setting appears on models with the 20-channel D/A output option. When integrated values are output through D/A output, a rated value (the same value as the measurement range) is continuously applied, the integrated value after the specified time elapses is assumed to be 100 %, and the D/A output at that point is assumed to be 5 V. The D/A output from 0 % of the integrated value (0 V) to 100 % of the integrated value (5 V) is assumed to vary linearly with time, and the ratio of the actual input level to this assumed line determines the D/A output value.
For the relationship between measured integrated D/A output and voltage, see “Relationship between output items and d/a output voltage.”

▶ **Click here.**

Setting the rated time for integrated D/A output

- You can set the value in hours:minutes:seconds format in the following range.
  00000:00:00 to 10000:00:00
- This setting is valid in the following integration modes.
  - Manual integration mode
  - Real-time normal integration mode when the integration timer is set to 00000:00:00
- In the following integration modes, the rated time for integrated D/A output is set to the same time that the timer is set to.
  - Normal integration mode
  - Continuous integration mode
  - Real-time normal integration mode when the integration timer is not set to 00000:00:00
  - Real-time continuous integration mode

When the rated time for integrated D/A output is set to 00000:00:00, the D/A output for the integrated value is fixed at 0 V.

Integration resume action at power failure recovery (Integration Resume Action)

You can set how to resume the integration operation when the instrument is turned off due to a power failure or interruption and then turns back on.

Start

The integration result at the time the power is turned off is stored. When the power recovers, integration starts (continues) automatically.

Stop

The integration result at the time the power is turned off is stored. When the power recovers, the integration result up to the point when the power was turned off is displayed in the integration stopped state. You can start (continue) integration.

Error

The integration result at the time the power is turned off is stored. When the power recovers, the integration result up to the point when the power was turned off is displayed in the integration error state. You can start integration by resetting it. When integration is reset, the measurement result is displayed as “-----” (no data). If necessary, record the integration result up to that point before resetting it.
When the data update interval is Auto, integration resume action at power failure recovery is according to the action described for “Error.”

10 Waveform Display

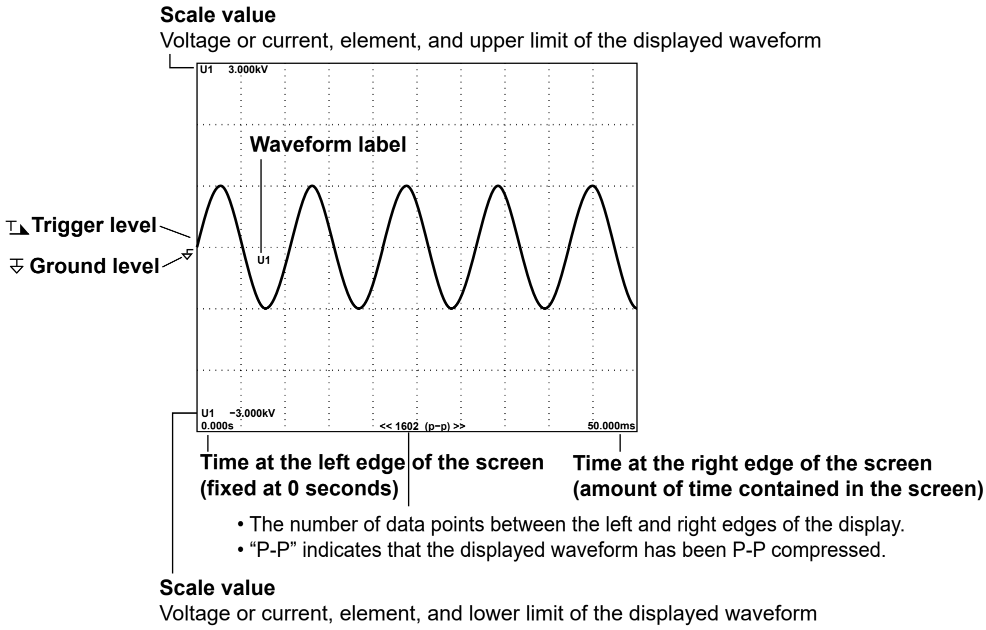
Waveform display (WAVE)

Press WAVE to display the waveforms of the following input signals.

- Input element’s voltage and current
- Motor evaluation function’s (option) speed and torque
- Auxiliary inputs (option) Aux1 and Aux2

Each time you press WAVE, the number of waveform display windows changes in the following order: none, 2, 3, 4, and 6.

Waveform display example



Measurement mode during waveform display

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 instrument to calculate 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.

- If the trigger level is not set properly, the start position of the waveform display (signal level at the left edge of the screen) will be unstable and waveforms may not be displayed.
- Even if waveforms are displayed, the measurement mode display at the upper left of the screen will be Normal Mode in the following cases:
  - During integration
  - Trigger mode is off.

  In Normal Mode, measurements are taken and sampled data is updated automatically at the data update interval. In this mode, there are limitations on the waveform display feature.

  ▶ **Click here.**

Display format (FORM)

The following display format settings are available.

- Number of waveform display windows (Format)
- Time axis (Time/div)
- Trigger (Trigger Settings)
- Advanced waveform display settings (Display Settings)
- Waveform mapping (Mapping)

Number of waveform display windows (Format)

You can divide the screen equally into windows, and assign waveforms to those windows. This feature is useful when there are many waveforms and it is difficult to view them all in a single display.

You can choose the number of windows from the following options:

- Single: No windows
- Dual: Two windows
- Triad: Three windows
- Quad: Four windows
- Hexa: Six windows

Depending on the number of windows, the number of points displayed vertically in each window changes as described below.

Single: 672 points, Dual: 336 points, Triad: 224 points, Quad: 168 points, Hexa: 112 points

When the screen is split, the number of displayed points along the vertical axis of a single window is halved.

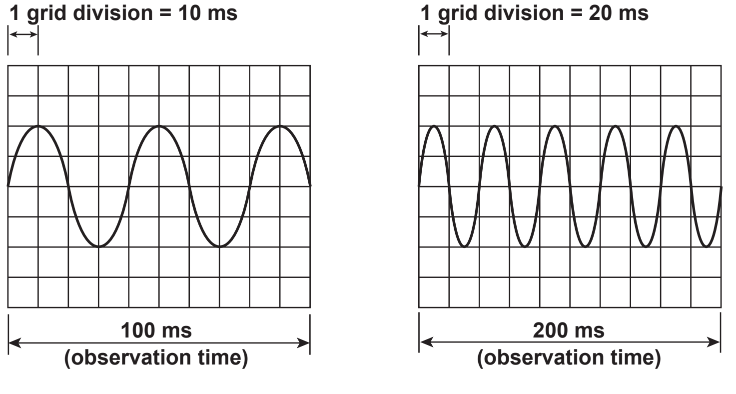
For how waveforms are mapped, see “Waveform mapping.”

▶ **Click here.**

Time axis (Time/div)

The time axis is set in time per grid division (time/div).

- When the data update interval is not Auto
  The time axis can be set up to the point in which the time corresponding to one screen is equal to the data update interval, in 1, 2, 5 steps. For example, when the data update interval is 500 ms, if you change the time-per-division in this order: 0.05 ms, 0.1 ms, 0.2 ms, 0.5 ms, 1 ms, 2 ms, 5 ms, 10 ms, 20 ms, 50 ms, the time corresponding to one screen changes in this order: 0.5 ms, 1 ms, 2 ms, 5 ms, 10 ms, 20 ms, 50 ms, 100 ms, 200 ms, 500 ms.
- When the data update interval is Auto
  The time per division can be changed in the range of 0.05 ms to 5 ms in 1, 2, 5 steps. This allows the time per screen to be changed in the range of 0.5 ms to 50 ms.



Difference between waveform sampling data and waveform display data

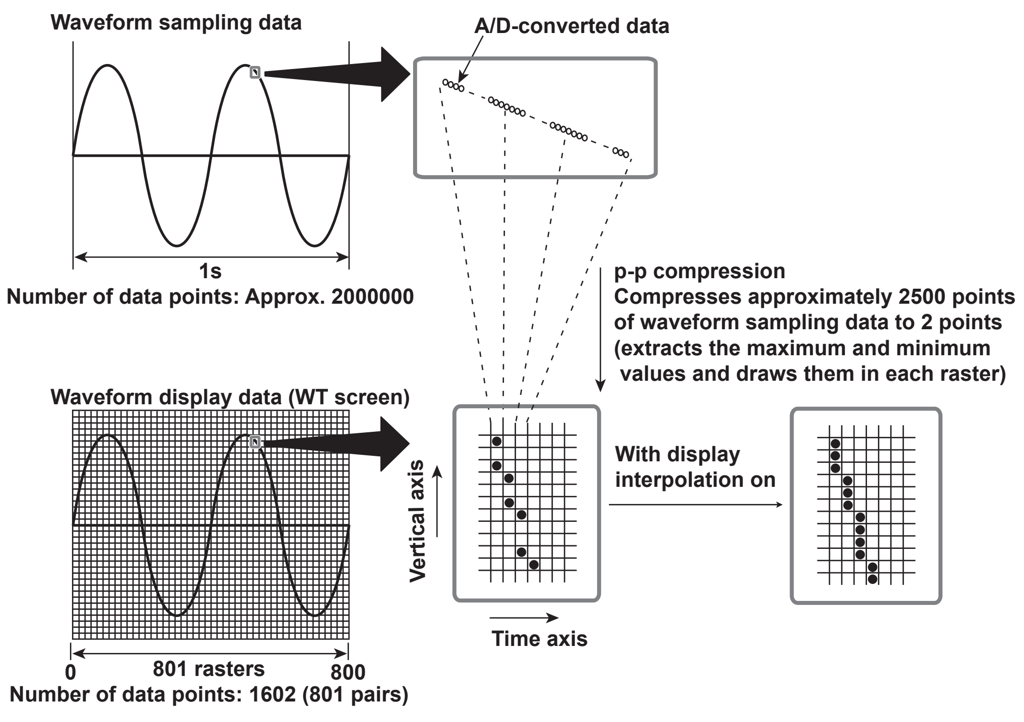
Waveform sampling data and waveform display data are both measured waveform data, but they differ in the following manner.

- **Waveform sampling data: Data derived through A/D conversion of the input signal**
  The A/D conversion rate of this instrument is approximately 2 MS/s. Therefore, if the data update interval is set to 1 s, the number of data points sampled from a single input signal in a single measurement is approximately 2000000 (see the figure below). Waveform sampling data is also called acquisition data (Acquisition Data) or raw wave data (Raw Wave Data).

- **Waveform display data: Waveform data displayed on this instrument's screen (1602 points)**
  When this instrument displays waveforms, data points (of waveform display data) are displayed in horizontal rasters (along the time axis). The number of rasters is 801. Each raster contains two points of waveform display data. The two data points are the maximum and minimum values of the waveform data in each raster. Therefore, the number of waveform display data points (the number of points displayed on the screen) for a single input signal is 1602.

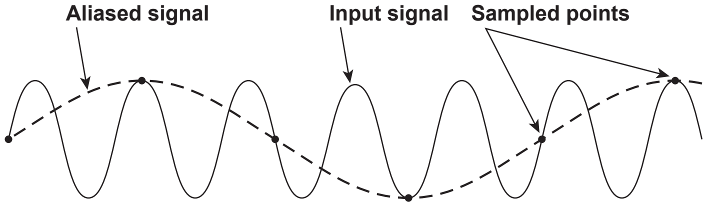
p-p compression

p-p compression is the compression method used to derive waveform display data from waveform sampling data. For example, if a 2-Hz sine wave is measured at a data update rate of 1 s, to display this waveform, this instrument converts the number of data points from approximately 2000000 to 1602 (801 pairs of maximum and minimum values). Thus, two points (a pair) of waveform display data are derived from approximately 2500 points of waveform sampling data. This conversion is called p-p (peak-peak) compression. The compression ratio of p-p compression varies depending on the data update interval and the horizontal scale (time axis) of the waveform display.



Aliasing

When the sample rate is low compared to the frequency of the input signal, the high frequency components of the signal are lost. In accordance with the Nyquist sampling theorem, the high frequency components in the signal are misread as low frequency components. This phenomenon is called *aliasing*.

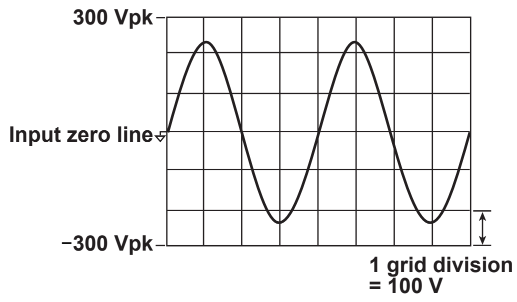


Vertical axis (Amplitude)

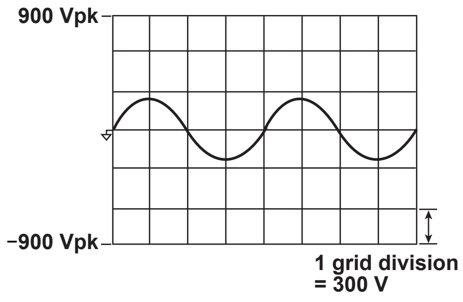
The height (display range) of the vertical axis is based on the specified crest factor and measurement range. For example, if the crest factor is set to CF3 and the voltage measurement range is set to 100 Vrms, the display range is set to ±300 Vpk (±3 × 100 Vrms) with the zero input line at the center. The waveform is clipped if this range is exceeded.

In the same way, if the crest factor is set to CF6 or CF6A and the voltage measurement range is set to 50 Vrms, the display range is set to ±300 Vpk (±6 × 50 Vrms) with the zero input line at the center.

When measured with a measurement range of 100 Vrms



When the same signal is measured with a measurement range of 300 Vrms



Trigger (Trigger Settings)

The trigger determines when a waveform is displayed. “Triggering” occurs when the trigger condition is satisfied and the waveform is ready to be displayed.

Trigger mode (Mode)

The trigger mode determines the conditions for updating the display. Select from the following options.

- **Auto (auto mode)**
  If the trigger conditions are met within a 100-ms timeout period, the instrument updates the displayed waveforms on each trigger occurrence. If not, this instrument automatically updates the displayed waveforms. If the period of the trigger signal is greater than 100 ms, the display is updated as the two conditions described above alternate. In such circumstances, change to normal mode.
- **Normal (normal mode)**
  The instrument updates the waveform display only when the trigger conditions are met. If no triggers occur, the display is not updated. If you want to view waveforms that the instrument cannot trigger on or if you want to check the ground level, use Auto mode.
- **OFF**
  Triggering is disabled. The display is updated at the data update interval. In this mode, there are limitations on the waveform display feature.
  ▶ Click here.

  When the data update interval is Auto, the trigger mode is set to OFF.

Trigger Source (Source)

The signal that this instrument checks for the trigger condition is referred to as the *trigger source*. Select from the following options. The available options vary depending on the installed elements.
U1, I1, U2, I2, U3, I3, U4, I4, U5, I5, U6, I6, Ext Clk (external clock)*

* When you select Ext Clk, the external signal applied to the external clock input terminal (EXT CLK) on the rear panel is used as the trigger source. For the specifications of the CLK terminal, see section 4.3 in the *Getting Started Guide*, IM WT1801R-03EN. When Ext Clk is set as the trigger source, the trigger level settings is invalid.

Trigger slope (Slope)

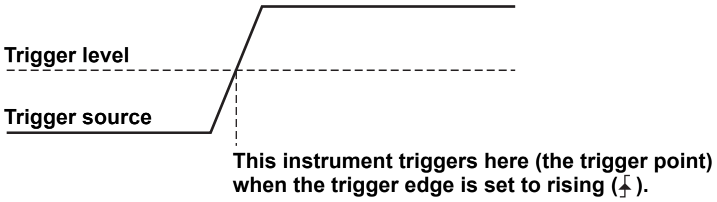
Slope refers to the movement of the signal from a low level to a high level (rising edge) or from a high level to a low level (falling edge). When the slope is used as one of the trigger conditions, it is called a trigger slope.
The following trigger slope settings are available for triggering the instrument.

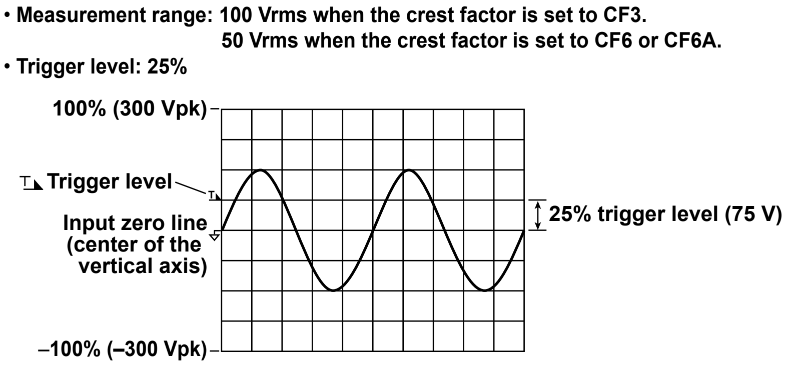
- ↑: When the trigger source changes from a level below the trigger level to a level above the trigger level (rising).
- ↓: When the trigger source changes from a level above the trigger level to a level below the trigger level (falling)
- ↑↓: Either rising or falling

Trigger level (Level)

The trigger level is the level at which the trigger slope is determined. When the trigger source passes through the trigger level on a rising or falling edge, a trigger occurs.

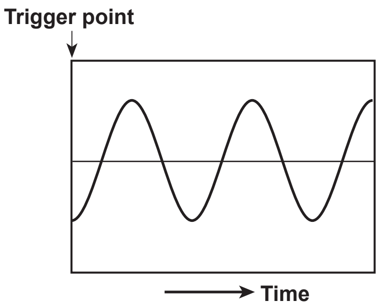
- You can set the trigger level in the range of 0.0 to ±100.0 %.
- A value of 100 % corresponds to half the height of the waveform display. If the zero level of the input signal is set to the center of the vertical axis, 100 % corresponds to the top of the waveform display and −100 % to the bottom of the waveform display. The upper and lower limits of the waveform display correspond to three times the voltage or current measurement range (range after scaling when scaling is in use) of each element when the crest factor is set to CF3. Likewise, the limits are six times when the crest factor is set to CF6 or CF6A.
- When Ext Clk is set as the trigger source, the trigger level setting is invalid.





Trigger point

The trigger point is the point at which a trigger occurs. The trigger point is always displayed at the left edge of the screen.
After the trigger is activated, the waveform display continues from the left of the screen to the right of the screen with the passage of time.
(The arrow below the word "Trigger point" in the figure below is just for illustration. The arrow does not appear on the actual display.)



- To prevent noise-related errors, the trigger feature has a hysteresis of approximately 1 % when the crest factor is set to CF3. For example, when the trigger slope is set to , a trigger will occur if the input signal level falls approximately 1 % below the trigger level and then passes through the trigger level on a rising edge. The trigger feature has a hysteresis of approximately 2 % when the crest factor is set to CF6 or CF6A.
- The waveform display trigger feature does not work when integration is in progress or has been stopped. Therefore, the waveform display start point (the signal level at the left edge of the screen) may not be stable. Also, the numeric data measurement period may not be synchronized with the waveform data measurement period.

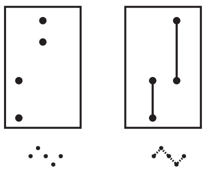
Advanced waveform display settings (Display Settings)

Display interpolation (Interpolate)

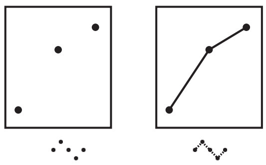
When there are less than 800 points of sampled data on the time axis, the displayed points (rasters) do not connect with each other. This zone where the display points are not connected is called the *interpolation zone*. Display interpolation is a feature that connects the points linearly so that the waveform is displayed smoothly.
You can set the interpolation method to any of the following options.

- ⋰⋱: No interpolation is performed. Only the data points are displayed.
- ⋀⋁: Linearly interpolates between two points.

- **Outside the interpolation zone**
  Vertical dots are connected. If the number of data points is 1602 or greater, the instrument determines the P-P compression values (the maximum and minimum sampled-data values in a given interval), and displays vertical lines (rasters) connecting each pair of maximum and minimum P-P compression values.



- **Inside the interpolation zone**



Grid (Graticule)

You can set the window grid from the following options.

- ▦: The grid is displayed with dotted lines.
- ⬚: The grid is displayed with a frame.
- ⊞: The grid is displayed with a cross hair.

Turning the scale value display on and off (Scale Value)

You can select whether to display the following values for each waveform.

- The upper and lower limits of the vertical axis
- The values at the left and right edges of the horizontal axis (time axis)

Turning the display of waveform labels on and off (Wave Label)

Select whether to display waveform labels.

Waveform mapping (Mapping)

Assignment mode (Mode)

You can assign waveforms to different windows on the screen. Select the assignment mode from the following options:

- Auto
  Waveforms with the display turned on are assigned to the windows by element number in the following order: voltage (U), current (I), speed,[1] torque,[1] Aux1,[2] Aux2[2].
- Fixed
  Waveforms are assigned to the windows by element number in the following order: voltage (U) and current (I), regardless of whether their displays are turned on. Speed[1] and Aux1[2] are displayed in the top window. Torque[2] and Aux2[2] are displayed in the second window from the top.
- User
  Waveforms of your choice can be assigned to the windows, regardless of whether their displays are turned on. You can select the display position in the range from 0 to 5. Waveforms are assigned in order from the top window, starting with number 0.

1 Available on models with the motor evaluation function
2 Available on models with the auxiliary input option

Display items (ITEM)

Displaying all waveforms (All ON)

The waveforms of all input signals are displayed.

Displaying no waveforms (All OFF)

No waveforms are displayed.

Waveforms to display (Display ON/OFF)

- You can select whether to display the waveform of each input signal of each element by selecting or clearing the signal's check box. Only the input signals of installed elements appear.
- On models with the motor evaluation option, you can turn on and off the waveform displays of the speed and torque input signals.
- On models with the auxiliary input option, you can turn on and off the waveform displays of the Aux1 and Aux2 input signals.

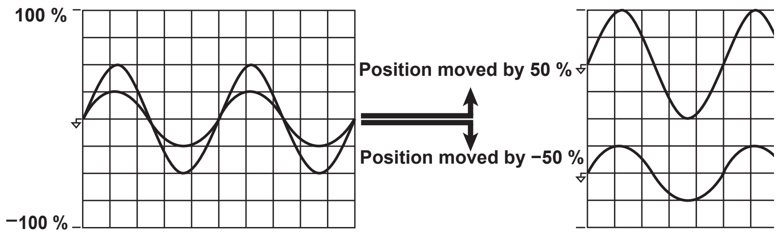
Vertical zoom (Vertical Zoom)

Each displayed waveform can be scaled. You can select from the following zoom factors:
0.1, 0.2, 0.25, 0.4, 0.5, 0.75, 0.8, 1, 1.14, 1.25, 1.33, 1.41, 1.5, 1.6, 1.77, 2, 2.28, 2.66, 2.83, 3.2, 3.54, 4, 5, 8, 10, 12.5, 16, 20, 25, 40, 50, 100

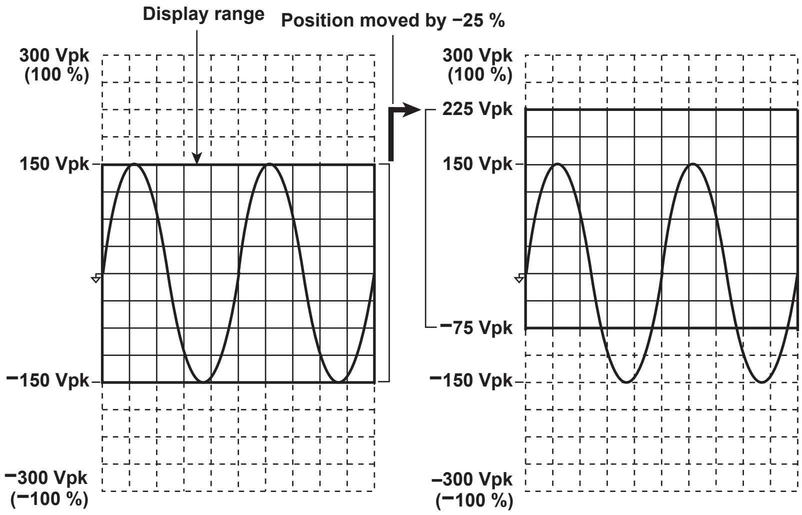
Vertical position (Vertical Position)

You can move the view vertically when you want to view the relationship between voltage and current waveforms or when the section of the waveform that you want to view does not fit into the display frame.

- You can set the trigger level in the range of 0.000 to ±130.000 %.
- When the zoom factor is set to 1, a value of 100 % corresponds to half the height (display range) of the waveform display (which is three times the measurement range when the crest factor is set to CF3 and six times the measurement range when the crest factor is set to CF6 or CF6A). The upper and lower vertical display limits of the screen are 100 % and −100 % from the center.



- As shown in the figure below, when the zoom factor is set to a value other than 1, the upper and lower display limits of the screen do not correspond to three times the measurement range (or to ±100 %) when the crest factor is set to CF3 and six times the measurement range (or to ±100 %) when the crest factor is set to CF6 or CF6A. Take the zoom factor into account when you set a waveform's position. In the figure below, the crest factor is set to CF3, the voltage range is 100 V, the zoom factor is 2, and the vertical position is shifted by −25 %. The waveform is shifted by the same amount that it would be if the zoom factor were set to 1 and the vertical position were shifted by −50 %.



If you want to zoom in on a specific part of a waveform, we recommend that you take the steps below.

1. Set the zoom factor to 1.
2. Following the instructions in this section for shifting a waveform's vertical position, shift the specific part of the waveform that you want to view closely to the center of the display.
3. Set the vertical zoom factor.

11 Trend Display

Other displays (OTHERS)

Press OTHERS to display the following screen.

- Trend display (Trend)
- Bar graph display (Bar)
- Vector display (Vector)
- Split display (with the numeric value display, Numeric+***)
- Split display (with the waveform display, Wave+***)
- Split display (with the trend display, Trend+***)
- High speed data capturing (High Speed Data Capturing)

Each time you press OTHERS, the display switches in the following order: trend, bar graph (option), vector (option), and split (the split display that you set previously).*

* The numeric display and waveform display are shown by default.

Trend display (Trend)

You can display the trends of measurement functions.

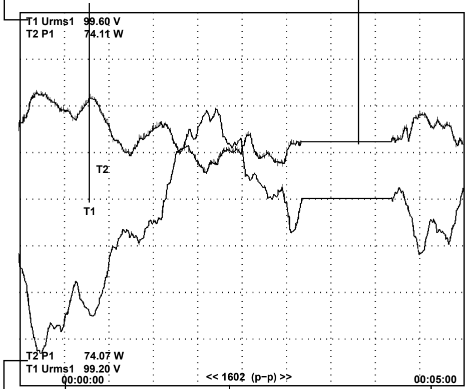
Example of trend display

Scale value
The trend number, measurement function, element, and upper limit of the displayed trend

When the display is held, trend values behave the same as numeric values.

When the display is un-held, the trend data from when the display was held appears.

Waveform label



Time at the right edge of the screen (amount of time contained in the screen)

- The number of data points between the left and right edges of the display.
- "P-P" indicates that the displayed trend has been P-P compressed.

Time at the left edge of the screen (fixed at 0 seconds)

Scale value
The trend number, measurement function, element, and lower limit of the displayed trend

Display format (FORM)

Number of trend display windows (Format)

You can choose the number of windows from the following options:

- Single: No windows
- Dual: Two windows
- Triad: Three windows
- Quad: Four windows

Depending on the number of windows, the number of points displayed vertically in each window changes as described below.

Single: 672 points, Dual: 336 points, Triad: 224 points, Quad: 168 points

When the screen is split, the number of displayed points along the vertical axis of a single window is halved.

Waveform mapping

Trends with the display turned on are assigned to the windows by trend number (T1 to T16). This is similar to the Auto option of the waveform display.

Time axis (Time/div)

The time axis is set in time per grid division (time/div). The time per division can be set in the range of 3 s to 1 day.

The trend data update interval is determined by the data update interval and the time axis (Time/div). For example, if the data update interval is 50 ms and you set Time/div to 3 s/div, the trend display is updated every 1 s. If you set the data update interval to 10 s and Time/div to 3 s/div, the trend display is updated every 10 s, and the trend data is displayed as a line graph, with each point separated by 10 s. If you set Time/div to 1 day/div, the trend display will be updated once every 1080 s regardless of the data update interval.

One division (1 div) on the trend display is equivalent to 80 rasters. For example, if you set Time/div to 1 day/div, one raster is 1080 s (which is equal to 1 day/80), the trend data update interval is 1080 s, and the displayed data is P-P compressed. For details on rasters and P-P compression, see “P-P compression.”

▶ Click here.

Restarting trends (Clear Trend Exec)

When you restart trends, the trend display up to that point is cleared, and the trends start over from the right edge of the screen.

In addition to pressing the Clear Trend Exec soft key, the following actions will restart trends.

- Change the function, element, or harmonic (option) of a trend display item.
- Change the trend time axis (horizontal axis) setting.

Advanced trend display settings (Display Settings)

These are the same as the advanced waveform display settings.

▶ Click here.

These settings are shared with the advanced waveform display settings. If you change the advanced settings on the trend display menu, the advanced settings in the waveform display also change. For example, if you set the display of the scale values to OFF on the trend display menu, the display of the scale values will also be set to OFF in the waveform display.

Display items (ITEM)

Turning the trend display on and off

Display (upper left corner of the list)

You can collectively show (All ON) or hide (All OFF) trend 1 (T1) to trend 16 (T16).

Trend numbers (T1 to T16)

For each of the trend waveforms of trend 1 (T1) to trend 16 (T16), you can select show (check box selected) or hide (check box not selected).

Function (Function)

You can select any of the measurement functions listed under "Items That This Instrument Can Measure."

▶ Click here.

Element (Element/Σ)

- You can select the element/wiring unit from the following options. The available options vary depending on the installed elements.
  Element1, Element2, Element3, Element4, Element5, Element6, ΣA, ΣB, ΣC
- If there are no elements assigned to a selected wiring unit, because the wiring unit has no data, its trend is displayed at the top or bottom of the screen. For example, if elements are assigned to ΣA but not to ΣB, the trends of measurement functions for ΣB appear at the top or bottom of the screen.

Harmonic order (Order, option)

When you select a function that has harmonic data, you can set the displayed harmonic order within the following range.
Total (Total value) or 0 (DC) to 500

The harmonic orders that can be specified vary depending on the measurement function. For details, see "Harmonic Measurement Function Orders."

▶ Click here.

The trends of orders that exceed the maximum measurable order are displayed at the top or bottom of the screen. For information about the maximum measurable harmonic order, see "Maximum harmonic order to be measured (Max Order)."

▶ Click here.

- Trends for which there is no corresponding numeric data are displayed at the top or bottom of the screen.
- If you choose to display the trend of a user-defined event (Ev1 to Ev8), the trend display shows 1 when the user-defined event is occurring (True) and 0 when it is not occurring (False).

Trend display scale

Setting the vertical scale (Scaling)

You can set the upper and lower limits of a trend window. Set the setup mode to one of the following options.

- Auto: Auto scaling is enabled. The upper and lower limits of the bar graph window are automatically determined based on the maximum and minimum displayed trend data values.
- Manual: Manual scaling is enabled. You can set the upper and lower limits manually.

Upper and lower limits for manual scaling (Upper Scale and Lower Scale)

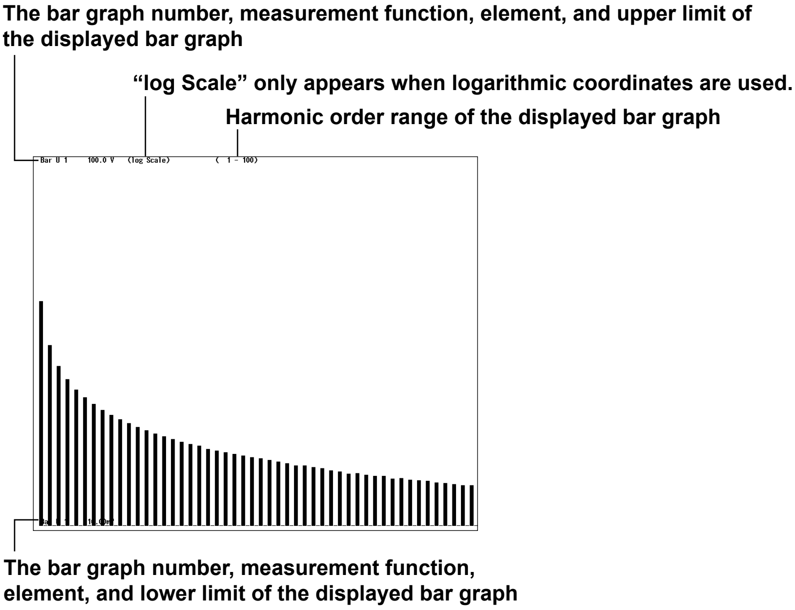
You can set in the range of –9.999T to 9.999T.

12 Bar Graph Display (Option)

Bar graph display (OTHERS(Bar))

On models with the harmonic measurement option or the simultaneous dual harmonic measurement option, you can display harmonics using bar graphs. The harmonic orders are lined up on the horizontal axis, and the vertical axis represents the amplitude of each harmonic.
You can configure three different bar graphs.

Example of bar graph display



- When logarithmic coordinates are used (Log Scale), if a value is negative, its absolute value is displayed with a red bar graph.
- If the analysis window width (number of cycles of the fundamental signal) that is determined by the fundamental frequency is shorter than the data update interval, bar graphs are not displayed. Set a longer data update interval. For details, see “Notes about the numeric data display.”
  ▶ Click here.
- The bar graphs of harmonic orders that exceed the maximum measurable order are not displayed.
  For information about the maximum measurable harmonic order, see “Maximum harmonic order to be measured (Max Order).”
  ▶ Click here.

Display format (FORM)

Number of bar graph display windows (Format)

You can choose the number of windows from the following options:
- Single: No windows. The data of bar graph (Item No.) 1 is displayed.
- Dual: Two windows. The data of bar graphs (Item No.) 1 and 2 is displayed.
- Triad: Three windows. The data of bar graphs (Item No.) 1 to 3 is displayed.

Bar graph display range (Start Order/End Order)

- You can set the range of harmonic orders to show in a bar graph.
- The range is the same for bar graphs 1 to 3.

Starting harmonic order (Start Order)

- You can set the value in the range of 0 to 490. However, the starting harmonic order cannot be more than –10 orders less than the ending order.
- When the measurement function of a bar graph is Φ, order 0 has no values, so you cannot display it in the bar graph.
- When the measurement function of a bar graph is ΦU or ΦI, orders 0 and 1 have no values, so you cannot display them in the bar graph.

Ending harmonic order (End Order)

You can set the value in the range of 10 to 500. However, the ending harmonic order cannot be more than 10 orders greater than the starting order. You cannot display bar graphs containing harmonic orders that are greater than the maximum measurable order (see section 6.6 in the Getting Started Guide, IM WT1801R-03EN).

Display items (ITEM)

Bar graph number (Item No.)

Select the bar graph you want to edit from 1 to 3.

Function (Function)

You can select the measurement function to display from the following options.
U, I, P, S, Q, λ, Φ, ΦU, ΦI, Z, Rs, Xs, Rp, Xp

Element (Element)

You can select the element from the following options. The available options vary depending on the installed elements.
Element1, Element2, Element3, Element4, Element5, Element6

Bar graph display scale

Setting the vertical scale mode (Scale Mode)

You can set the upper and lower limits of a bar graph window. Set the setup mode to one of the following options.

- Fixed
  - When the function (Function) is U, I, P, S, or Q, the scaling is logarithmic (Log).
  - When the function is λ, Φ, ΦU, ΦI, Z, Rs, Xs, Rp, or Xp, the scaling is linear (Linear).
  - The upper and lower limits of the bar graph window are automatically determined based on the maximum and minimum displayed trend data values. The lower and upper limits for λ are −1 and 1. For Φ, ΦU, and ΦI, the minimum and maximum values are –180 to 180°. Negative values correspond to phase lagging and positive values to phase leading.
- Manual
  Manual scaling is enabled. You can set the type, upper limit, and X-axis position of the vertical scale.

Vertical scale type (Vertical Scale)

This setting is valid when the vertical scale mode is set to Manual. Select linear (Linear) or log (Log).

Upper limit (Upper Scale)

This setting is valid when the vertical scale mode is set to Manual. You can set a value in the range of 0 to 9.999T.

X-axis position (X Axis Position)

This setting is valid when you set the vertical scale mode to Manual and the vertical scale type to Linear. You can set the point at which the Y-axis coordinate is 0 to Bottom (the bottom of the screen) or Center (the center of the screen).

13 Vector display (Option)

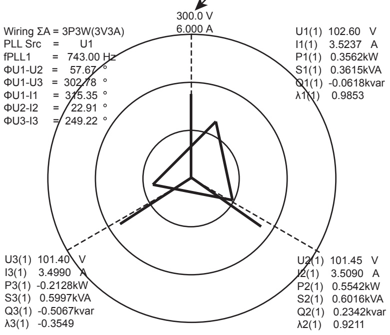
Vector display (OTHERS(Vector))

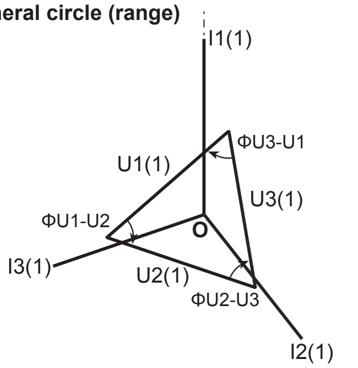
On models with the harmonic measurement option or the simultaneous dual harmonic measurement option, you can select a wiring unit to display vectors of the phase differences and amplitudes (rms values) of the fundamental signals, U(1) and I(1), in each element in the unit. The positive vertical axis is set to zero (angle zero), and the vector of each input signal is displayed.

Example of vector display

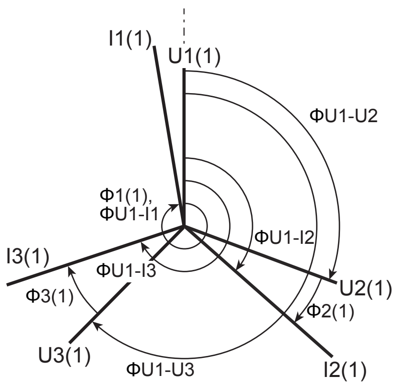
For a 3P3W system with a three-voltage, three-current method
- **U1(1), U2(1), and U3(1) are line voltages.**
- **I1(1), I2(1), and I3(1) are line currents.**

Size of the peripheral circle (range)



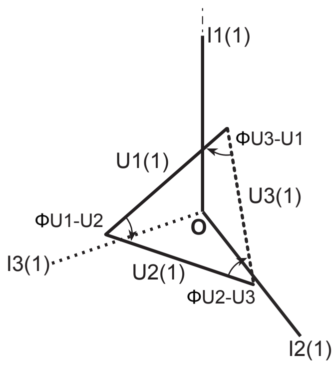


For a 3P4W (three-phase, four-wire system)
- **U1(1), U2(1), and U3(1) are line voltages.**
- **I1(1), I2(1), and I3(1) are line currents.**



For a 3P3W (three-phase, three-wire system)
- **U1(1), U2(1), and U3(1) are line voltages.**
- **I1(1), I2(1), and I3(1) are line c urrents.**

However, U3(1) and I3(1) are not actually measured for the 3P3W system. The vectors are displayed through computation.



If the analysis window width (number of cycles of the fundamental signal) that is determined by the fundamental frequency is shorter than the data update interval, vectors are not displayed. Set a longer data update interval. For details, see "Notes about the numeric data display."

▶ Click here.

Display format (FORM)

Number of vector display windows (Format)

You can choose the number of windows from the following options:

- Single: No windows. The data of vector (Item No.) 1 is displayed.
- Dual: Two windows. The data of vectors (Item No.) 1 and 2 is displayed. However, in the split display, the data of vector 1 is displayed.

Turning the display of numeric data on and off (Numeric)

Select whether to show numeric data (on or off). You can display the size of each signal and the phase differences between signals. For the phase difference display formats, see “Phase difference display formats.”

▶ Click here.

Display items (ITEM)

Vector number (Item No.)

Select the vector you want to set: 1 or 2.

Element and wiring unit (Object)

Select the element or wiring unit to display from the following options. The available options vary depending on the installed elements.

Element1, Element2, Element3, Element4, Element5, Element6, ΣA, ΣB, ΣC

Vector zoom (U Mag/I Mag)

You can change the size of vectors. You can specify separate zoom factors for the fundamental waves U(1) and I(1). When you zoom a vector, the value for the size of the peripheral circle of the vector changes according to the zoom factor.

Setting the zoom factor of the vector of fundamental waveform U(1) (U Mag)

You can set the zoom factor in the range of 0.100 and 100.000.

Setting the zoom factor of the vector of fundamental waveform I(1) (I Mag)

You can set the zoom factor in the range of 0.100 and 100.000.

If the zoom factor is too large, the vector will exceed the display range and will not be displayed properly. Reduce the zoom factor so that the vector is displayed within the display range.

14 Split Display

Split display (OTHERS)

You can split the screen into top and bottom halves and select a display to show in each half. You can select the following items.

- Split display with the numeric display (Numeric+***)
- Split display with the waveform display (Wave+***)
- Split display with the trend display (Trend+***)

Split display with the numeric display (Numeric+***)

Numeric data is displayed in the top half of the screen. Select the display to show in the bottom half of the screen from the following options.

- Wave: Waveform
- Trend: Trend
- Bar: Bar graph*
- Vector: Vector*

* Available on models with the harmonic measurement option or simultaneous dual harmonic measurement option

Split display with the waveform display (Wave+***)

Waveforms are displayed in the top half of the screen. Select the display to show in the bottom half of the screen from the following options.

- Numeric: Numeric data
- Trend: Trend
- Bar: Bar graph*
- Vector: Vector*

* Available on models with the harmonic measurement option or simultaneous dual harmonic measurement option

Split display with the trend display (Trend+***)

Trends are displayed in the top half of the screen. Select the display to show in the bottom half of the screen from the following options.

- Numeric: Numeric data
- Wave: Waveform
- Bar: Bar graph*
- Vector: Vector*

* Available on models with the harmonic measurement option or simultaneous dual harmonic measurement option

When the setup parameter list is displayed (the INPUT INFO key is lit), it appears in the top half of the screen, and the display that you assigned in the Others menu to the top window in the split display is displayed in the bottom half of the screen.

Split display settings

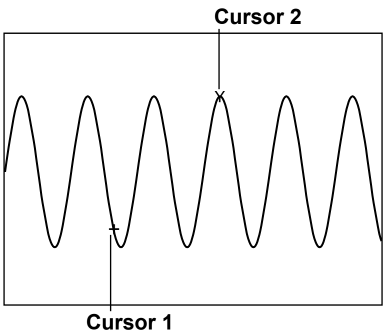
Press FORM to switch between the FORM menus of the display that you assigned to the top half of the screen in the split display and the display that you assigned to the bottom half of the screen in the split display. Likewise, press ITEM to switch between ITEM menus.

15 Cursor Measurement

Cursor measurement (CURSOR)

You can place cursors on displayed waveforms, trends, and bar graphs and display the values at the cursor locations.

Example of cursors in the waveform display



You can specify the following items.

- Turning cursor measurement on and off (Cursor)
- Waveform measured by cursor 1 (+) (C1+ Trace)
- Waveform measured by cursor 2 (x) (C2x Trace)
- Cursor path (Cursor Path)
- Position of cursor 1 (+) (C1+ Position)
- Position of cursor 2 (x) (C2x Position)
- Linking cursor movement (Linkage)

Turning cursor measurement on and off (Cursor)

- ON: Cursor measurement is performed.
- OFF: Cursor measurement is not performed.

Waveform measured by cursor 1 (+) (C1+ Trace)

This item only appears in the waveform and trend displays. It does not appear in the bar graph display.

In the waveform display

You can select the waveform to measure with cursor 1 (+) from the following options. The available options vary depending on the installed elements.

U1, I1, U2, I2, U3, I3, U4, I4, U5, I5, U6, I6, Speed,[1] Torque,[1] Aux1,[2] Aux2[2]

1 Available on models with the motor evaluation function

2 Available on models with the auxiliary input option

In the trend display

You can set the trend to measure with cursor 1 (+) to a trend from T1 to T16.

Waveform measured by cursor 2 (x) (C2x Trace)

You can select the waveform to measure with cursor 2 (x). The options are the same as those for cursor 1 (+) (C1+ Trace).

▶ Click here.

Cursor path (Cursor Path)

Because this instrument uses P-P compression on sampled data, two values (a maximum and a minimum value) are displayed at each time-axis point. You can choose the path that the cursors move through and the data points that are measured by the cursors from the following options.

- Max: Cursors move along and measure the maximum values on the time axis.
- Min: Cursors move along and measure the minimum values on the time axis.
- Mid: Cursors move through the middles of the maximum and minimum values on the time axis, and they measure the values in the middle of the maximum and minimum values.

This item only appears in the waveform display. It does not appear in the trend or bar graph display.

Position of cursor 1 (+) (C1+ Position)

You can set the position of cursor 1 (+) in the following range.

- Waveform display: 0 (the left edge of the screen) to 800 (the right edge of the screen)
- Trend display: 0 (the left edge of the screen) to 1601 (the right edge of the screen)
- Bar graph display: 0 (DC) to 500 (500^{th} harmonic)

Position of cursor 2 (x) (C2x Position)

You can set the position of cursor 2 (x). The ranges within which you can set the position are the same as those for cursor 1 (+) (C1+ Position).

▶ Click here.

Linking cursor movement (Linkage)

Set Linkage to ON to move cursor 1 (+) and cursor 2 (x) without changing the distance between them. Specify C1+Position to set the positions of the cursors.

Measurement items

In the waveform display

Y+	The vertical-axis (Y-axis) value of cursor 1 (+)
Yx	The vertical-axis (Y-axis) value of cursor 2 (x)
ΔY	The difference between the vertical-axis (Y-axis) values of cursor 1 (+) and cursor 2 (x)
X+	The horizontal-axis (X-axis) value of cursor 1 (+)
Xx	The horizontal-axis (X-axis) value of cursor 2 (x)
ΔX	The difference between the horizontal-axis (X-axis) values of cursor 1 (+) and cursor 2 (x)
1/ΔX	The reciprocal of the difference between the horizontal-axis (X-axis) values of cursor 1 (+) and cursor 2 (x)

In the trend display

Y+	The vertical-axis (Y-axis) value of cursor 1 (+)
Yx	The vertical-axis (Y-axis) value of cursor 2 (x)
ΔY	The difference between the vertical-axis (Y-axis) values of cursor 1 (+) and cursor 2 (x)
X+	The horizontal-axis (X-axis) value of cursor 1 (+) With the left edge of the screen being 0 seconds, the time from the left edge of the screen is indicated.
Xx	The horizontal-axis (X-axis) value of cursor 2 (x) With the left edge of the screen being 0 seconds, the time from the left edge of the screen is indicated.
ΔX	The difference between the horizontal-axis (X-axis) values of cursor 1 (+) and cursor 2 (x)
D+	The date and time at the position of cursor 1 (+) The date and time of measurement are displayed in this format: Year/ Month/Day Hour:Minute:Second.
Dx	The date and time at the position of cursor 2 (x) The date and time of measurement are displayed in this format: Year/ Month/Day Hour:Minute:Second.

- If immeasurable data exists, “***” is displayed in the measured value display area.
- ΔY can be measured even when the units of the cursors are different. In such case, the measured result will not have a unit.

In the bar graph display

Y1+	The vertical-axis (Y-axis) value of cursor 1 (+) of bar graph 1
Y1x	The vertical-axis (Y-axis) value of cursor 2 (x) of bar graph 1
ΔY1	The difference between the vertical-axis (Y-axis) values of cursor 1 (+) and cursor 2 (x) of bar graph 1
Y2+	The vertical-axis (Y-axis) value of cursor 1 (+) of bar graph 2
Y2x	The vertical-axis (Y-axis) value of cursor 2 (x) of bar graph 2
ΔY2	The difference between the vertical-axis (Y-axis) values of cursor 1 (+) and cursor 2 (x) of bar graph 2
Y3+	The vertical-axis (Y-axis) value of cursor 1 (+) of bar graph 3
Y3x	The vertical-axis (Y-axis) value of cursor 2 (x) of bar graph 3
ΔY3	The difference between the vertical-axis (Y-axis) values of cursor 1 (+) and cursor 2 (x) of bar graph 3

Cursor movement

In the waveform display

- Cursors move along the selected waveform.
- The unit of cursor movement is the amount of time contained in one screen ÷ 800.

- If immeasurable data exists, "***" is displayed in the measured value display area.
- ΔY can be measured even when the units of the cursors are different. In such case, the measured result will not have a unit.
- The range of the vertical axis that can be measured using cursors is within ±300 % when the crest factor is set to CF3 and within ±600 % when the crest factor is set to CF6 or CF6A.

In the trend display

- Cursors move along the selected trend.
- You can set the cursor position relative to the left edge of the screen in points by assuming the left edge to be 0 points and the right edge 1601 points.
- You can move through the displayed data one point at a time.

In the bar graph display

- Two cursors (+ and x) are displayed in each graph (bar graph 1 to bar graph 3).
- You can set the cursor positions in terms of harmonics.
- On the bar graph, harmonics are displayed indicating the cursor positions.
  - The position of cursor 1 (+) is indicated in this format: "Order+:2."
  - The position of cursor 2 (x) is indicated in this format: "Orderx:55."
- The harmonics indicating the positions of cursors 1 (+) and 2 (x) are the same for all bar graphs: bar graph 1 to bar graph 3.

If immeasurable data exists, "***" is displayed in the measured value display area.

16 High Speed Data Capturing

High speed data capturing (OTHERS(High Speed Data Capturing))

This instrument can measure every 5 ms and save the measurement data to a file. This instrument can also synchronize with other instruments and make measurements when an external sync signal is applied to the external start signal I/O (MEAS START) terminal.
High speed data capturing takes advantage of the fact that in a balanced three-phase circuit, the instantaneous values of the three phases of the rms voltage (UrmsΣ), the rms current (IrmsΣ), and the power (PΣ) add up to a direct current. For a three-phase three-wire system or three-phase four-wire system, this instrument can measure the rms voltage (UrmsΣ), the rms current (IrmsΣ), and the power (PΣ) with fast response. In an unbalanced three-phase circuit, the measured values will wobble. This indicates that the instantaneous power consumed by the load is fluctuating.
When the measured values wobble, you can stabilize the measured voltage (U), current (I), and power (P) values for each element and the measured UmeanΣ, ImeanΣ, Ur-meanΣ, and Ir-meanΣ values for each wiring unit by setting a low cutoff frequency for the HS filter. However, if the cutoff frequency of the HS filter is set low, the response to changes in measured values will be slower.

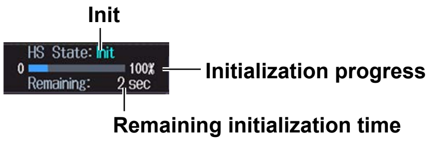
Display indicators for high speed data capturing

High speed data capturing state

- **Ready**
  - "Ready" is displayed when high speed data capturing has been reset and is ready to start high speed data capturing.
  - When the number of data captures is set to a value other than Infinite, the number of data captures appears to the right of Count.

- **Start**
  - "Start" is displayed when high speed data capturing is running.
  - The number of data captures that have been performed is displayed to the right of "Captured."

- **Init (Initialize)**
  - “Init” is displayed when high speed data capturing is being initialized.
  - A bar graph appears indicating the initialization progress.
  - Remaining initialization time is displayed to the right of Remaining.



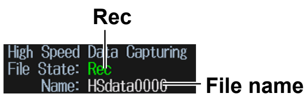
* Initialization takes place when high speed data capturing mode is enabled or when high speed data capturing conditions are changed.
If the initialization time is short, the indicator may not be visible.

File recording state

This indicator appears when you set Record to File to ON.

- **Ready**
  - “Ready” is displayed when file recording is possible and is ready to start high speed data capturing.
  - “Ready” is displayed when high speed data capturing stops and all file recording processing is complete.

- **Rec(Record)**
  - “Rec” is displayed when file recording is running and writing is taking place regularly.
  - The name of the file that is being recorded to appears to the right of “Name.”



- **Stop**
  “Stop” is displayed when file recording is complete and file recording stops.

- **Error**
  - “Error” is displayed when a write error occurs during file recording and file recording stops.
  - The measurement operation of high speed data capturing continues without stopping.

High speed data capturing initialization

- High speed data capturing is initialized when:
  - A change is made from normal measurement to high speed data capturing.
  - When any of the following settings is changed.
    - Voltage/current measurement mode
    - HS filteron/off state
    - HS filter’s cutoff frequency
    - Trigger
    - Fundamental measurement conditions such as the measurement range and wiring system
- The time required for initialization is indicated below. For example, when the cutoff frequency is 1 Hz, the time required is approximately 2.7 s.

$$\frac{2.7}{\text{HS filter's cutoff frequency}}\ [\text{s}]$$

However, if the value of the above formula is less than 250 ms, the time required is 250 ms.

Measurement functions

For the symbols and definitions of the measurement functions that you can measure using high speed data capturing, see "High speed data capturing measurement functions" under "Items That This Instrument Can Measure."

▶ Click here.

Data capture interval

The data capture interval depends on the External Sync setting as follows:

- When External Sync is off: 5 ms
- When External Sync is on: Depends on the external sync signal received through the external start signal I/O (MEAS START) terminal. Synchronizable intervals are 1 ms to 100 ms.

Display update interval

The display update interval is approximately 1 s.

Numeric data display

The numeric data is displayed for each measurement function that was last measured within the display update interval.

You cannot make individual changes to the displayed measurement functions. Use the PAGE UP and PAGE DOWN keys to change the display.

The number of displayed pages varies according to the installed options as follows:

Motor evaluation function	Auxiliary input	Number of pages
Not installed	Not installed	2 pages
Installed	Not installed	4 pages
Not installed	Installed	4 pages

- For U or I, if the measured value exceeds 300 %, an overload indication "–OL–" appears. When you are measuring with the highest measurement range, if the measured value exceeds 140 %, an overload indication "–OL–" appears.
- For P, if either U or I is overloaded, an overload indication "–OL–" appears.
- UΣ, if the measured voltage of any input elements assigned to the same wiring unit is overloaded, an overload indication "–OL–" appears. The same holds true for IΣ and PΣ.
- When rounding to zero is on, UΣ and IΣ are displayed as zero when the following conditions are met in relation to the maximum voltage and current ranges in the input elements assigned to the same wiring unit.
  - When the crest factor is set to CF3
    Urms or Irms is 0.3 % or less. Umn, Urmn, Imn, or Irmn is 2 % or less.
  - When the crest factor is set to CF6 or CF6A
    Urms or Irms is 0.6 % or less. Umn, Urmn, Imn, or Irmn is 4 % or less.

Basic measurement conditions

The fundamental measurement conditions of high speed data capturing are the same as those of normal measurement.

However, the following limitations apply to the wiring system and line filter.

Wiring system during high speed data capturing

- When the wiring system is set to any of the following settings, you can measure the voltage (U), current (I), and power (P).
  - 1P2W: Single-phase two-wire system (DC input)
  - 3P4W: Three-phase four-wire system
  - 3P3W(3V3A): Three-voltage three-current method

- When the wiring system is set to any of the following settings, the voltage (UΣ), current (IΣ), and power (PΣ) for the wiring unit are not measured and are displayed as "-------" (no data). An error message will appear when you set the wiring system or run high speed data capturing.
  - 1P3W: Single-phase three-wire system
  - 3P3W: Three-phase three-wire system

Line filter during high speed data capturing

- You can also set a line filter for high speed data capturing. This setting is not shared with normal measurement. Even if you change the line filter setting during high speed data capturing, the line filter setting for normal measurement will remain unchanged.
- The line filter is always on in high speed data capturing mode. You cannot turn it off. The LINE FILTER key and the Line Filter indicator light at the top of the screen.
- Set the cutoff frequency in the following range. In normal measurement, you can select 1 MHz, but this is not possible in high speed data capturing.
  0.1 kHz to 100.0 kHz (0.1 kHz steps), 300 kHz

Limitations on modifying the settings during high speed data capturing

During high speed data capturing, there are some settings that cannot be changed and functions that cannot be executed. For details, see appendix 9.

High speed data capturing (HS) settings (FORM)

The following high speed data capturing (HS) settings are available.

- Number of data captures (Capture Count)
- Viewing and optimizing the maximum capturing count (Optimize Count)
- Capture control settings (Control Settings)
- Recording to a file (Record to File)
- Starting and stopping high speed data capturing (Start/Stop)

Number of data captures (Capture Count)

The timeout value can be set to Infinite or in the range of 1 to 10000000.

Viewing and optimizing the maximum capturing count (Optimize Count)

- This instrument calculates the maximum capturing count for the save destination of the captured data file from the number of numeric data items specified in Item Settings.
- You can change the capturing count in the range of 0 to the calculated maximum capturing count.
- You can select Set to set the capturing count to the maximum capturing count. This does not work when the count is 0.
- This feature does not work when Record to File is set to OFF.

- If you enable automatic CSV conversion (Auto CSV Conversion) and set the storage destination for the high speed data capturing files to internal memory or a USB memory device, the maximum capturing count is calculated by assuming approximately 20 % of the available internal memory or USB memory to be valid for storing the high speed data capturing files (*.WTS and *.HDS files).
- If the maximum capturing count is displayed as 0, the save destination device for the high speed data capturing file does not have enough free space. Make more space available, by deleting files or by other means.
- If you change the number of numeric data items specified in Item Settings after you set the number of data captures, you will need to set the number of data captures again as the maximum capturing count will change.

Capture control settings (Control Settings)

Voltage and current measurement modes (U/I Measuring Mode)

Select the mode for measuring voltage and current.

Setting

Select the method for setting the voltage and current measurement modes from the following options.

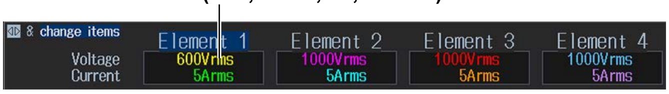
- Each: Set the mode separately for the voltage and current of each input element.
- All: Set the mode for the voltages and currents of all installed input elements at the same time.

U1 to I6

Select the voltage and current measurement modes from the following options.
rms, mean, dc, r-mean

For details on how the voltage and current values are determined in each measurement mode, see appendix 1.

Voltage/current measurement mode
(rms, mean, dc, r-mean)



If the voltage and current measurement mode settings differ for elements assigned to the same wiring unit, the voltage (UΣ) and current (IΣ) of the wiring unit are not measured and are displayed as “-------” (no data).

HS filter

Turning on the HS (high speed) filter stabilizes the measured values. The HS filter averages the measured values. This is different from the line filter.

Enable or disable the HS filter, and set the cutoff frequency. Set the cutoff frequency in the following range.
1 Hz to 1000 Hz (in 1 Hz steps)

Turning it off disables the HS filter.

You can stabilize the measured voltage (U), current (I), and power (P) values for each element and the measured UmeanΣ, ImeanΣ, Ur-meanΣ, and Ir-meanΣ values for each wiring unit by specifying a low cutoff frequency for the HS filter. However, the response to changes in the measurement data will be slower.

Trigger (Trigger Settings)

The trigger is what starts high speed data capturing. "Triggering" occurs when the trigger condition is satisfied and high speed data capturing is executed.

All the trigger settings for high speed data capturing are shared with those for displaying waveforms. If you change these settings in the high speed data capturing menu, the waveform display trigger settings will also change. For example, if you set the trigger mode to OFF in the high speed data capturing menu, the trigger mode for waveform display will also be set to OFF.

Trigger mode (Mode)

This setting is the same as the waveform display trigger mode setting.

▶ Click here.

Trigger Source (Source)

This setting is the same as the waveform display trigger source setting.

▶ Click here.

Trigger slope (Slope)

This setting is the same as the waveform display trigger slope setting.

▶ Click here.

Trigger level (Level)

This setting is the same as the waveform display trigger level setting.

▶ Click here.

External sync (External Sync)

This instrument can synchronize with other instruments and make measurements when an external sync signal is applied to the external start signal I/O (MEAS START) terminal.

- OFF: This instrument does not synchronize with an external start signal but instead captures data every 5 ms.
- ON: This instrument captures data in sync with an external start signal.

For the specifications of the external start signal input/output terminals, see section 3.4 in the Getting Started Guide, IM WT1801R-03EN.

- When External Sync is set to ON, the trigger settings are invalid. The trigger feature operates as if the trigger mode was set to OFF.
- To measure in sync with an external signal, set External Sync to ON and apply a number of pulses equal to or greater than the specified number of data captures + 1 to the external start signal I/O (MEAS START) terminal.
- To synchronize multiple instruments and perform high speed data capturing, synchronize the instrument on which External Sync has been set to ON to the instrument on which External Sync has been set to OFF. When you synchronize these instruments, make sure that they are set to the same number of data captures.

Recording to a file (Record to File)

- If you set Record to File to ON, when high speed data capturing starts, this instrument saves the following two files in binary format.
  - High speed data capturing data file (.WTS): The measured data is saved to this file.
  - High speed data capturing header file (.HDS): The measurement conditions, settings, and recording information are saved to this file.
- File name extensions are added automatically.
- The file recording state (File State) appears in the upper left of the screen. The file recording state is indicated as "Ready," "Rec," "Stop," or "Error," depending on the state of high speed data capturing.
- If you set the save destination to internal memory or a USB memory device, a high speed data capturing data file (.WTS) can contain up to 1 GB of data or 10000000 data captures.
- This instrument cannot load measurement data that has been recorded on a file.

- Recording to a file stops and the file recording status is set to Stop in the following cases. The measurement operation of high speed data capturing continues without stopping.
  - The memory space to store files is running low.
  - The high speed data capturing data file size exceeds the maximum value (1 GB).
  - High speed data capturing is performed 10000000 times.
- Do not output captured data through communication and record it to a file at the same time. Recording to file may stop and file recording status may change to error due to slow communication output speed or slow recording speed.
- In the following cases, the data update rate may exceed the rate at which data is recorded to file, recording to file may stop, and the file recording status may change to error.
  - When you perform consecutive operations in the setup menu.
  - When this instrument receives consecutive communication commands.
  - When you operate this instrument over FTP.
  - When you save to a USB memory device with a slow write speed.
- If the write speed of the destination USB memory device is slow and the data update rate exceeds the speed of recording to file, recording to file may stop. This may be avoided by the following methods.
  - Reduce the number of items that are being saved.
  - Use a faster USB memory device.
- If it takes a long time to write to a USB memory device, recording to file may be forced to end and data may not be saved. When this happens, the file recording state is indicated as "Error."
- Conversion to ASCII format (.csv) uses a pair of files that consists of a high speed data capturing data file (.wts) and a high speed data capturing header file (.hds) with the same name. Do not change the names of stored high speed data capturing data (.wts) and header (.hds) files of different sets of data to the same name. If you do so, this instrument may malfunction and internal memory or USB memory device may be damaged when you convert the data to ASCII format (.csv).
- If the USB memory device is unplugged during file recording or the file recording status becomes Error, the data created by high speed data capturing may be corrupted. In such cases, conversion to ASCII format (.csv) is not possible. Be sure to unplug the USB memory device when file recording is in the Ready state.
- When you turn off this instrument, the contents of the internal RAM disk are lost. Save the contents of the RAM disk to internal memory or a USB memory device or network drive before you turn off this instrument.
- Note that there is a limitation on the number of times data can be written to the internal memory or USB memory device.

Same conditions (File Settings)

File list display and save destination settings (File List)

By setting CSV Path Selection Mode to ON, you can set separate save destinations for binary data and CSV files. For how to configure the file list display and how to operate files and folders, see “File operations (Utility).”

▶ Click here.

If the storage device (drive) is set to a USB memory device and the device is unplugged, the storage device will automatically switch to the internal memory.

Automatic CSV conversion (Auto CSV Conversion)

You can choose whether to automatically create an ASCII format high speed data capturing file (.csv) from the high speed data capturing data file (.wts) and the high speed data capturing header file (.hds) that are saved when high speed data capturing stops. You can save the ASCII format high speed data capturing file (.csv) to a separate folder from the high speed data capturing data file (.wts) and the high speed data capturing header file (.hds).

CSV Path Selection Mode

When CSV Path Selection Mode is OFF (this instrument functions identically to the WT1800 and WT1800E)

- When the WTS and HDS file save destination is the internal RAM disk ([RAM-0])
  CSV files are created in the root folder of the USB memory device ([USB-0]). If a USB memory device is not available, CSV files will not be created.
- When the WTS and HDS file save destination is not the internal RAM disk ([RAM-0])*
  CSV files are created in the same folder as the WTS and HDS file save destination.
  * WTS and HDS files cannot be saved to a network drive.

When CSV Path Selection Mode is ON

- CSV files are created in the save destination specified with the File List (conversion CSV) menu.

If the size of the created CSV file exceeds 2 GB, a CSV file will be created for the captured data up to 2 GB.

Saved items (Item Settings)

Select whether to store a numeric data item by selecting or clearing its check box.

Items for which there is no measurement data are displayed as “-------” (no data), and no data is saved for them.

Automatic file naming (Auto Naming)

This is the same as the auto naming feature for saving and loading data.

▶ Click here.

File name (File Name)

This is the same as the file name setting for saving and loading data.

▶ Click here.

Comment (Comment)

This is the same as the file name setting for saving and loading comments.

▶ Click here.

Manually converting to CSV format (CSV Convert)

You can convert the selected high speed data capturing data file to ASCII format (.csv). This menu item appears when you press the File List soft key to display the file list.

Starting and stopping high speed data capturing (Start/Stop)

Starting high speed data capturing (Start)

- High speed data capturing starts.
- When high speed data capturing starts, the following operations are performed.
  - If the trigger mode is set to OFF, data is captured.
  - If the trigger mode is set to Auto or Normal, this instrument waits for a trigger to occur. When a trigger occurs, data is captured.
  - “HS State: Start” appears in the upper right of the screen.
  - When file recording is on, high speed data capturing data (.wts) and header (.hds) files are created. “File State: Rec” and the file name appear in the upper left of the screen.

While “File State: Rec” is displayed, the icon indicating that the storage device is being accessed is not displayed, but the device is constantly accessed. Do not unplug the USB memory device or turn the power off. Doing so may damage the storage device or corrupt the data.

High speed data capturing stop (Stop)

- High speed data capturing stops.
- When high speed data capturing stops, the following operations are performed.
  - “HS State: Ready” appears in the upper right of the screen.
  - When file recording is on, writing to the high speed data capturing data (.wts) and header (.hds) files ends, and the files are closed. “File State: Ready” appears in the upper left of the screen.
  - When file recording is on and automatic CSV conversion is on, a high speed data capturing file (.CSV) is created in ASCII format.

Automatic stopping of high speed data capturing

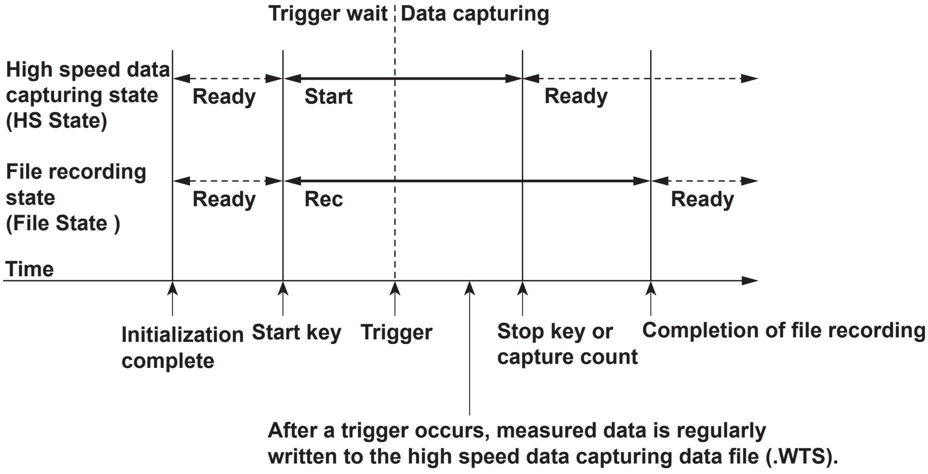
- High speed data capturing stops automatically when the specified number of high speed data captures have been made.
- The same operations are performed as when high speed data capturing is stopped manually.

High speed data capturing stops automatically when External Sync is on and the following conditions are met for the external start signal applied to this instrument.

- The external start signal is not applied for 1 s or longer.
- The period of the external start signal is less than 1 ms.

High speed data capturing operation

Example when the trigger mode is set to Auto or Normal



Display items (ITEM)

Number of Columns (Column Num)

Set the number of columns to 4 or 6.

Column number (Column No.)

Select the number of the column that you want to edit.

Element (Element/Σ)

This is the same as the element (Element/Σ) item of the Matrix display.

▶ Click here.

Selecting elements directly (ELEMENT)

This is the same as selecting elements directly in the 4-, 8-, and 16-value displays.

▶ Click here.

Resetting the settings (Reset Items Exec)

You can reset columns settings.

Turning the display frame on and off (Display Frame)

This is the same as turning the display frame on and off in the 4-, 8-, and 16-value displays.

▶ Click here.

Displaying peak over-range occurrence information (Display Peak Over Status)

You can select whether to show (ON) or hide (OFF) peak over-range occurrence information.

Peak over-range occurrence information (Peak Over Status)

- If a peak over-range occurs in an input signal even once while high speed data capturing is running, the input signal is displayed in red.

  Example when a peak over-range occurs in U1 and U2

- When display frames for measured values are displayed, display frames of measured values within which a peak over-range has occurred are displayed in red.
- Even if you stop high speed data capturing, the peak over-range occurrence information does not disappear. The peak over-range occurrence information will disappear (will be reset) when you restart high speed data capturing or change the settings.

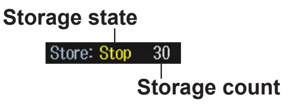
The input peak over-range indicator in the center of the top section of the screen lights in red only while a peak over-range is occurring.

17 Data Storage

You can store numeric data in binary format to the internal RAM disk, internal memory, or a USB memory device. You can store the data at the data update interval or at a specified time 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). You can convert stored binary data to ASCII (.csv) format. You can analyze the converted data on a PC. You cannot use this instrument to recall stored data.

Storage indications

When the storage state is any state other than that of being reset, the storage state and store count appear in the upper left of the screen.



Start

Storage in progress.

Stop

Storage stopped.

Ready

The storage mode is real-time storage mode, integration-synchronized storage mode, or event-synchronized storage mode, and this instrument is ready to begin storing.

Cmpl (Complete)

- This instrument has completed the specified number of storage operations.
- This instrument is in real-time storage mode and the scheduled storage stop time has passed.

When storage is reset, no storage state is displayed in the upper left of the screen.

Limitations on changing the settings during storage

While data is being stored, there are some settings that you cannot change and functions that you cannot execute. For details, see appendix 9.

Storage conditions (STORE SET)

The following storage configuration menus are available.

- Storage control (Control Settings)
- Stored items (Item Settings)
- Same conditions (File Settings)

Storage control (Control Settings)

Store mode (Store Mode)

You can choose any of the following methods for starting and stopping storage.

- **Manual (manual storage mode)**
  When press STORE START, numeric data is stored at the storage interval for the number of times specified by the storage count.

- **Real Time (real-time storage mode)**
  Storage starts after you press STORE START and the scheduled storage start time arrives. You can store numeric data at the storage interval until the storage stop time (or just the storage count) arrives.

- **Integ Sync (integration-synchronized storage mode)**
  - Storage starts after you press STORE START and integration starts. You can store numeric data at the storage interval until integration stops (or just until the storage count is reached).
  - Storage continues even when integration is reset by the integration timer. When the integration timer is reset, the storage interval timer is also reset.

- When independent integration is enabled or the data update interval is Auto, storage cannot be performed in integration-synchronized storage mode.
- When the data update interval is Auto and storage interval is not 00:00:00, storage cannot be performed.

- **Event (event-synchronized storage mode)**
  Storage starts after you press STORE START, the measured data is updated, and a user-defined event occurs. You can store numeric data each time the measured data is updated until the storage count is reached.

- **Single Shot (single-shot storage mode)**
  Numeric data is stored whenever you press STORE START. You can store numeric data until the storage count is reached.

Storage count (Count)

- The timeout value can be set to Infinite or in the range of 1 to 9999999.
- When the storage count is set to infinity, it is set to 9999999.
- Storage will stop before the specified storage count if the storage destination runs out of available memory or the stored data size exceeds the maximum value (1 GB).

Viewing and optimizing the maximum storage count (Optimize Count)

- This instrument calculates the maximum storage count for the storage destination according to the number of data types specified in the Item Settings.
- You can change the storage count to a value from 0 to the calculated maximum storage count.
- You can select Set to set the maximum storage count to the current storage count. This does not work when the count is 0.

- If you enable automatic CSV conversion (Auto CSV Conversion) and set the storage destination for the storage data to internal memory or a USB memory device, the maximum storage count is calculated by assuming 20 % of the available internal memory or USB memory to be valid for storing the storage data (*.WTS and *.HDS files).
- If the maximum storage count is displayed as 0, there is not enough available space in the storage device. Make more space available, by deleting files or by other means.
- If you change the number of stored items specified in Item Settings after you set the storage count, you will need to set the storage count again as the maximum storage count will change.

Storage interval (Interval)

You can set the interval at which numeric data is stored.

- You can set the value in hours:minutes:seconds format in the following range. If you set the interval to 00:00:00, the numeric data will be stored at the numeric data update interval.
  00:00:00 to 99:59:59
- When the storage mode is set to Integ Sync, storage continues even when integration is reset by the integration timer. When the integration timer is reset, the storage interval timer is also reset.
- This mode is invalid when the storage mode is set to Event or Single Shot.
- When the data update interval is Auto, the interval is set to 50 ms.
- 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.

▶ Click here.

Scheduled times for real-time storage mode (Real Time Control)

These settings are only valid when the storage mode is set to Real Time. You can set the year, month, day, hour, minute, and second of the storage start and stop times. Be sure to set the storage stop time to a time after the storage start time. You can set the values within the following ranges.

- Year: Four-digit Gregorian year
- Hour:Minute:Second: 00:00:00 to 23:59:59
- Now: The scheduled storage start time is set to the current time.
- Copy: The scheduled storage start time is copied into the scheduled storage stop time.

- In the scheduled time settings, February can be set up to 31 days. If you do so, an error message will appear when you start storage. Set the scheduled times appropriately.
- This instrument recognizes leap years when it executes the storage operation.

Trigger event for event-synchronized storage mode (Trigger Event)

These settings are only valid when the storage mode is set to Event. You can select the user-defined event whose occurrence will cause storage to start. If you select a disabled user-defined event, storage cannot start. For configuring user-defined events, see “User-Defined Events.”

▶ Click here.

Storage of the Numeric Data at Store Start (Store At Start)

- Select whether to store the numeric data at store start.
- You can configure this setting when:
  - The storage mode is set to Manual, and the storage interval is not 00:00:00.
  - The storage mode is set to Real Time control, and the storage interval is not 00:00:00.
  - When the Storage Mode is Integ Sync.

Stored items (Item Settings)

You can set which numeric data items to store. You can choose to store the displayed numeric items (Displayed Numeric Items) or the selected items (Selected Items).

Displayed numeric items (Displayed Numeric Items)

The numeric data items displayed on the screen are stored. The stored items vary as indicated below depending on the display.

- When numeric values are displayed in the 4-, 8-, or 16-value display or the matrix display
  All the measurement functions on the page that is displayed when storage starts are saved in the order that they are displayed.
- When numeric values are displayed in the single or dual harmonics list
  In addition to the data described above, the data of harmonics that are not displayed on the screen is stored up to the maximum measurable order (Max Order).
- When numeric values are displayed in the all items or custom display
  Items cannot be stored. If you attempt to store, an error message will be displayed.
- In non-numeric displays (e.g., waveform display, trend display)
  Items are stored based on the numeric display settings. For example, when the waveform display is shown, if the 16-value display would appear when you were to press NUMERIC, then the data for the measurement functions on the page of the 16-value display that would appear is stored.

Even if the display format or display items of numeric data are changed while storage is in progress, items will be stored based on the numeric data display settings that were in effect at the start of storage.

Selected items (Selected Items)

You can select the types of numeric data to store. To select which types of numeric data to store, use items (Items).

Items (Items)

If you set the numeric data items to store to Selected Items, you can select which numeric data to store.

Element (Element)

To select an element or wiring unit that you want to store the data of, select or clear its check box. You can select from the following options.
Element1, Element2, Element3, Element4, Element5, Element6, ΣA, ΣB, ΣC

Function (Function)

Select whether to store the data by selecting or clearing its check box. You can select any of the measurement function types listed under “Items That This Instrument Can Measure.”

▶ Click here.

* When the data update interval is set to Auto, the following data update status information is saved automatically.
- UpdateStsPwr: Input element data update status for normal measurement
  This is saved automatically.
- UpdateStsMtr: Motor evaluation data update status for normal measurement
  This is saved automatically on models with the motor evaluation function (option).
- UpdateStsAux: Auxiliary signal input data update status for normal measurement
  This is saved automatically on models with the auxiliary input option.
- UpdateStsHrm: Input element data update status for harmonic measurement
  This is saved automatically on models with the harmonic measurement option or the simultaneous dual harmonic measurement option.

Selecting all functions (All ON)
The data of all measurement functions is stored.

Deselecting all functions (All OFF)
Data is not stored for all measurement functions.

Preset 1 (Preset 1)
The data of the following measurement functions is stored for all elements and wiring units.*
Urms, Irms, FreqU, FreqI, P, S, Q, λ, Φ

Preset 2 (Preset 2)
The data of the following measurement functions is stored for all elements and wiring units.*
WP, WP+, WP–, q, q+, q–, Time, WS, WQ

* If the wiring system setting (Wiring) is configured so that a wiring unit does not exist, the data for the functions of that wiring unit is not stored. For example, if ΣC does not exist, the data for ΣC is not stored.

Save conditions (File Settings)

- Stored measurement data is saved in binary format to storage data files (.wts).
- Measurement conditions, settings, and storage information are saved in binary format to header files (.hds).
- File name extensions are added automatically.
- When the save destination is set to internal memory or USB memory device, up to 1 GB can be saved.
- Stored data cannot be loaded into this instrument.

▶ Click here.

File list display and save destination settings (File List)

By setting CSV Path Selection Mode to ON, you can set separate save destinations for binary data and CSV files. For how to configure the file list display and how to operate files and folders, see “File operations (Utility).”

▶ Click here.

If the storage device (drive) is set to a USB memory device and the device is unplugged, the storage device will automatically switch to the internal memory.

Automatic CSV conversion (Auto CSV Conversion)

You can choose whether to automatically create an ASCII format storage data file (.csv) from the storage data file (.wts) and the header file (.hds) that are saved when storage finishes or is reset.

When CSV Path Selection Mode is OFF (this instrument functions identically to the WT1800 and WT1800E)

- When the WTS and HDS file save destination is the internal RAM disk ([RAM-0])
  CSV files are created in the root folder of the USB memory device ([USB-0]). If a USB memory device is not available, CSV files will not be created.
- When the WTS and HDS file save destination is not the internal RAM disk ([RAM-0])*
  CSV files are created in the same folder as the WTS and HDS file save destination.
  * WTS and HDS files cannot be saved to a network drive.

When CSV Path Selection Mode is ON

- CSV files are created in the save destination specified with the File List (conversion CSV) menu.

Automatic file naming (Auto Naming)

This is the same as the auto naming feature for saving and loading data.

▶ Click here.

File name (File Name)

This is the same as the file name setting for saving and loading data.

▶ Click here.

Comment (Comment)

This is the same as the file name setting for saving and loading comments.

▶ Click here.

Manually converting to CSV format (CSV Convert)

You can convert the selected stored data to ASCII format (.csv). This menu item appears when you press the File List soft key to display the file list.

- Data storage may fail under the following circumstances. When this happens, an asterisk appears in the storage state indication. The storage count includes the missing stored data.
  - When you perform consecutive operations in the setup menu.
  - When this instrument receives consecutive communication commands.
  - When you operate this instrument over FTP.
- If you choose to store data through USB and the write speed of the connected USB memory device is slow, a new numeric data storage operation may begin before the previous operation is finished, and some of the numeric data may be lost. When this happens, an asterisk appears in the storage state indication. The storage count includes the missing stored data. You can avoid the loss of numeric data during storage by:
  - Setting a longer data update interval.
  - Reducing the number of stored data types.
  - Using a faster USB memory device.
- If it takes a long time to write to a USB memory device, storage may be forced to end and stored data may not be saved. When this happens, the storage state is indicated as “Error.”
- Conversion to ASCII format (.csv) uses a pair of files that consists of a storage data file (.wts) and a header file (.hds) with the same name. Do not change the names of stored numeric data (.wts) and header (.hds) files for different sets of data to the same name. If you do so, this instrument may malfunction and USB memory device may be damaged when you convert the data to ASCII format (.csv).
- If the USB memory device is unplugged while storage is in progress, the stored data may be corrupted. If this occurs, the data cannot be converted to ASCII format (CSV). Be sure to unplug the USB memory device after storage has been reset or has completed (Cmpl).
- When you turn off this instrument, the contents of the internal RAM disk are lost. Save the contents of the RAM disk to internal memory or a USB memory device or network drive before you turn off this instrument.
- Note that there is a limitation on the number of times data can be written to the internal memory or USB memory device.

Starting, stopping, and resetting storage (STORE START, STORE STOP, and STORE RESET)

Starting storage (STORE START)

- When press STORE START, storage starts under one of the conditions described below, depending on the storage mode.
  - Manual storage mode (Manual)
    Storage starts immediately.
  - Real-time storage mode (Real Time)
    This instrument enters into a storage-ready state. Storage starts when the scheduled storage start time arrives.
  - Integration-synchronized storage mode (Integ Sync)
    This instrument enters into a storage-ready state. Storage starts when integration starts.
  - Event-synchronized storage mode (Event)
    This instrument enters into a storage-ready state. Storage starts when a user-defined event occurs.
  - Single-shot storage mode (Single Shot)
    Storage starts immediately. Numeric data is stored whenever you press STORE START.
- When storage starts, the STORE START key lights, and “Store:Start” appears in the upper left of the screen.
- When this instrument is in a storage-ready state, the STORE START key blinks, and “Store:Ready” appears in the upper left of the screen.
- After storage is reset, a storage data file (.wts) and header file (.hds) are created when storage starts again.
- When the storage state is “Stop,” you can restart storage. When you restart storage, the stored data continues to be written to the file from before storage was stopped.
- When the storage state is “Cmpl,” you cannot restart storage until you reset it. After storage is reset, a stored data file (.wts) and header file (.hds) are created when storage starts again.

Stopping storage (STORE STOP)

- You can temporarily stop storage by pressing STORE STOP.
- When storage stops, the STORE STOP key blinks, and “Store:Stop” appears in the upper left of the screen.
- When the storage count is zero and this instrument is in a storage-ready state (Ready)* and you press STORE STOP, storage is reset. The storage data file (.wts) and storage header file (.hds) are deleted.
  * This state can occur in real-time storage mode when you have pressed STORE START but the scheduled storage start time has not yet arrived (the storage operation has not begun).

Storage completion

- Depending on the storage mode, storage automatically stops and the storage state changes to “Cmpl” under any of the following conditions.
  - Manual storage mode (Manual)
    Storage continues until the storage count is reached.
  - Real-time storage mode (Real Time)
    Storage continues until the storage count or the scheduled storage stop time.
  - Integration-synchronized storage mode (Integ Sync)
    Storage continues until the storage count is reached, and then storage is completed (Cmpl). When integration stops, the following occurs.
    - If integration cannot be restarted without being reset, the storage state changes to “Stop.”
    - If integration can be restarted without being reset, the storage state changes to “Ready.”
  - Event-synchronized storage mode (Event)
    Storage continues until the storage count is reached.
  - Single-shot storage mode (Single Shot)
    Storage continues until the storage count is reached.
- After storage is completed, the following occurs.
  - The STORE STOP key lights, and “Store:Cmpl” appears in the upper left of the screen.
  - Writing to the storage data file (.wts) and header file (.hds) finishes, and the files are closed.

- When automatic CSV conversion (Auto CSV Conversion) is enabled, an ASCII format storage data file (.csv) is created.

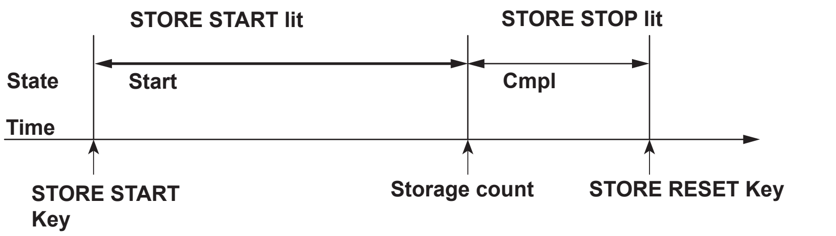
Storage will stop before the specified storage count if the storage destination runs out of available memory or the stored data size exceeds the maximum value (1 GB).

Resetting storage (STORE RESET)

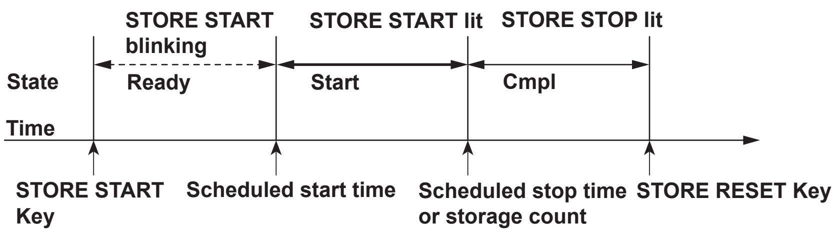
- When you reset storage, the storage state is reset and the storage state indicator disappears.
- If you reset storage when storage state is Stop, writing to the storage data file (.wts) and header file (.hds) finishes, and the files are closed. When automatic CSV conversion (Auto CSV Conversion) is enabled, an ASCII format storage data file (.csv) is created.
- When storage state is completed (Cmpl), the storage data file (.wts) and header file (.hds) are already closed, so no file operations are performed when you reset storage.

Storage operations in each storage mode

Manual (manual storage mode)

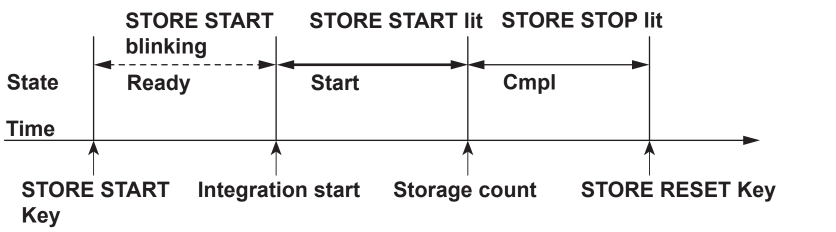


Real Time (real-time storage mode)

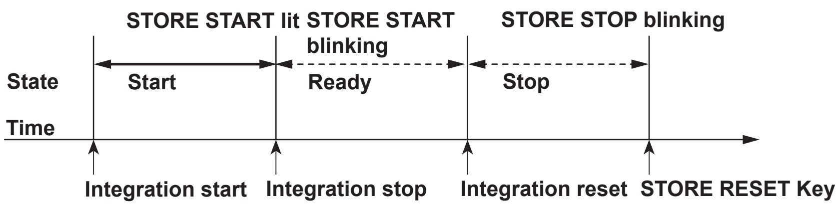


Integ Sync (integration-synchronized storage mode)

When the storage count is reached before integration stops

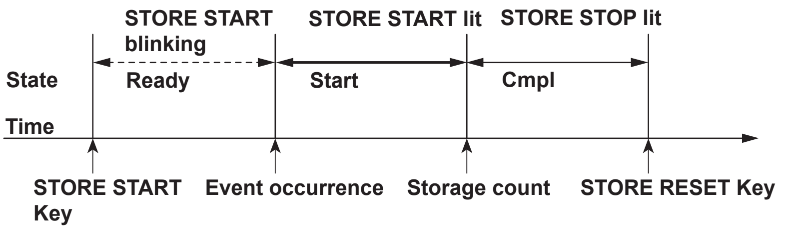


When integration stops before the storage count is reached (illustration of operations after integration starts)

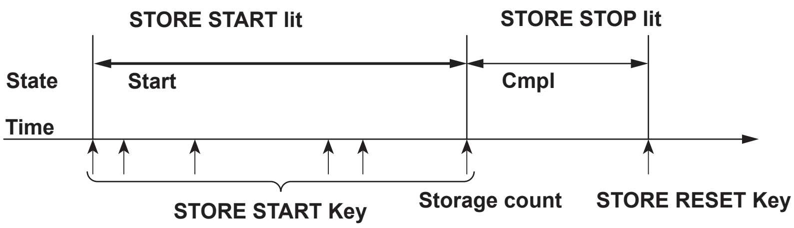


- If you reset integration after it has been stopped, the storage state changes to complete (Cmpl). Writing to the storage data file (.wts) and header file (.hds) finishes, and the files are closed.
- If you restart integration after it has been stopped, the storage state changes to start (Start). The stored data continues to be written to the file from before storage was stopped.

Event (event-synchronized storage mode)



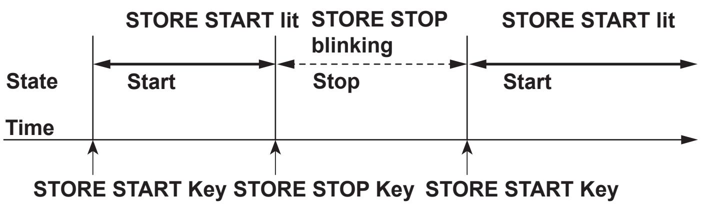
Single Shot (single-shot storage mode)



Storage operations performed when you press STORE STOP when storage is in progress

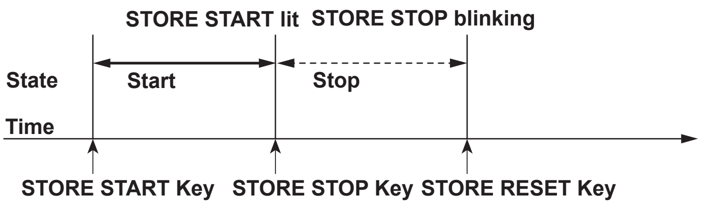
Restarting storage

When you press STORE START, STORE STOP, and then STORE START



Resetting storage

When you press STORE START, STORE STOP, and then STORE RESET

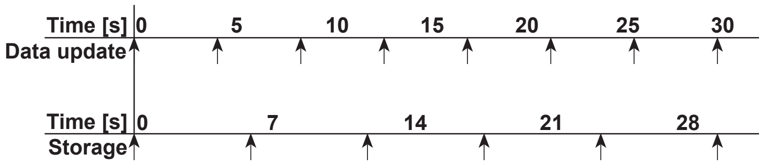


Storage operation when the storage interval is not an integer multiple of the data update interval

Here we will examine a case when the data update interval is 5 s and the storage interval is 7 s. How storage is performed varies as indicated below depending on the storage mode.

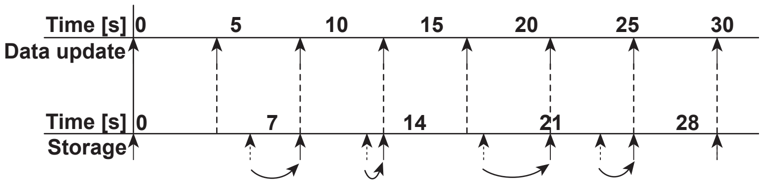
When the storage mode is not set to Integ Sync

Storage is performed according to the storage interval.



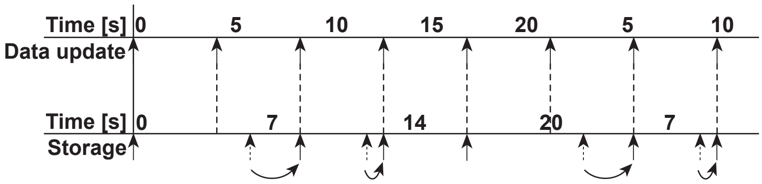
When the storage mode is Integ Sync and the integration mode is not Continuous or R-Continuous

Storage is performed at the first data update after the storage interval passes.



When the storage mode is Integ Sync and the integration mode is Continuous or R-Continuous

Storage is performed at the first data update after the storage interval passes. Storage continues even when integration is reset by the integration timer. When the integration timer is reset, the storage interval timer is also reset. The following figure is an example for when the integration timer is set to 20 s.



- When the storage of numeric data at store start (Store At Start) is enabled, storage starts when the time is at 0 s (store start).
- Storage is performed when the integration mode is continuous integration mode or real-time continuous integration mode, the integration timer time elapses, and the integrated values are reset. In the above example, the integration timer is set to 20 s, so the data is stored after 20 s have passed, and then the integrated values are reset.

Operations when values are held

If you press HOLD when storage is in progress, the displayed values are held, and storage is performed as follows:

- When the storage mode is set to Manual and the storage interval is 00:00:00, when the storage mode is set to Real Time and the storage interval is 00:00:00, or when Storage Mode is set to Event
  The storage operation stops, but integration does not.
- When the storage mode is set to Single Shot
  The held display values are stored. Even during integration, the held display values are stored.
- In all other cases
  The held display values are stored. During integration, the values being measured are stored.

- The media access icon appears only when files are created at the start of storage and when files are closed at the completion or resetting of storage, but the instrument is actually accessing the storage device as needed. During the period between when files are created and when they are closed, do not unplug the USB memory device or turn off the power. Doing so may damage the storage device or corrupt the data.
- When a point has no numeric data, NAN, OL, OF, ERROR, or a blank space will be stored instead. Blanks are stored for measurement functions that appear blank on the screen, such as zero-order (DC) and first-order values for ΦU and ΦI.
- Functions ΔU1 to ΔPΣ are stored according to the delta calculation type that you selected in the delta calculation settings.
- When this instrument automatically changes the range during storage, because measured data is not acquired, the storage operation is suspended and no measured data is stored. After this instrument finishes changing the range, storage resumes.

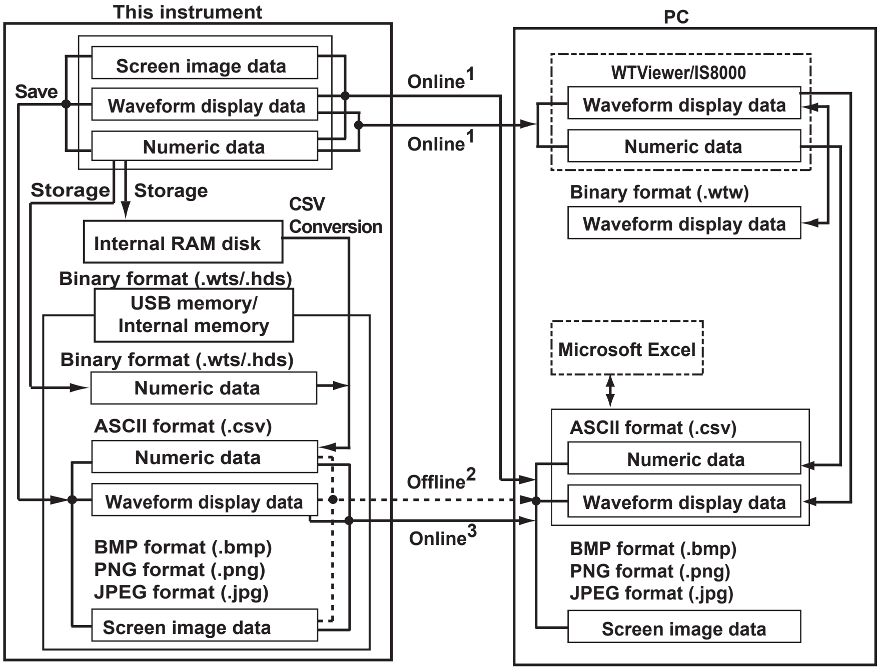
18 Saving and Loading Data

You can save numeric data, waveform display data, screen image data, and setup data to the internal memory, USB memory device, or network drive.
For saving screen image data, see “Saving screen images.”

▶ Click here.

You can also load setup data from a storage device into this instrument.
Further, you can rename, copy, and delete data files.

Loading numeric data, waveform display data, and screen image data into a PC



1 Data acquisition using USB, Ethernet, or GP-IB
2 Data acquisition using USB memory
3 Data acquisition via network drive

Storage device for saving and loading

This instrument can access the following three types of storage devices for saving and loading data.

Internal RAM disk (RAM−0)

The internal RAM disk of this instrument.

Internal memory (User)

The internal memory of this instrument.

USB memory device (USB−0/USB−1)

A USB memory device that is connected to the USB port of this instrument. USB2.0 mass storage devices compatible with USB Mass Storage Class Ver. 1.1 can be connected to the instrument.

Network drive (Network)

A storage device on the network. You can use a network storage device by connecting the instrument to an Ethernet network.

When you turn off this instrument, the contents of the internal RAM disk are lost. Save the contents of the RAM disk to internal memory or a USB memory device or network drive before you turn off this instrument.

Notes about using USB devices

- Plug a USB memory device to the USB port for peripherals (type A) directly, not through a USB hub.
- Use portable USB memory devices that are compatible with USB Mass Storage Class version 1.1.
- You cannot use protected USB memory devices (such as those that contain encrypted content).
- Only plug compatible USB keyboards, mouse devices, or memory devices to the USB ports for peripherals.
- Do not plug and unplug multiple USB devices repetitively. Provide at least a 10-second interval between unplugging and plugging.
- Do not plug or unplug USB devices from the time when the instrument is turned on until operation becomes available (approximately 20 to 30 seconds).
- This instrument can handle up to two USB memory devices.

Saving setup data (Save Setup)

You can save the setup data of this instrument to the specified storage device. The date, time, and communication setup data is not saved.

The extension is .SET.

For details on the save conditions, see “Save conditions.”

▶ Click here.

Saving waveform display data (Save Wave)

You can save data measured by this instrument to a file in ASCII format (.csv). The waveforms displayed on the screen are saved.

For details on the save conditions, see “Save conditions.”

▶ Click here.

The waveform display data that this instrument saves is not the sampled waveform data that is acquired at this instrument’s sample rate (approx. 2 MS/s). Waveform display data is the 1602 points obtained by applying P-P compression to the sampled waveform data for the purpose of displaying the waveform.

Saving numeric data (Save Numeric)

You can save numeric data measured by this instrument to a file in ASCII format (.csv).

For details on the save conditions, see “Save conditions.”

▶ Click here.

When you save numeric data and a point has no numeric data, NAN, OL, OF, ERROR, or a blank space will be saved instead. Blanks are saved for measurement functions that appear blank on the screen, such as zero-order (DC) and first-order values for ΦU and ΦI.

Save conditions

File list display and save destination settings (File List)

On the file list, specify the save destination. For how to configure the file list display and how to operate files and folders, see “File operations (Utility).”

▶ Click here.

Saved items (Item Settings)

This menu appears only when “Saving numeric data (Save Numeric)” is selected.

Displayed numeric items (Displayed Numeric Items)

The saved items vary as indicated below depending on the display.

- When numeric values are displayed in the 4-, 8-, or 16-value display or the matrix display
  All the measurement functions on the page that are displayed when saving starts are saved in the order that they are displayed.
- When numeric values are displayed in the single or dual harmonics list
  In addition to the data described above, the data of harmonics that are not displayed on the screen is saved up to the maximum measurable order (Max Order).
- When numeric values are displayed in the all items or custom display
  The data cannot be saved. If you attempt to save the data, an error message is displayed.
- In non-numeric displays (e.g., waveform display, trend display)
  Items are saved based on the numeric display settings. For example, when the waveform display is shown, if the 16-value display would appear when you were to press NUMERIC, then the data for the measurement functions on the page of the 16-value display that would appear is saved.

Selected items (Selected Items)

You can select the types of numeric data to save.

Items (Items)

If you selected Selected Items, select which numeric data to save.

- **Element (Element)**
  To select an element or wiring unit that you want to store the data of, select or clear its check box. You can select from the following options.
  Element1, Element2, Element3, Element4, Element5, Element6, ΣA, ΣB, ΣC

- **Function (Function)**
  Select whether to store the data by selecting or clearing its check box. You can select any of the measurement function types listed under “Items That This Instrument Can Measure.”
  ▶ Click here.

- **Selecting all functions (All ON)**
  The data of all measurement functions is saved.

- **Deselecting all functions (All OFF)**
  Data is not saved for all measurement functions.

- **Preset 1 (Preset 1)**
  The data of the following measurement functions is saved for all elements and wiring units.*
  Urms, Irms, FreqU, FreqI, P, S, Q, λ, Φ

- **Preset 2 (Preset 2)**
  The data of the following measurement functions is saved for all elements and wiring units.*
  WP, WP+, WP–, q, q+, q–, Time, WS, WQ

* If the wiring system setting (Wiring) is configured so that a wiring unit does not exist, the data for the functions of that wiring unit is not saved. For example, if ΣC does not exist, the data for ΣC is not saved.

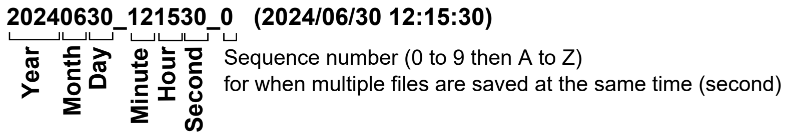
Automatic file naming (Auto Naming)

Numbering (Numbering)

The instrument automatically adds a four-digit number from 0000 to 0999 after the common name (specified with the File Name setting) and saves the file.

Date (Date)

The date and time when the file is saved are used as its name. The file name specified for the File Name setting is ignored.



A sequence number is appended to the date and time when multiple files are saved at the same time (second). The number starts at 0 and is incremented by one each time a file is added. The number 9 is followed by letters of the alphabet.

OFF

The auto naming feature is disabled. The name that you specify using the File Name setting is used. If there is a file with the same name in the save destination folder, you cannot save the data.

Save destination folder for storage caused by user-defined events

In the drive specified in the Store Set menu, a folder is automatically created with the date (year, month, and day) as its name, and data is saved to files in that folder whose names are specified by the auto naming feature. If the number of files in the save destination folder exceeds 1000, a new folder is automatically created with the date and an incremented sequence number (000 to 999) as its name, and the data continues to be saved in the new folder.

File name (File Name)

You can set the common file name that is used when the auto naming feature is turned off or when the auto naming feature is set to Numbering. The maximum number of characters that you can use for file names and folder names is 32 characters. The following restrictions apply.

- Of those characters on the keyboard that appears on the screen, the characters that can be used are 0-9, A-Z, a-z, _, -, =, (,), {, }, [,], #, $, %, &, ~, !, `, and @. @ cannot be entered consecutively.
- The following exact strings cannot be used due to MS-DOS limitations:
  AUX, CON, PRN, NUL, CLOCK, LPT1, LPT2, LPT3, LPT4, LPT5, LPT6, LPT7, LPT8, LPT9, COM1, COM2, COM3, COM4, COM5, COM6, COM7, COM8, COM9
- Keep the full path name (absolute path from the root folder) within 255 characters. If this is exceeded, an error will occur when you perform file operations (save, copy, rename, create folder, etc.). When an operation is being performed on a folder, the full path is up to the name of the folder. When an operation is being performed on a file, the full path is up to the name of the file.

The following additional restrictions apply when you use the file name auto naming feature.

- If you set auto naming to Numbering, the file name will be the text that you specify as the file name with a 4-character sequence number.
- If you set auto naming to Date (date and time), the characters that you entered for the file name will not be used. File names will only consist of the date information.

Comment (Comment)

You can add a comment that consists of up to 30 characters when you save a file. You do not have to enter a comment. You can use all characters and spaces that are displayed on the keyboard. The comment appears at the bottom of the screen.

Settings that are shared with those of other menus

The following settings are shared by the menus for saving the custom display configuration, storing data, saving and loading data, and saving screen images.

- File list display and save destination settings (File List)
- Automatic file naming settings (Auto Naming)
- File name (File Name)

The comment settings (Comment) are shared by the menus for storing data, saving and loading data, saving screen images, and the menus for printing screen images and numeric data.

Saving (Save Exec)

Saves the data to the specified save destination with the specified file name.

- It can take anywhere from a few seconds to a few tens of seconds for this instrument to save the data, depending on the number of waveforms being saved, the data update interval, and the speed to transfer data to the destination storage device. It will take longer for this instrument to save the data when there are many waveforms to be saved or the data update interval is long.
- Measurement stops while this instrument is saving data. After this instrument finishes saving or saving is canceled, measurement resumes.
- To save data when the data update interval is 20 s, enable the hold feature, perform a single-shot measurement, and then save the data after the data update is completed for the single-shot measurement.

Because the header section of files saved by this instrument use a format that is common to YOKOGAWA measurement devices, they contain some data that is not used by this instrument.

Loading setup data (Load Setup)

On the file list, specify a file to load setup data from. The extension is .SET. For how to configure the file list display and how to operate files and folders, see “File operations (Utility).”

▶ Click here.

Loading (Load Exec)

Data is loaded from the specified file.

- If you change the extension of the saved data file, by using a PC or some other device, the instrument will no longer be able to load it.
- When setup data is loaded from a file, the setup data for each key is changed to match the loaded settings, and it cannot be changed back. We recommend that you save the current settings before loading different setup data from a file.
- The date, time, and communication setup data is not saved. So even if you load setup data from a file, the date, time, and communication settings will not change.
- Setup data saved on products with incompatible firmware versions cannot be loaded.
- Setup data saved on products that have different product element configurations, options, and the like cannot be loaded.
- This instrument is not compatible with the setup data files of the WT1800 or WT1801E.

File operations (Utility)

You can perform file operations such as creating folders on the storage device, deleting and copying files, and changing file names. Use the up and down cursor keys to select the file or folder that you want to control from the file list.

Storage device displayed in the file list

▶ Click here.

- Up to 512 files and folders can be displayed in the file list. If there are more than a total of 512 files and folders in a given folder, the file list for that folder will display only 512 files and folders. There is no way to set which files and folders are displayed.
- When you turn off this instrument, the contents of the internal RAM disk are lost. Save the contents of the RAM disk to internal memory or a USB memory device or network drive before you turn off this instrument.

Sorting the file list (Sort To)

You can sort the file list by file name, size, or date and time.

Display format

Select whether to display a list of files or to display thumbnails.

Selecting the type of file to list (File Filter)

You can limit the type of files that appear in the list by selecting an extension.

Changing the storage device (Change Drive)

You can select the storage device that you want to control. The instrument displays various storage devices as follows:

- RAM-0: The instrument's internal RAM disk
- User: The instrument's internal memory
- USB-0: A USB memory device that is connected first to the USB port of this instrument.
- USB-1: A USB memory device that is connected second to the USB port of this instrument.
- Network: Network storage device

Deleting files and folders (Delete)

You can delete selected files and folders.

Renaming files and folders (Rename)

You can rename a selected file or folder.

Making folders (Make Dir)

You can make folders. You can use the same characters in folder names that you can in file names.

Copying and moving files and folders (Copy, Move)

You can copy or move selected files and folders to other storage device or folders. You can copy or move multiple files at the same time.

Operations (Operation)

You can select the following operations.

- Delete: Delete file and folders
- Rename: Rename files and folders
- Make Dir: Make folders (directories)
- Copy: Copy files and folders
- Move: Move files and folders

Selecting files (Set/Reset)

You can select and deselect files and folders you want to control. This is useful when you want to copy or delete several files at once.

Selecting all files (All Set/All Reset)

- **Selecting all files (ALL Set)**
  When the cursor is on a drive or folder in the file list, select ALL Set to select all the files and folders in the device or folder that the cursor is on.
- **Deselecting all files (ALL Reset)**
  All the selected files and folders are deselected.

Jump to the specified file or folder (Jump To)

You can make the cursor jump to a file or folder at a specified numeric position in the file list. The first item in the file list is number zero.
Selectable range: 0 to 999

Other operations (More...)

You can select the following operations.

- Sort To: Sort the file list.
- Display Type: Select the display format (list or thumbnail).
- Filter: Select the type of file to list.
- Change Drive: Change the storage device.

Executing an operation

You can execute the operation that you specified in the Operation setting.

19 Saving Screen Images

You can save screen image data to files in BMP, PNG, and JPEG formats.

Conditions for saving screen image data (IMAGE SAVE MENU)

File list display and save destination settings (File List)

On the file list, specify the save destination. For how to configure the file list display and how to operate files and folders, see “File operations (Utility).”

▶ Click here.

When you turn off this instrument, the contents of the internal RAM disk are lost. Save the contents of the RAM disk to internal memory or a USB memory device or network drive before you turn off this instrument.

Screen image data format (Format)

You can select the format to save to from the options listed below.

- The extension is .BMP. The file size is approximately 100 KB for black and white mode and approximately 1.5 MB for color mode.
- PNG: The extension is .PNG. The file size is approximately 25 KB for black and white mode and approximately 100 KB for color mode.
- JPEG: The extension is .JPG. The file size is approximately 200 KB for color mode.

The file sizes listed here are for reference. Actual file sizes will vary depending on the image that is saved.

Screen image colors (Color)

You can select the color format to save to from the following options.

- OFF: Data is saved in black and white.
- Color: Data is saved using 65536 colors.
- Reverse: Data is saved using 65536 colors. The image background is white.
- Gray: Data is saved using 16 grayscale levels.

Automatic file naming (Auto Naming)

This is the same as the auto naming feature for saving and loading data.

▶ Click here.

File name (File Name)

This is the same as the file name setting for saving and loading data.

▶ Click here.

Comment displayed at the bottom of the screen (Comment)

This is the same as the file name setting for saving and loading comments.

▶ Click here.

Saving a screen image (IMAGE SAVE)

Save the screen image to a file.

20 Ethernet Communication (Network)

You can configure TCP/IP parameters and use the optional Ethernet interface to perform the following tasks.

TCP/IP

TCP/IP settings for connecting to an Ethernet network.
Set the IP address, subnet mask, and default gateway.

▶ Click here.

FTP server (FTP Server)

You can connect the instrument as an FTP server to a network.
You can connect to this instrument from a PC on the same network and retrieve setup data, numeric data, waveform display data, and screen image data.

▶ Click here.

Web server (Web Server)

You can connect the instrument as a Web server to a network.
You can connect to the instrument from a PC on the same network and monitor the instrument display from the PC.

▶ Click here.

Network drive (Net Drive)

You can save the setup data of this instrument, numeric data, waveform display data, and screen image data to a network drive. You can also load the setup data from a network drive into this instrument.

▶ Click here.

SNTP

The instrument clock can be set using SNTP. When this instrument is turned on, the date and time are set automatically.

▶ Click here.

To connect a PC to the instrument, use a hub or router, and connect to a network. Do not connect a PC directly to the instrument.

TCP/IP (TCP/IP)

Configure the settings that the instrument needs to connect to a network.

DHCP

DHCP is a protocol that temporarily allocates settings that a PC needs to connect to the Internet.
To connect to a network that has a DHCP server, turn the DHCP setting on. When DHCP is turned on, the IP address can be automatically obtained when the instrument is connected to a network. (You do not have to set it manually.)
If you set DHCP to OFF, set the appropriate IP address, subnet mask, and default gateway for your network.

DNS

DNS is a system used to associate Internet host names and domain names with IP addresses. Given AAA.BBBBB.com, AAA is the host name and BBBBB.com is the domain name. You can use host names and domain names to access the network instead of using IP addresses, which are just numbers. The instrument allows you to specify the host by name, instead of by IP address. You can set the domain name and the DNS server address (0.0.0.0 by default). For details, consult your network administrator.

DNS servers (DNS Server1/DNS Server2)

You can specify up to two DNS server addresses: primary and secondary. If querying fails with the primary DNS server, the secondary DNS server is automatically used to find the mapping of the host name and domain name to the IP address.

Domain suffixes (Domain Suffix1/Domain Suffix2)

The domain suffix is a piece of information that is automatically added when a query is made to a DNS server using only a portion of the domain name. For example, if BBBBB.co.jp is registered as a domain suffix and a query is made using “AAA,” the name “AAA.BBBBB.co.jp” is searched for.
You can specify up to two domain suffixes: Domain Suffix1 and Domain Suffix 2.
You can use up to 127 characters. The characters that you can use are 0 to 9, A−Z, a−z, and dashes.

TCP/IP settings are applied when you select Bind and press SET in the dialog box or when you turn on the instrument the next time.

FTP server (FTP/Web Server)

You can connect the instrument as an FTP server to a network.

Set the user name, password, and time out that will be used by devices on the network to access the instrument.

User name (User Name)

Set the user name that will be used to access the instrument from a PC. If you set the user name to “anonymous,” you can connect to the instrument without entering a password.

- Number of characters: Up to 32
- Usable characters: All ASCII characters that are displayed on the keyboard

Password (Password)

Set the password that will be used to access the instrument from a PC.

- Number of characters: Up to 32
- Usable characters: All ASCII characters that are displayed on the keyboard

Timeout (Time Out)

If a connection cannot be established between the instrument and the PC within the amount of time specified here, the instrument aborts the connection process.

You can set the timeout time in the range of 1 to 3600.

To apply the settings that you specified, press Entry.

FTP server overview

When the instrument is connected to the network as an FTP server, the following features become available.

FTP server feature

From a PC, you can view a list of files that are stored in the instrument storage device (the internal RAM disk, internal memory or a storage device that is connected to it) and retrieve files.

Web server (FTP/Web Server)

You can connect the instrument as a Web server to a network.
Set the user name and password that will be used by devices on the network to access the instrument.

User name (User Name)

Set the user name that will be used to access the instrument from a PC. If you set the user name to “anonymous,” you can connect to the instrument without entering a password.

- Number of characters: Up to 32
- Usable characters: All ASCII characters that are displayed on the keyboard

Password (Password)

Set the password that will be used to access the instrument from a PC.

- Number of characters: Up to 32
- Usable characters: All ASCII characters that are displayed on the keyboard

- Time Out is a setting used by the FTP server feature. It is not necessary for the Web server feature.
- To apply the settings that you specified, press Entry.

Web server overview

When the instrument is connected to the network as an Web server, the following features become available.

Web server feature

You can display the screen of this instrument on the PC and control this instrument through the Ethernet network.
There are three types of screens: Home, Control, and Links.

Instrument information (Home)

Information about the instrument is displayed.

Control from the PC (Control)

- LCD area: The same information as that on the instrument’s LCD is displayed. You can perform the same operations as when a USB mouse is connected to this instrument. (See section 1.3 in the User’s Manual IM WT1801R-02EN.)
- Resolution setting: Set the resolution of the LCD area.
  - LOW: 512×384
  - HIGH: 1024×768
- Message: Messages are displayed.
- Control panel area: You can control the instrument in the same manner as if you were using the keys on the instrument.
- Auto refresh start/stop button: You can start or stop the auto refreshing of the LCD area and control panel area.
- Screen refresh interval setting: You can set the auto refresh interval of the LCD area and control panel area to Off, 200 ms, 500 ms, 1 s, 3 s, or 5 s.

Link (Link)

You can access linked pages.

- The Web server function is unavailable when the instrument is manipulating files.

Network drive (Net Drive)

You can save the setup data of this instrument, numeric data, waveform display data, and screen image data to a network drive. You can also load the setup data from a network drive into this instrument.

FTP server (FTP Server)

Specify the IP address of an FTP server on the network. You can save numeric data, waveform display data, and screen image data to the server and load setup data from it. In a network with a DNS server, you can specify the host name and domain name instead of the IP address.

Login name (Login Name)

Specify the login name.
- Number of characters: Up to 32
- Usable characters: All ASCII characters that are displayed on the keyboard

Password (Password)

Specify the password that corresponds to the login name.
- Number of characters: Up to 32
- Usable characters: All ASCII characters that are displayed on the keyboard

Passive mode (Passive)

Turn FTP passive mode on or off.
In passive mode, the FTP client sets the port number for data transfer. Enable passive mode when you have set an external FTP server as a network drive or when you are accessing an FTP server through a firewall.

Timeout (Time Out)

If the instrument cannot transfer files for a certain amount of time, it disconnects from the FTP server.
You can set the timeout time in the range of 1 to 3600.

Connecting to the network drive (Connect/Disconnect)

When you press Connect, this instrument connects to the specified network drive. When you press Disconnect, the network drive is disconnected.

SNTP

The instrument clock can be set using Simple Network Time Protocol (SNTP). When this instrument is turned on, the date and time are set automatically.

SNTP server (SNTP Server)

Specify the IP address of the SNTP server that the instrument will use. In a network with a DNS server, you can specify the host name and domain name instead of the IP address.

Timeout (Time Out)

If the instrument cannot connect to the SNTP server for a certain amount of time, it aborts the operation.
You can set the timeout time in the range of 1 to 60.

Executing time adjustment (Adjust)

The instrument clock is synchronized to the SNTP server clock.

Automatic adjustment (Adjust at Power On)

You can configure the instrument so that its clock is automatically synchronized to the SNTP server clock when the instrument is turned on when it is connected to the network.

Time difference from Greenwich Mean Time (Time Difference from GMT)

This is the same as the “Setting the Time Difference from Greenwich Mean Time (Time Difference From GMT)” setting in the date and time settings.

▶ Click here.

The Time Difference from GMT setting is shared with the same setting found in the SNTP settings in the date and time settings (Date/Time). If you change this setting in the Ethernet communication (Network) settings, the Time Difference from GMT in the date and time settings (Date/Time) also changes.

21 Utility

Utility (UTILITY)

You can configure the following settings.

Overview (Overview)

You can view the system and setup data of this instrument.

▶ Click here.

Initialize settings (Initialize Settings)

You can reset the instrument settings to their factory default values.

▶ Click here.

Remote control (Remote Control)

You can select the method for connecting a PC to this instrument to control it.

▶ Click here.

System configuration (System Config)

You can set the date and time, time synchronization, menu and message language, LCD brightness, backlight on/off, USB keyboard language, and USB communication features. You can also format storage devices.

▶ Click here.

Ethernet communication (Network)

You can configure TCP/IP, FTP server, network drive, and SNTP settings.

▶ Click here.

D/A output (D/A Output Items, option)

You can configure D/A output settings.

▶ Click here.

Self-test (Selftest)

You can test the keyboard and memory operations.

▶ Click here.

Overview (System Overview)

You can display the following information about this instrument.

Item	Description
Model	The model number
Suffix	The suffix code
No.	The instrument number and MAC address
Version	The firmware version
Element Configuration	The input element type
Options	The options
Link Date	The firmware date
Product ID	A unique number assigned to each instrument (This number is necessary for the purchase of additional options.)

Initializing the Settings (Initialize Settings)

You can reset the instrument settings to their factory default values. This feature is useful when you want to cancel all the settings that you have entered or when you want to redo measurements from scratch.

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

Items that cannot be reset

The following settings cannot be reset.
Date and time, communication, menu language, message language, and environment

To reset all settings to their default values

While holding down the RESET key, turn the power switch on. All settings except the date and time settings (display on/off setting will be reset) will be reset to their factory default values.

Remote control (Remote Control)

This is the communication interface used to control the instrument from a PC. The three available communication interfaces are GP-IB, USB, and network.

For details, see the Communication Interface User's Manual, IM WT1801R−17EN.

- Only use one communication interface: GP-IB, USB, or Network. If you send commands simultaneously from more than one communication interface, the instrument will not execute the commands properly.
- "REMOTE" appears at the top center of the screen when the instrument is communicating with a PC in remote mode. All keys except LOCAL are disabled in Remote mode.

GP−IB

Connects the instrument to a PC using GP-IB.*

* Applicable to models with the GP-IB interface option

Address (Address)

- You can set the value in the range of 0 to 30.
- Each device that can be connected via GP-IB has a unique address within the GP-IB system. This address is used to distinguish between different devices. Therefore, you must assign a unique address to the instrument when connecting it to a PC or other device.

When the controller is communicating with the instrument or with other devices through GP-IB, do not change the address.

Notes about connections

- Several cables can be used to connect multiple devices. However, no more than 15 devices, including the controller, can be connected on a single bus.
- When connecting multiple devices, you must assign a unique address to each device.
- Use cables that are no longer than 2 m in length to connect devices.
- Make sure the total length of all cables does not exceed 20 m.
- When devices are communicating, have at least two-thirds of the devices on the bus turned on.
- To connect multiple devices, use a star or daisy-chain configuration. Loop and parallel configurations are not allowed.

USB

Connects this instrument to a PC using USB.

To connect the instrument to a PC through the USB port, carry out the following procedure.

- Install the YOKOGAWA USB TMC (Test and Measurement Class) driver on your PC. For information about how to obtain the YOKOGAWA USB TMC driver, contact your nearest YOKOGAWA dealer. You can also access the YOKOGAWA USB driver download webpage and download the driver (https://tmi.yokogawa.com/library/).
- Do not use USB TMC drivers (or software) supplied by other companies.

Network

Connects this instrument to a PC using Ethernet.

IP address (IP Address)

Displays the TCP/IP setting that you specified in the Ethernet communication settings.

▶ Click here.

Timeout (Time Out)

If a connection cannot be established between the instrument and the PC within the amount of time specified here, the instrument aborts the connection process.

You can set the timeout time to Infinity or a value between 1 and 3600.

You must set TCP/IP parameters to connect this instrument to an Ethernet network.

▶ Click here.

Notes about connections

- To connect the instrument to a PC, be sure to use straight cables and to connect through a hub or router. Proper operation is not guaranteed for a one-to-one connection using a crossover cable.
- Use a cable that is compatible with your network environment (transmission speed).
  STP (Shielded Twisted-Pair) cable

Clearing remote mode (LOCAL)

To clear remote mode, press LOCAL.

▶ Click here.

System configuration (System Config)

You can configure the following settings.

- Date and time
- Language
- LCD adjustment
- USB keyboard language
- Environment settings (Preference)
- Crest factor

Date and time setting (Date/Time)

The instrument date and time.

Turning the display on and off (Display)

Set whether to show the date and time on this instrument.

Method for setting the date and time (Type)

You can set the method for setting the date and time to any of the following options.

- Manual: Set the date or time manually.
- SNTP: Use an SNTP server to set the time (valid when Ethernet communication is being used).

Date and Time Setting (Date/Time)

This setting is valid when the method for setting the date and time is set to Manual.
Set the date and time.

- Setting the date
  The format for setting the date is YYYY/MM/DD (year/month/day). Set the last two digits of the Gregorian year.
- Setting the time
  The format for setting the time is HH:MM:SS (hour:minute:second). Set the hour based on a 24-hour clock.

Time difference from Greenwich Mean Time (Time Difference from GMT)

This setting appears 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 instrument and Greenwich Mean Time in 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 website at the following URL: https://www.worldtimeserver.com/

- This instrument does not support Daylight Saving 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.
- This instrument manages 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.

Language (Language)

You can set the language that is used in the setup menu and messages.

Menu language (Menu Language)

You can choose to display menus in any of the following languages.

- English
- Japanese
- Chinese
- German

Message language (Message Language)

Error messages appear when errors occur. You can choose to display these messages and the help using one of the following languages. The error codes for error messages are the same for all languages. For details on error messages, see the appendix in the User's Manual, IM WT1801R-02EN.

- English
- Japanese
- Chinese
- German

- Even if you set the menu or message language to a language other than English, some terms will be displayed in English.
- You can set different languages for the menu language and message language. 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.

Adjusting the LCD (LCD)

You can adjust the brightness of the LCD. You can also turn off the LCD.

Turning Off the LCD (LCD Turn OFF)

You can turn off the LCD. When the LCD is off, you can turn it back on by pressing a key.

Automatically turning off the LCD (Auto OFF)

The LCD turns off automatically when there are no key operations for a given time period. The LCD turns back on when you press a key.

Auto Off Time (Auto OFF Time)

You can set the time after which the LCD turns off automatically to a value within the following range.
1min to 60min

Adjusting the Brightness (Brightness)

You can adjust the brightness in the range of 1 (darkest) to 10 (brightest). You can prolong the LCD service life by decreasing the LCD brightness or by turning off the LCD when you do not need to view it.

Display color (Color Settings)

- **Graph color (Graph Color)**
  You can choose the colors that are used to display the data in the waveform, trend, and vector displays from the following options.
  - Default (Default)
    CH1 to CH16 are displayed with different colors.
  - Classic (Classic)
    The color scheme is the same as that of the WT1600. Some channels from CH1 to CH16 share the same color.

On the waveform display, trend display, and vector display, the display data responding to CH1 to CH16 is as follows:

	Waveform Display	Trend Display	Vector Display
CH1	U1	T1	U1
CH2	I1	T2	I1
CH3	U2	T3	U2
CH4	I2	T4	I2
CH5	U3	T5	U3
CH6	I3	T6	I3
CH7	U4	T7	U4
CH8	I4	T8	I4
CH9	U5	T9	U5
CH10	I5	T10	I5
CH11	U6	T11	U6
CH12	I6	T12	I6
CH13	Speed/Aux1	T13	–––
CH14	Torque/Aux2	T14	–––
CH15	–––	T15	–––
CH16	–––	T16	–––

- **Grid intensity (Grid Intensity)**
  You can set the grid (Grid) intensity in the range of 1 (darkest) to 8 (brightest).

- **Color theme (Base Color)**
  - Gray (Gray): WT1800R's original color
  - Blue (Blue): Color used on the conventional WT1800 series

  Set the menu color theme to gray (Gray) or blue (Blue).

USB keyboard language (USB Keyboard)

Select the USB keyboard language to use when entering file names, comments, and so on. You can use the following keyboards that conform to USB Human Interface Devices (HID) Class Ver. 1.1.

- English: 104 keyboard
- Japanese: 109 Keyboard

For details on how the instrument keys are mapped to the keys on a USB keyboard see appendix 6.

Environment settings (Preference)

Number of displayed digits (Resolution)

You can set the number of numeric data digits to display to 4 digits or 5 digits. However, the number of displayed digits for integration measurement functions is fixed to six.

Frequency display when the frequency measurement is less than lower limit (Freq Display at Frequency Low)

When the frequency of the input signal is lower than the frequency that this instrument can measure, you can choose to display the frequency as “0” or “Error.”

Motor display when the pulse frequency measurement is less than the lower limit (Motor Display at Pulse Freq Low, option)

When the pulse frequency of the torque or speed input signal is lower than the frequency that this instrument can measure, you can choose to display the values of motor evaluation measurement functions as “0” or “Error.”

Decimal point and separator when data is saved in ASCII (.csv) format (Decimal Point for CSV File)

When you save data in ASCII format (.csv), you can choose what type of decimal point to use and how to separate the data.

- Period (Period): The decimal point is a period, and the separator is a comma.
- Comma (Comma): The decimal point is a comma, and the separator is a semicolon.

Integration resume action at power failure recovery (Integration Resume Action)

▶ Click here.

Menu font size (Font Size)

You can set the menu font size to Small or Large.

Rounding to zero (Rounding to Zero)

- ON
  When the voltage or current measurement is any of the following values, Urms, Umn, Urmn, Irms, Imn, Irmn, and other measurement functions based on these measurement functions are displayed and output as zero. λ or Φ is displayed and output as error [Error].
  - When the crest factor is set to CF3
    Urms, Uac, Irms, or Iac is 0.3 % or less. Umn, Urmn, Imn, or Irmn is 2 % or less.
  - When the crest factor is set to CF6 or CF6A
    Urms, Uac, Irms, or Iac is 0.6 % or less. Umn, Urmn, Imn, or Irmn is 4 % or less.
- OFF
  The measured values are displayed and output as they are.

Crest factor (Crest Factor)

▶ Click here.

D/A output (D/A Output Items, option)

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

Output items (Item)

The measurement functions that you select under Function and Element/Σ appear here.

Function (Function)

- You can select any of the measurement functions listed under "Items That This Instrument Can Measure."
  ▶ Click here.
- To output integrated values through D/A conversion, set the rated time for integrated D/A output.
  ▶ Click here.
- You can also choose not to output a measurement function (None). The output for channels that have been set to none is 0 V, because they have no corresponding numeric data.
- When the D/A output range mode is set to Fixed, the D/A output of channels whose measurement function has been set to Z, Rs, Xs, Rp, Xp, or F1 to F20 is Fixed at 0 V. The output is produced when the range mode is set to Manual.

Element (Element/Σ)

- You can select the element/wiring unit from the following options. The available options vary depending on the installed elements.
  Element1, Element2, Element3, Element4, Element5, Element6, ΣA, ΣB, ΣC
- If an element in the selected wiring unit does not exist, because there is no data, the output is 0 V. For example, if elements are assigned to ΣA but not to ΣB, the output for the measurement function for ΣB is 0 V.

Harmonic order (Order, option)

When you select a function that has harmonic data, you can set the displayed harmonic order within the following range.
Total (Total value) or 0 (DC) to 500

The harmonic orders that can be specified vary depending on the measurement function. For details, see "Harmonic measurement function orders."

▶ Click here.

The outputs of orders that exceed the maximum measurable order are 0 V. For information about the maximum measurable harmonic order, see "Maximum harmonic order to be measured (Max Order)."

▶ Click here.

D/A output range mode (Range Mode)

You can select the D/A output range mode from the following options.

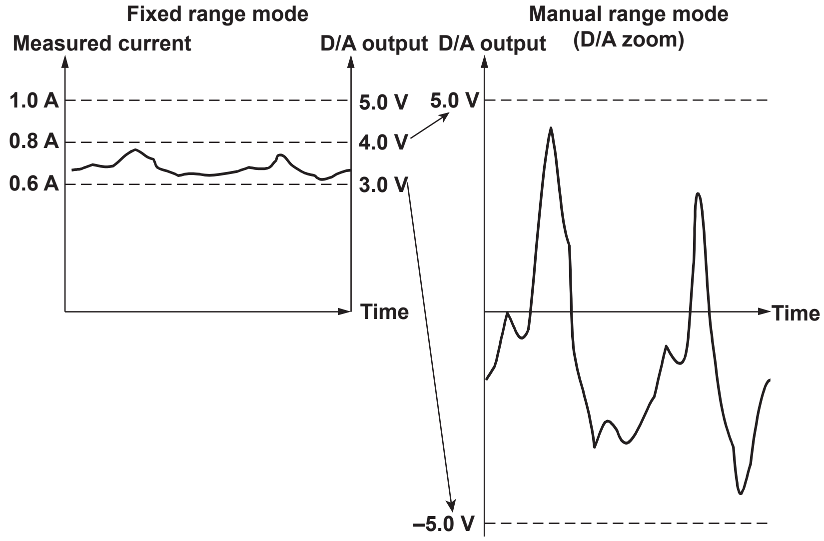
Fixed (Fixed range mode)

Outputs +5 V when the rated value of each measurement function is received. For details, see "Relationship between output items and the D/A output voltage."

▶ Click here.

Manual (Manual range mode)

You can set which measurement function values result in a D/A output of -5 V, and which result in a D/A output of +5 V.
This enables the D/A output to be expanded or reduced for each channel (D/A zoom). For example, if you are measuring a current that fluctuates between 0.6 A and 0.8 A with a measurement range of 1 A, when the D/A output range mode is Fixed, the D/A output voltage will fluctuate between 3.0 V and 4.0 V. When you want to observe the fluctuations more closely, you can use the D/A zoom feature. If you set the D/A output range mode to Manual and set the minimum value to 0.6 and the maximum value to 0.8, this instrument will produce −5 V when the measured current value is 0.6 A and +5 V when the measured current value is 0.8 A.



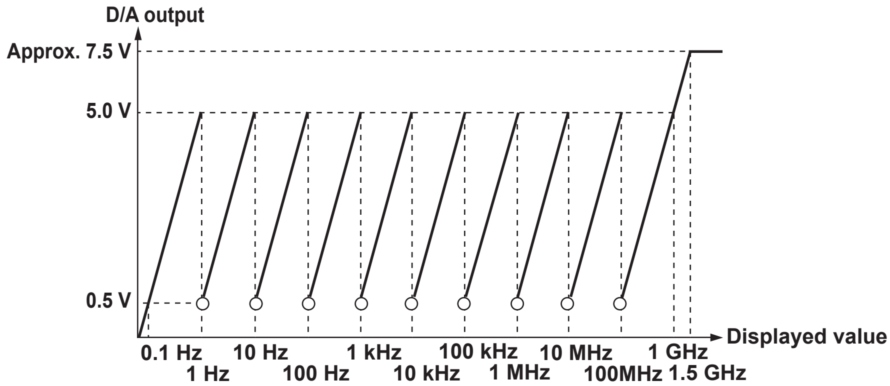
Maximum (Max) and minimum (Min) range values

When the D/A output range mode is Manual, you can set the maximum (Max) and minimum (Min) values within the following range.
–9.999T to 9.999T

- The output is 0 V if a measurement function is not selected or if there is no numeric data.
- If a scaling factor such as a VT ratio, CT ratio, or power coefficient is applied to a voltage, current, or power value and scaling is enabled, this instrument produces 100 % output (5 V) when the scaled measured value is the same as the scaled rated value (measurement range × scaling factor).
- For Σ functions, this instrument produces 100 % output (5 V) when the measured value is equivalent to the value that is measured when all of the elements in the group are at their rated values. When the elements have different scaling factors, this instrument produces 100 % output (5 V) when the scaled measured values are the same as the scaled rated values (measurement range × scaling factor).

Relationship between output items and D/A output voltage

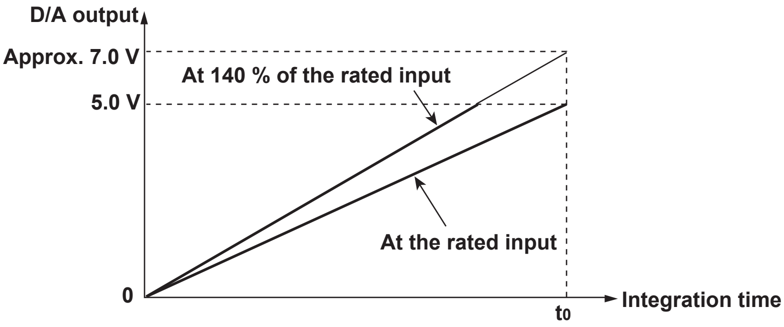
Frequency (the figure is simplified)



User-defined events

- When the event is occurring (True): +5 V
- When the event is not occurring (False): 0 V

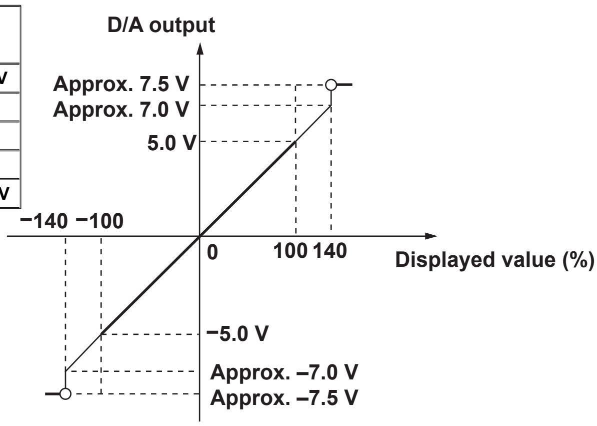
Integrated values



t0: The rated time of integrated D/A output in manual integration mode.
The timer time in normal or continuous integration mode.

Other items

Displayed value	Output
140 %	Approx. 7.0 V
100 %	5.0 V
0 %	0 V
−100 %	−5.0 V
−140 %	Approx. −7.0 V



- The outputs for λ, Φ, EaU, and EaI do not exceed ±5 V. When the display format of Φ is set to 360 degrees, the output for Φ ranges from 0 V to +5 V. When the display format of Φ is set to 180 degrees (lagging 180° to leading 180°), the output for Φ ranges from −5 V to +5 V. However, when an error occurs, the output is approximately 7.5 V. Only the outputs for U−pk and I−pk are approximately −7.5 V when an error occurs.
- The outputs for η1 to η4, Uhdf, Ihdf, Phdf, Uthd, Ithd, Pthd, Uthf, Ithf, hvf, hcf, and Slip* are +5 V at 100 %.
- The outputs for Utif and Itif are +5 V at 100.
- The output for an analog torque signal is +5 V when the torque reaches the value of the input range × the torque scaling factor × the input signal slope (this is the rated value).[1] For example, when the input range is 10 V, if the scaling factor is set to 1 N·m of torque per 1 V of input voltage, the output is +5 V when the torque is 10 N·m.
- The output for an analog rotating speed signal is +5 V when the rotating speed reaches the value of the input range × the revolution scaling factor × the input signal slope (this is the rated value).[1] For example, when the input range is 10 V, if the scaling factor is set to 100 rpm per 1 V of input voltage, the output is + 5 V when the rotating speed is 1000 rpm.
- The output for a pulse rotating speed signal is −5 V when the rotating speed reaches the value specified for Pulse Range Upper × −1, and the output is +5 V when the rotating speed reaches the value specified for Pulse Range Upper.[1]
- The output for a pulse torque signal is −5 V when the torque reaches the value specified for Pulse Range Upper × −1, and the output is +5 V when the torque reaches the value specified for Pulse Range Upper.[1]
- The output for SyncSp is +5 V when SyncSp is at the rated value for Speed.[1]
- The output for Pm is +5 V when Pm reaches the motor output value obtained from the rated values for the torque and rotating speed.[1]

- The output for Aux1 or Aux2 is +5 V when Aux1 or Aux2 reaches the value of the input range × the scaling factor for Aux1 or Aux2 × the auxiliary signal slope (this is the rated value).[2]

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

Self-test (Selftest)

You can test the keyboard and memory operations.

Test item (Test Item)

You can perform the following tests.

Memory test (Memory)

You can test the internal memory to determine whether it is functioning normally. If it is, “Pass” appears. If an error occurs, “Failed” appears. When the test is completed, “Test Completed” is displayed.

Key test (Key Board)

- The panel key test checks the front panel keys. If the name of the key that you press is displayed, the key is operating properly.
- The test is successful if you press the left and right cursor keys and the front panel indicators turn on and off one by one.
- To exit from the key test, press ESC twice.

Keyboard test (Soft Key)

This test appears when you set Test Item to Key Board. You can test whether the keyboard displayed on the screen is functioning properly. If the characters that you type appear correctly in the keyboard’s input box, the keyboard is functioning properly.

Executing a Test (Test Exec)

The selected self-test starts.

If an error occurs during a self-test

If an error occurs even after you perform self-tests numerous times, contact your nearest YOKOGAWA dealer.

22 Other Features

You can set the following items.

- Zero-level compensation (CAL)
- NULL feature (NULL SET)
- Enabling and disabling the NULL feature (NULL)
- Clearing remote mode (LOCAL)
- Key lock (KEY LOCK)

Zero-level compensation (CAL)

Zero-level compensation is the process of creating a zero-input condition using the internal circuit of this instrument and setting the level at that point to the zero level. It must be performed to meet the specifications of this instrument.

- Press CAL to execute zero level compensation.
- This instrument automatically performs zero-level compensation after you change the measurement range or input filter.

- To make accurate measurements, we recommend that you execute zero-level compensation after warming up the instrument for at least 30 minutes. Also, the ambient temperature should be stable and within the specified range (see chapter 5 in the Getting Started Guide, IM WT1801R-03EN).
- If the measurement range and input filter remain the same for a long period of time, the zero level may change due to the changes in the environment surrounding this instrument. If this happens, we recommend that you execute zero-level compensation.
- There is a feature that automatically performs zero-level compensation during integration (integration auto calibration).

  ▶ **Click here.**

- Zero-level compensation is not executed when the measurement range is changed by the auto range feature during integration.

NULL feature (NULL SET)

You can use the NULL feature to subtract the DC offset while a measurement cable or external sensor is connected.

Items to configure NULL settings for (Target Element)

All

Each time you press NULL, you can enable or disable the NULL feature for all the following input signals.

- U and I signals of each element
- Speed and Torque signals (models with the motor evaluation option)
- Aux1, Aux2 (model with the auxiliary input option)

Select

Press NULL to select the input signals that you want to enable, hold, or disable the NULL feature for.

Voltage (U)

- All: You can enable or disable the NULL feature for the voltage signals of all elements at the same time.
- U1 to 6: You can enable or disable the NULL feature for the voltage signals of each element separately.

Current (I)

- All: You can enable or disable the NULL feature for the current signals of all elements at the same time.
- I1 to 6: You can enable or disable the NULL feature for the current signals of each element separately.

Motor (Motor)

- All: You can enable or disable the NULL feature for the Speed and Torque signals at the same time.
- Speed, Torque: You can enable or disable the NULL feature for the Speed and Torque signals separately.

Auxiliary input (Aux)

- All: You can enable or disable the NULL feature for the Aux1 and Aux2 signals at the same time.
- Aux1, Aux2: You can enable or disable the NULL feature for the Aux1 and Aux2 signals separately.

NULL Status (Status)

Enable or disable the NULL feature for each input signal.

- ON: When press NULL, this instrument sets or updates the NULL value. Afterwards, the NULL value is used to correct the measurement function values.
- Hold: The function of this key varies depending on whether the NULL value has yet to be set or has already been set.
  - When the NULL value has yet to be set
    When you press NULL and enable the NULL feature, this instrument sets the NULL value. Afterwards, the NULL value is used to correct the measurement function values. If you press NULL again, the NULL feature is disabled, but this instrument saves the specified NULL value.
  - When the NULL value has already been set
    Even if you press NULL and enable the NULL feature, the NULL value is not updated. The saved NULL value discussed above is used to correct the measurement function values.

  For example, if you turn on the power and then immediately enable the NULL feature, the NULL value has not yet been set, so the value measured then is used as the NULL value. If you press NULL again in this state, the NULL feature is disabled. The set NULL value is stored in the instrument. If you press NULL and enable the NULL feature, the NULL value is not updated. The saved NULL value discussed above is used to correct the measurement function values.
- OFF: Even if you press NULL, the NULL feature is not enabled. Measurement function values are produced with no NULL correction.

The held NULL value is cleared under the following circumstances.

- Operations that cause the NULL values of all inputs to be cleared
  - Turning on the power (the NULL values are not backed up when you turn off the power)
  - Initializing the settings
  - Loading a setup data file
- Operations that cause the NULL value of the input whose settings were changed to be cleared
  - Switching between direct current input and external current sensor input
  - Changing the Sense Type setting for the Speed or Torque motor evaluation input signal

NULL values

When you enable the NULL feature, the following measurement values are used as the NULL values.

- Udc and Idc (simple voltage and current averages)
- Speed and Torque signals (models with the motor evaluation option)
- Aux1, Aux2 (model with the auxiliary input option)

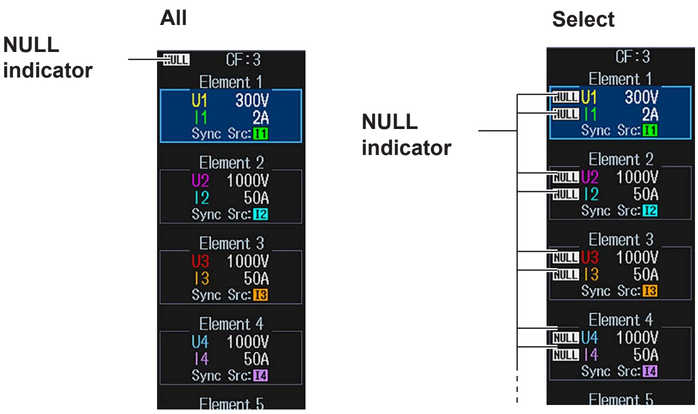
Measurement Functions Affected by the NULL Feature

All measurement functions are affected by the NULL values.

- If there are no previously measured values for Udc, Idc, Speed, Torque, Aux1, or Aux2, because for example the NULL feature has been turned on before any measurements have been made, the NULL values are set to zero.
- For measurement functions that are calculated based on an element's voltage and current values, the NULL values are subtracted from the sampled voltage and current values.
- For motor evaluation measurement functions and auxiliary input measurement functions, the NULL values are subtracted from the calculated numeric data.

Enabling and disabling the NULL feature (NULL)

- You can execute the NULL feature. The NULL key lights.
  The NULL indicator lights as described below depending on how the Target Element setting has been set.
  - All: The NULL indicator lights in the upper right of the screen.
  - Select: The NULL indicator lights to the left of the element, motor or AUX inputs, which are located on the right side of the screen.



- If you press NULL while the NULL feature is enabled, the NULL key light and NULL indicators turn off, and the NULL feature is disabled.

- To make accurate measurements, we recommend that you execute zero-level compensation before enabling the NULL feature.
- The NULL feature is disabled when:
  - The power is turned on.
  - The settings are initialized.
  - A setup data files loaded.
  - You switch between direct current input and external current sensor input.
  - You change the sense type setting for the speed or torque motor evaluation input signal.
- If the NULL feature is enabled or disabled while the display is held, the NULL indicator will light or turn off, but the held data will not be affected. Also, the NULL indicator will be highlighted.
- The DC values that the NULL value is based on when the NULL feature is ON are held, but the upper limit of the NULL value is ±10 % of the range when the crest factor is set to CF3. The upper limit of the NULL value is ±20 % of the range when the crest factor is set to CF6 or CF6A.
- When the range is changed, the NULL value upper limit will be determined by the new range. The NULL value upper limit will also be adjusted when the range is decreased by the auto range feature.

Clearing remote mode (LOCAL)

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

Key lock (KEY LOCK)

When you enable the key lock, this instrument behaves as described below. You can use the key lock to prevent unintentional operations.

- All key operations are disabled except the power switch and SHIFT+LOCAL (KEY LOCK).
- The key lock indicator (“LOCK”) appears in the upper right of the screen.

The key lock on/off state is retained even when the power is turned off.

Appendix

Appendix 1 Symbols and Determination of Measurement Functions

Measurement functions of normal measurement

(Table 1/3)

Measurement function		Formula For the symbols in the formulas, see the notes provided 2 pages later.				
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
		$\sqrt{AVG[u(n)^2]}$	$\frac{\pi}{2\sqrt{2}} AVG[\lvert u(n) \rvert]$	$AVG[u(n)]$	$AVG[\lvert u(n) \rvert]$	$\sqrt{RMS^2 - DC^2}$
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
		$\sqrt{AVG[i(n)^2]}$	$\frac{\pi}{2\sqrt{2}} AVG[\lvert i(n) \rvert]$	$AVG[i(n)]$	$AVG[\lvert i(n) \rvert]$	$\sqrt{RMS^2 - DC^2}$
Active power P [W]		$AVG[u(n) \cdot i(n)]$				
Apparent power S [VA]	TYPE1, TYPE2	Select from Urms • Irms, Umn • Imn, Udc • Idc, Umn • Irms, 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.[1]				
	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 lead (D) and lag (G) display conditions vary depending on the S and Q expressions. • If the S and Q expressions are TYPE1 or TYPE2, lead is displayed as D and lag as G.[2] • If the S and Q expressions are TYPE3, negative reactive power Q is displayed as D and positive as G. 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. 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 = |U + pk| or |U − pk| whichever is larger		Current crest factor $CfI = \frac{Ipk}{Irms}$ Ipk = |I + pk| or |I − pk| whichever is larger		
Corrected Power Pc [W]		IEC76-1 (1976), IEEE C57.12.90-2010		IEC76-1(2011)		
		$\frac{P}{P1 + P2\left(\frac{Urms}{Umn}\right)^2}$ P1, P2: coefficients defined in the applicable standards		$P\left(1 + \frac{Umn - Urms}{Umn}\right)$		

1 If the data update interval is Auto, for elements with the sync source rectifier set to ON, s is fixed to 1.s

2 If the data update interval is Auto, for elements with the sync source rectifier set to ON, the display is fixed to G (When 360° display format is in use, the phase is displayed in the range of 0 to 180°).

(Table 2/3)

	Measurement function		Formula For the symbols in the formulas, see the notes provided on the next page.
Integration	Integration time [h:m:s]	Time	Time from integration start to integration stop
Integration	Watt-hours [Wh]	WP WP+ WP−	When the watt-hour integration method for each polarity is Charge/Discharge[1] $\left[\frac{1}{N}\sum_{n=1}^{N}\{u(n)\cdot i(n)\}\right]\cdot \text{Time}$ 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 formulas for all iterations where u(n) • i(n) is positive. WP− is the sum of the above formulas for all iterations where u(n) • i(n) is negative.
Integration	Watt-hours [Wh]	WP WP+ WP−	When the watt-hour integration method for each polarity is Sold/Bought[1] $\left[\frac{1}{N}\sum_{n=1}^{N}\{u(n)\cdot i(n)\}\right]\cdot \text{Time}$ 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.
Integration	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.
Integration	Ampere hours [Ah] q q+ q−	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 formulas for all iterations where i(n) is positive. q− is the sum of the above formulas for all iterations where i(n) is negative.
Integration	Volt-ampere hours WS[2][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.
Integration	Var hours WQ[2][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.

	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
Σ functions	UΣ [V]		(U1 + U2) / 2		(U1 + U2 + U3) / 3	
Σ functions	IΣ [A]		(I1 + I2) / 2		(I1 + I2 + I3) / 3	
Σ functions	PΣ [W]		P1 + P2			P1 + P2 + P3
Σ functions	SΣ [VA]	TYPE1, TYPE2	S1 + S2	$\frac{\sqrt{3}}{2}(S1 + S2)$	$\frac{\sqrt{3}}{3}(S1 + S2 + S3)$	S1 + S2 + S3
Σ functions	SΣ [VA]	TYPE3	$\sqrt{P\Sigma^2 + Q\Sigma^2}$			
Σ functions	QΣ [var]	TYPE1[3]	Q1 + Q2			Q1 + Q2 + Q3
Σ functions	QΣ [var]	TYPE2	$\sqrt{S\Sigma^2 - P\Sigma^2}$			
Σ functions	QΣ [var]	TYPE3	Q1 + Q2			Q1 + Q2 + Q3
Σ functions	PcΣ [W]		Pc1 + Pc2			Pc1 + Pc2 + Pc3

1 When the data update interval is Auto, the watt hour integration method for each polarity will only calculate the charge or discharge.

2 When the data update interval is Auto, WS and WQ will not be calculated.

3 When the data update interval is Auto, QΣ that includes elements with the sync source rectifier set to ON is calculated with TYPE2.

(Table 3/3)

Measurement function			Formula For the symbols in the formulas 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[1] WP+1 + WP+2			WP+1 + WP+2 + WP+3
			When the watt-hour integration method for each polarity is Sold/Bought[1] 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[1] WP–1 + WP–2			WP–1 + WP–2 + WP–3
			When the watt-hour integration method for each polarity is Sold/Bought[1] 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[2] [VAh]		$\frac{1}{N}\sum_{n=1}^{N} S\Sigma(n)\cdot \text{Time}$ SΣ(n) is the nth apparent power Σ function. N is the number of data updates. The unit of time is hours.			
	WQΣ[2] [varh]		$\frac{1}{N}\sum_{n=1}^{N} \lvert Q\Sigma(n)\rvert\cdot \text{Time}$ 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 [°]		$\cos^{-1}\left(\frac{P\Sigma}{S\Sigma}\right)$			

1 When the data update interval is Auto, the watt hour integration method for each polarity will only calculate the charge or discharge.

2 When the update mode is Auto, WSΣ and WQΣ will not be calculated.

- u(n) denotes instantaneous voltage.
- i(n) denotes instantaneous current.
- n denotes the nth measurement period. The measurement period is determined by the sync 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 sync 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 WT310/WT310HC/WT330 and the selected wiring system pattern.
- The numbers 1, 2, and 3 used in the formulas 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.
- Formula TYPE3 for SΣ and QΣ can only be selected on models with the harmonic measurement option.
- On this instrument, S, Q, λ, and Φ are derived through the calculation of the measured values of voltage, current, and active power. (However, when TYPE3 is selected, Q is calculated directly from the sampled data.) Therefore, for distorted signal input, the value obtained on the instrument 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 of harmonic measurement (option)

(Table 1/4)

Measurement function	Formula: Numbers and Characters in the Parentheses: dc (when k = 0)	Formula: Numbers and Characters in the Parentheses: 1 (when k = 1)	Formula: Numbers and Characters in the Parentheses: k (when k = 1 to max)	Formula: Total value (Total) (No parentheses)
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)[1]	$S(dc) = P(dc)$	$S(k) = \sqrt{P(k)^2 + Q(k)^2}$		$S = \sqrt{P^2 + Q^2}$
Reactive power Q( ) [var] (TYPE3)[1]	$Q(dc) = 0$	$Q(k) = U_r(k) \cdot I_j(k) - U_j(k) \cdot I_r(k)$		$Q = \sum_{k=min}^{max} Q(k)$
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[2][Hz]	Frequency of the PLL source of harmonic group 2 (PLL source 2)			

(Continued on next page)

1 For details on the types of S and Q formulas, see “Apparent power, reactive power, and corrected power formulas (formula)” in chapter 8, “Computation.”

2 When the data update interval is Auto, fPLL2 will not be measured.

- 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	Formula: 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 Formula Is the Total Value (Total)	When the Denominator of the Distortion Factor Formula 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 $U(Total) = \sqrt{\sum_{k=min}^{max} U(k)^2}$, $I(Total) = \sqrt{\sum_{k=min}^{max} I(k)^2}$, $P(Total) = \sum_{k=min}^{max} P(k)$

- 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		Formula			
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 on the types of SΣ and QΣ formulas, see "Apparent power, reactive power, and corrected power formulas (formula)" in chapter 8, "Computation."

- The numbers 1, 2, and 3 used in the formulas 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 calculated for Σ.

(Table 4/4)

Measurement function	Formula
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(°)	Phase angles of the fundamental waves of U1 to I6 with respect to the falling edge of the Z terminal input of the motor evaluation function (option)
EaU2(°)	
EaU3(°)	
EaU4(°)	
EaU5(°)	
EaU6(°)	
EaI1(°)	
EaI2(°)	
EaI3(°)	
EaI4(°)	
EaI5(°)	
EaI6(°)	

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

Delta Calculation Functions

Calculated results are determined by substituting all of the sampled data in the table into the formulas for voltage U and current I.* The sync source used in delta calculation 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 calculation.

Measurement function	Delta Calculation Type	Symbols and Meanings The calculation 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	Calculated differential voltage	ΔU1[Udiff]	u1—u2
	3P3W→3V3A	Unmeasured line voltage calculated in a three-phase three-wire system	ΔU1[Urs]	u1—u2
	Delta→Star	Phase voltage calculated 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 calculated 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	Calculated 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 calculated 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 ΔPΣ=ΔP1 + ΔP2 + ΔP3	ΔPΣ[PΣ]	—
	Star→Delta	—	—	—

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

* The formulas for voltage U and current I listed in "Symbols and Determination of Measurement Functions"

- 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 calculation measurement function symbols have no relation to the element numbers.
- For details on the rms, mean, dc, rmean, and ac formulas of delta calculation mode, see page 1 of the appendix.
- We recommend that you set the measurement range and scaling (conversion ratios and coefficients) of the elements that are undergoing delta calculation 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	How to Find, Formula
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 instrument calculates the torque pulse coefficient and torque pulse offset from torque values (the unit is N·m) at the upper and lower Normally use a scaling factor of 1. If you are using a unit other than N·m, set the unit conversion ratio.
SyncSp	$\frac{120 \cdot \text{the frequency of the frequency measurement source (Hz)}}{\text{Number of motor poles}}$ • The unit of sync 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
Slip [%]	$\frac{\text{SyncSp} - \text{Speed}}{\text{SyncSp}} \cdot 100$
Pm	$\frac{2\pi \cdot \text{Speed} \cdot \text{Torque}}{60} \cdot \text{Scaling coefficient}$ 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		How to Find, Formula	
Electrical angle [°]	EaU	$\tan^{-1}\dfrac{U_r(1)}{U_j(1)} - B$	Ur(1): real part of the fundamental voltage Uj(1): imaginary part of the fundamental voltage B: offset
	EaI	$\tan^{-1}\dfrac{I_r(1)}{I_j(1)} - B$	Ir(1): real part of the fundamental current Ij(1): imaginary part of the fundamental current B: offset

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

Measurement functions for auxiliary input (option)

Measurement function	How to Find, Formula
AUX1	**S(AX + B) – NULL** S: scaling factor A: slope of the auxiliary signal X: average value of the auxiliary 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 auxiliary signal X: average value of the auxiliary signal's input voltage (AVG[AUX_input2(n)]) B: offset NULL: null value

- AUX_input1(n) and AUX_input2(n) denote the instantaneous auxiliary input.
- n denotes the nth measurement period. The measurement period is determined by the sync 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 sync source setting.

High speed data capturing measurement functions

Measurement function		How to Find, Formula	
U[V]*1	RMS	True rms value	$\sqrt{\dfrac{1}{N}\sum_{n=0}^{N-1} \mathrm{HSFilter}[u(n)^2]}$
	MEAN	Rectified mean value calibrated to the rms value	$\dfrac{\pi}{2\sqrt{2}} \times \dfrac{1}{N}\sum_{n=0}^{N-1} \mathrm{HSFilter}[\lvert u(n)\rvert]$
	RMEAN	Current rectified mean value	$\dfrac{1}{N}\sum_{n=0}^{N-1} \mathrm{HSFilter}[\lvert u(n)\rvert]$
	DC	Simple average	$\dfrac{1}{N}\sum_{n=0}^{N-1} \mathrm{HSFilter}[u(n)]$

(Continued on next page)

Measurement function		How to Find, Formula
I[A][1]	RMS	True rms value $\sqrt{\frac{1}{N}\sum_{n=0}^{N-1} \text{HSFilter}\,[i(n)^2]}$
	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	Current 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	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]	Current 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 (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]	Current 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	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]	Current 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 (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 (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 $\frac{1}{N}\sum_{n=0}^{N-1} \text{HSFilter }[torque(n)]$
Speed		Simple average $\frac{1}{N}\sum_{n=0}^{N-1} \text{HSFilter }[speed(n)]$
Pm		See "Motor output Pm" on page App-8.
AUX1		Simple average $\frac{1}{N}\sum_{n=0}^{N-1} \text{HSFilter }[aux1(n)]$
AUX2		Simple average $\frac{1}{N}\sum_{n=0}^{N-1} \text{HSFilter }[aux2(n)]$

1 The cutoff frequency of the HS filter needs to be set properly according to the frequency of the circuit under measurement.
2 This value does not have physical meaning when three-phase AC wiring is used.

- In the above formulas, 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 calculation.

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

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

Power

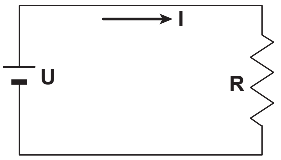
Electrical energy can be converted into other forms of energy and used. For example, it can be converted into the heat in an electric heater, the torque in a motor, or the light in a fluorescent or mercury lamp. In these kinds of examples, the work that electricity performs in a given period of time (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 formula above is retrieved from the power supply and consumed by resistance R (in ohms) every second.

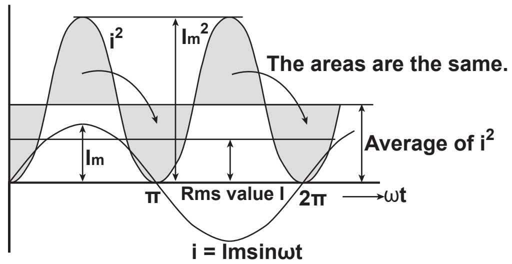


Alternating current

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 Imsinωt (where Im is the maximum value of the current, ω is the angular velocity defined as ω = 2πf, and f is the frequency of the sinusoidal alternating current). The thermal action of this alternating current is proportional to i2, 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):

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

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.

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

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

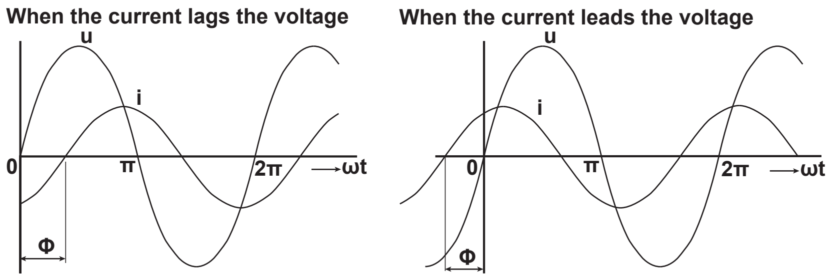
Vector display of alternating current

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

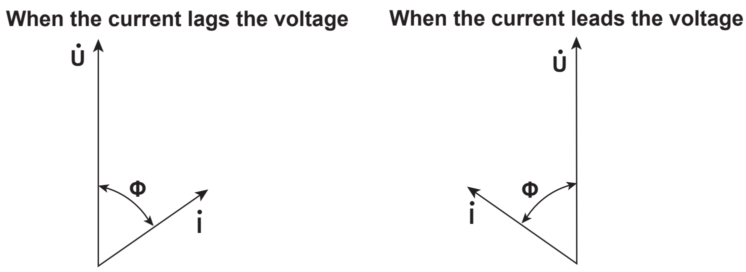
Voltage: u = Umsinωt

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.

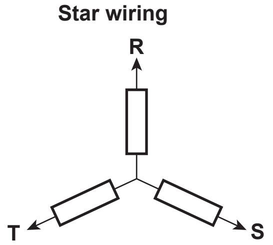


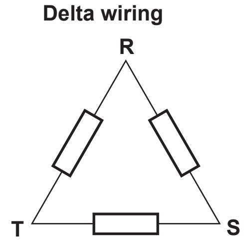
A vector display is used to clearly convey the magnitude and phase relationships between the voltage and current. A positive phase angle is represented by a counterclockwise angle with respect to the vertical axis. Normally, a dot is placed above the symbol representing a quantity to explicitly indicate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



Three-Phase AC Wiring

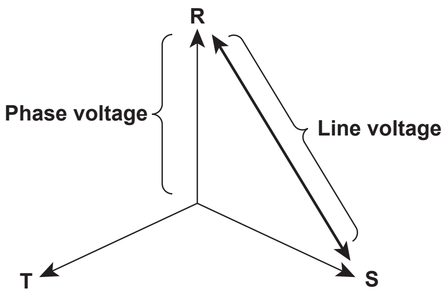
Generally three-phase AC power lines or loads are connected in star wiring configurations or delta wiring configurations.





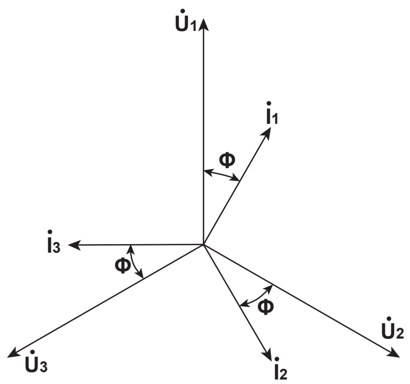
Vector Display of Three-Phase Alternating Current

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.

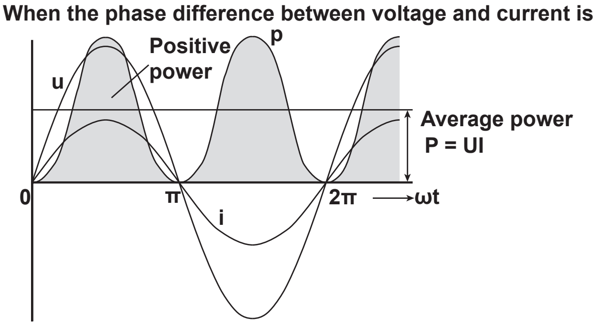
p is the sum of the time-independent term, $UI\cos\Phi$, and the AC component term of the voltage or current at twice the frequency, $-UI\cos(2\omega t - \Phi)$.

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

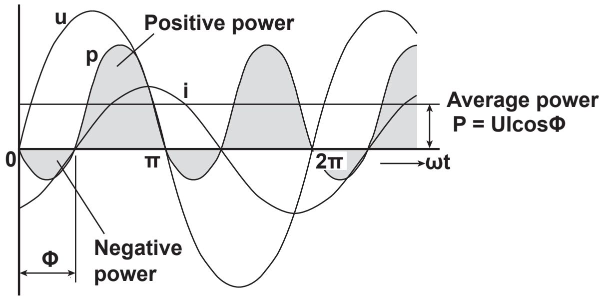
$P = UI\cos\Phi$ [W]

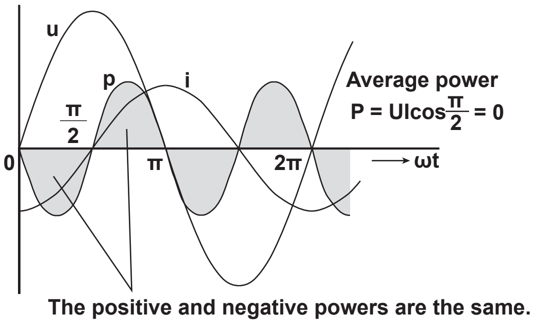
Even if the voltage and current are the same, the power varies depending on the phase difference Φ. The section above the horizontal axis in the figure below represents positive power (power supplied to the load), and the section below the horizontal axis represents negative power (power fed back from 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 Φ = π/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





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]

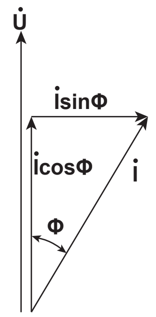
$P = UI\cos\Phi$ [W]

$\cos\Phi$ is called the power factor and is expressed as λ. It is the ratio of active power to apparent 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, $I\cos\Phi$, and a perpendicular component, $I\sin\Phi$. Active power P, which is equal to $UI\cos\Phi$, is the product of voltage U and the current component $I\cos\Phi$. The product of voltage U and the current component $I\sin\Phi$ 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 nth 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.
- Circuit breakers and fuses
  Excessive harmonic current can cause erroneous operation and blow fuses.
- Communication cables
  The electromagnetic induction caused by harmonics creates noise voltage.
- Control devices
  Harmonic distortion of control signals can lead to erroneous operation.
- Audio visual devices
  Harmonics can cause degradation of performance and service life, noise-related video flickering, and damaged parts.

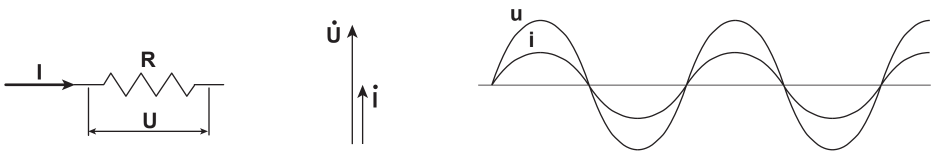
AC RLC circuits

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 following formula. I_m denotes the maximum current.

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

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

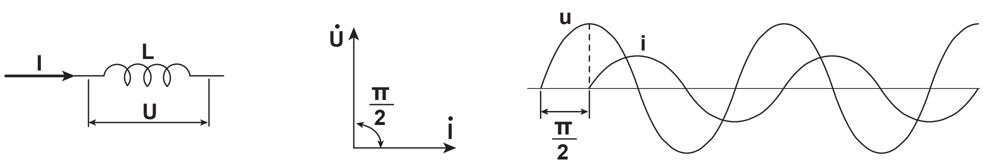


Inductance

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 following formula.

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

Expressed using rms values, the formula 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.

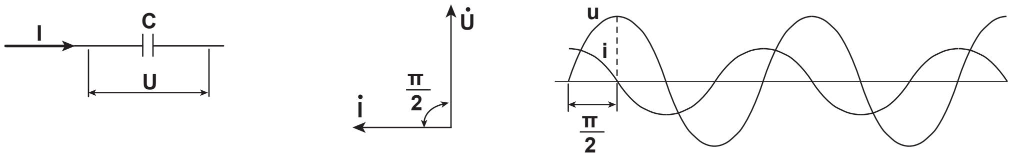


Capacitance

The current i when an AC voltage whose instantaneous value $u = U_m\sin\omega t$ is applied to capacitance C [F] is expressed by the following formula.

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

Expressed using rms values, the formula 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.



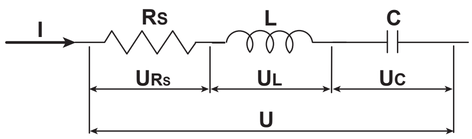
Series RLC circuits

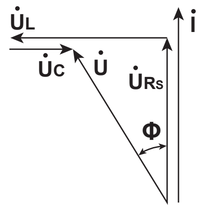
The formulas below express the voltage relationships when resistance R_S [Ω], inductance L [H], and capacitance C [F] are connected in series.

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

$$= I\sqrt{(Rs)^2 + (X_L - X_C)^2} = I\sqrt{RS^2 + XS^2}$$

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





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

$$X_S = X_L - X_C$$

$$Z = \sqrt{RS^2 + XS^2}$$

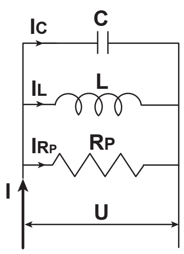
Parallel RLC circuits

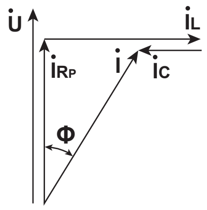
The formulas below express the current relationships when resistance R_P [Ω], inductance L [H], and capacitance C [F] are connected in parallel.

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

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

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





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

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

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

Appendix 3 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 five for numbers up to 60000 and four digits for larger numbers.

When the crest factor is set to 3

Active power range of each element

Current Range	Voltage Range [V]					
[A]	1.5000	3.0000	6.0000	10.000	15.000	30.000
10.000 m	15.000 mW	30.000 mW	60.000 mW	100.00 mW	150.00 mW	300.00 mW
20.000 m	30.000 mW	60.000 mW	120.00 mW	200.00 mW	300.00 mW	600.00 mW
50.000 m	75.00 mW	150.00 mW	300.00 mW	500.00 mW	0.7500 W	1.5000 W
100.00 m	150.00 mW	300.00 mW	600.00 mW	1.0000 W	1.5000 W	3.0000 W
200.00 m	300.00 mW	600.00 mW	1.2000 W	2.0000 W	3.0000 W	6.0000 W
500.00 m	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
10.000 m	600.00 mW	1.0000 W	1.5000 W	3.0000 W	6.0000 W	10.000 W
20.000 m	1.2000 W	2.0000 W	3.0000 W	6.0000 W	12.000 W	20.000 W
50.000 m	3.0000 W	5.0000 W	7.500 W	15.000 W	30.000 W	50.000 W
100.00 m	6.0000 W	10.000 W	15.000 W	30.000 W	60.000 W	100.00 W
200.00 m	12.000 W	20.000 W	30.000 W	60.000 W	120.00 W	200.00 W
500.00 m	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
10.000 m	30.000 mW	60.000 mW	120.000 mW	200.00 mW	300.00 mW	600.00 mW
20.000 m	60.000 mW	120.000 mW	240.00 mW	400.00 mW	600.00 mW	1200.00 mW
50.000 m	150.00 mW	300.00 mW	600.00 mW	1000.00 mW	1.5000 W	3.0000 W
100.00 m	300.00 mW	600.00 mW	1200.00 mW	2.0000 W	3.0000 W	6.0000 W
200.00 m	600.00 mW	1200.00 mW	2.4000 W	4.0000 W	6.0000 W	12.0000 W
500.00 m	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	Voltage Range [V]					
[A]	**60.000**	**100.00**	**150.00**	**300.00**	**600.00**	**1000.0**
10.000 m	1200.00 mW	2.0000 W	3.0000 W	6.0000 W	12.0000 W	20.000 W
20.000 m	2.4000 W	4.0000 W	6.0000 W	12.0000 W	24.000 W	40.000 W
50.000 m	6.0000 W	10.0000 W	15.000 W	30.000 W	60.000 W	100.000 W
100.00 m	12.0000 W	20.000 W	30.000 W	60.000 W	120.000 W	200.00 W
200.00 m	24.000 W	40.000 W	60.000 W	120.000 W	240.00 W	400.00 W
500.00 m	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	Voltage Range [V]					
[A]	**1.5000**	**3.0000**	**6.0000**	**10.000**	**15.000**	**30.000**
10.000 m	45.000 mW	90.000 mW	180.000 mW	300.00 mW	450.00 mW	900.00 mW
20.000 m	90.000 mW	180.000 mW	360.00 mW	600.00 mW	900.00 mW	1800.00 mW
50.000 m	225.00 mW	450.00 mW	900.00 mW	1500.00 mW	2.2500 W	4.5000 W
100.00 m	450.00 mW	900.00 mW	1800.00 mW	3.0000 W	4.5000 W	9.0000 W
200.00 m	900.00 mW	1800.00 mW	3.6000 W	6.0000 W	9.0000 W	18.0000 W
500.00 m	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	Voltage Range [V]					
[A]	**60.000**	**100.00**	**150.00**	**300.00**	**600.00**	**1000.0**
10.000 m	1800.00 mW	3.0000 W	4.5000 W	9.0000 W	18.0000 W	30.000 W
20.000 m	3.6000 W	6.0000 W	9.0000 W	18.0000 W	36.000 W	60.000 W
50.000 m	9.0000 W	15.0000 W	22.500 W	45.000 W	90.000 W	150.000 W
100.00 m	18.0000 W	30.000 W	45.000 W	90.000 W	180.000 W	300.00 W
200.00 m	36.000 W	60.000 W	90.000 W	180.000 W	360.00 W	600.00 W
500.00 m	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 6 or 6A

Active power range of each element

Current Range	Voltage Range [V]					
[A]	0.7500	1.5000	3.0000	5.0000	7.500	15.000
5.0000 m	3.7500 mW	7.500 mW	15.000 mW	2.5000 mW	37.500 mW	75.00 mW
10.000 m	7.500 mW	15.000 mW	30.000 mW	50.000 mW	75.00 mW	150.00 mW
25.000 m	18.750 mW	37.500 mW	75.00 mW	125.00 mW	187.50 mW	375.00 mW
50.000 m	37.500 mW	75.00 mW	150.00 mW	250.00 mW	375.00 mW	0.7500 W
100.00 m	75.00 mW	150.00 mW	300.00 mW	500.00 mW	0.7500 W	1.5000 W
250.00 m	187.50 mW	375.00 mW	0.7500 W	1.2500 W	1.8750 W	3.7500 W
500.00 m	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	Voltage Range [V]					
[A]	30.000	50.000	75.00	150.00	300.00	500.00
5.0000 m	150.00 mW	250.00 mW	375.00 mW	0.7500 W	1.5000 W	2.5000 W
10.000 m	300.00 mW	500.00 mW	0.7500 W	1.5000 W	3.0000 W	5.0000 W
25.000 m	0.7500 W	1.2500 W	1.8750 W	3.7500 W	7.500 W	12.500 W
50.000 m	1.5000 W	2.5000 W	3.7500 W	7.500 W	15.000 W	25.000 W
100.00 m	3.0000 W	5.0000 W	7.500 W	15.000 W	30.000 W	50.000 W
250.00 m	7.500 W	12.500 W	18.750 W	37.500 W	75.00 W	125.00 W
500.00 m	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	Voltage Range [V]					
[A]	0.7500	1.5000	3.0000	5.0000	7.500	15.000
5.0000 m	7.5000 mW	15.000 mW	30.000 mW	50.000 mW	75.000 mW	150.00 mW
10.000 m	15.000 mW	30.000 mW	60.000 mW	100.000 mW	150.00 mW	300.00 mW
25.000 m	37.500 mW	75.000 mW	150.00 mW	250.00 mW	375.00 mW	750.00 mW
50.000 m	75.000 mW	150.00 mW	300.00 mW	500.00 mW	750.00 mW	1.5000 W
100.00 m	150.00 mW	300.00 mW	600.00 mW	1000.00 mW	1.5000 W	3.0000 W
250.00 m	375.00 mW	750.00 mW	1.5000 W	2.5000 W	3.7500 W	7.5000 W
500.00 m	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	Voltage Range [V]					
[A]	30.000	50.000	75.00	150.00	300.00	500.00
5.0000 m	300.00 mW	500.00 mW	750.00 mW	1.5000 W	3.0000 W	5.0000 W
10.000 m	600.00 mW	1000.00 mW	1.5000 W	3.0000 W	6.0000 W	10.0000 W
25.000 m	1.5000 W	2.5000 W	3.7500 W	7.5000 W	15.000 W	25.000 W
50.000 m	3.0000 W	5.0000 W	7.5000 W	15.000 W	30.000 W	50.000 W
100.00 m	6.0000 W	10.0000 W	15.000 W	30.000 W	60.000 W	100.000 W
250.00 m	15.000 W	25.000 W	37.500 W	75.000 W	150.00 W	250.00 W
500.00 m	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	Voltage Range [V]					
[A]	0.7500	1.5000	3.0000	5.0000	7.500	15.000
5.0000 m	11.2500 mW	22.500 mW	45.000 mW	75.000 mW	112.500 mW	225.00 mW
10.000 m	22.500 mW	45.000 mW	90.000 mW	150.000 mW	225.00 mW	450.00 mW
25.000 m	56.250 mW	112.500 mW	225.00 mW	375.00 mW	562.50 mW	1125.00 mW
50.000 m	112.500 mW	225.00 mW	450.00 mW	750.00 mW	1125.00 mW	2.2500 W
100.00 m	225.00 mW	450.00 mW	900.00 mW	1500.00 mW	2.2500 W	4.5000 W
250.00 m	562.50 mW	1125.00 mW	2.2500 W	3.7500 W	5.6250 W	11.2500 W
500.00 m	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	Voltage Range [V]					
[A]	30.000	50.000	75.00	150.00	300.00	500.00
5.0000 m	450.00 mW	750.00 mW	1125.00 mW	2.2500 W	4.5000 W	7.5000 W
10.000 m	900.00 mW	1500.00 mW	2.2500 W	4.5000 W	9.0000 W	15.0000 W
25.000 m	2.2500 W	3.7500 W	5.6250 W	11.2500 W	22.500 W	37.500 W
50.000 m	4.5000 W	7.5000 W	11.2500 W	22.500 W	45.000 W	75.000 W
100.00 m	9.0000 W	15.0000 W	22.500 W	45.000 W	90.000 W	150.000 W
250.00 m	22.500 W	37.500 W	56.250 W	112.500 W	225.00 W	375.00 W
500.00 m	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 4 Setting the Measurement Period

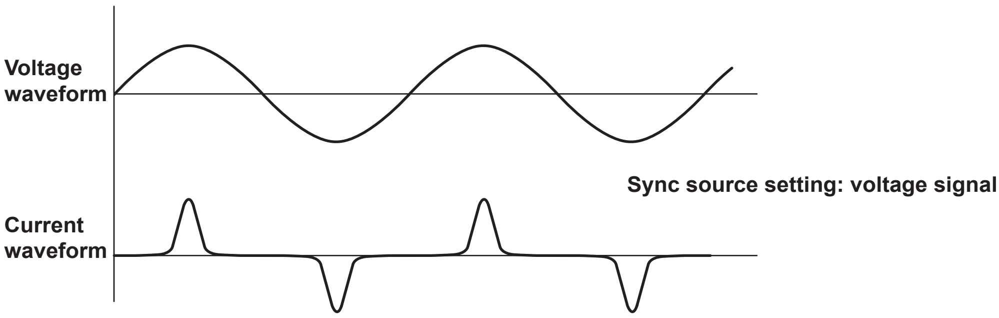
To make correct measurements with the instrument, you must set its measurement period properly.

This instrument 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 instrument 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 sync source. The measurement period is automatically determined inside the instrument when you specify the sync source.

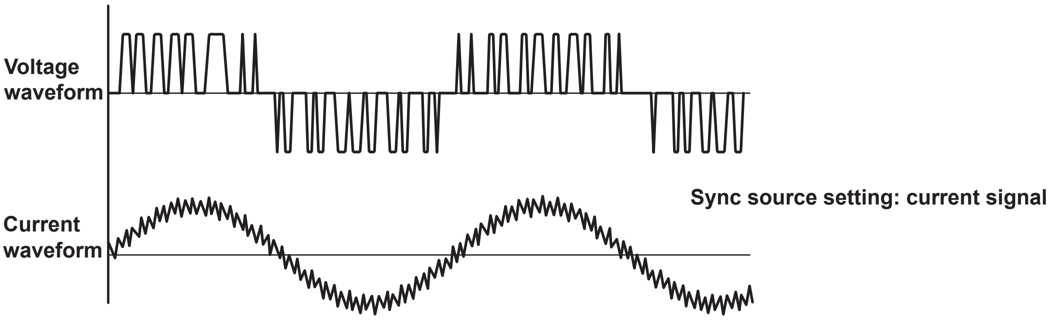
You can select the sync source signal from the options listed below.
U1, I1, U2, I2, U3, I3, U4, I4, U5, I5, U6, I6, Ext Clk (external clock), and None
* The available options vary depending on the installed elements.
For example, if the sync source for input element 1 is set to I1, an integer multiple of the period of I1 becomes the measurement period. By averaging the sampled data in this measurement period, the instrument calculates the measured values for input element 1, such as U1, I1, and P1.

Deciding whether to use voltage or current input as the sync source

Select input signals with stable input levels and frequencies (with little distortion) as sync sources. Correct measured values can only be obtained if the period of the sync source signal is detected accurately. On the instrument, display the frequency of the input signal that you have selected as the sync source, and confirm that the frequency is being measured correctly. The most suitable sync 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 sync source to the voltage signal.

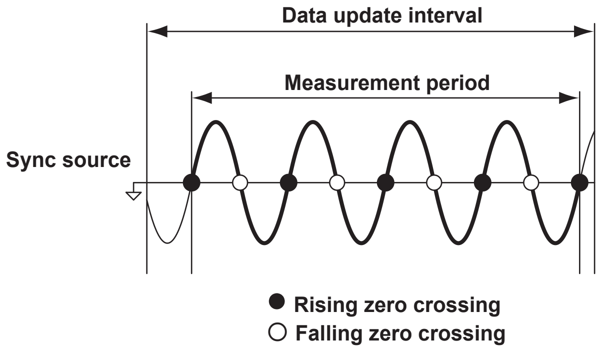


As another example, if an inverter is being measured and the current waveform distortion is smaller than the voltage waveform distortion, set the sync source to the current signal.



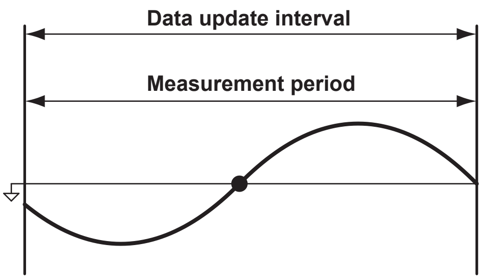
Zero crossing

- The rising (or falling) zero crossing is the time when the sync source passes through level zero (the center of the amplitude) on a rising (or falling) slope. The measurement period on the WT310/WT310HC/WT330 is between the first rising (or falling) zero crossing and the last rising (or falling) zero crossing in the data update interval.
- This instrument 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 sync source cannot be detected

If the total number of rising and falling zero crossings on the input signal that has been set as the sync 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 the frequency levels detectable by the frequency measurement circuit, see the conditions listed under “Accuracy” under “Frequency measurement” in section 5.5, “Features,” in the Getting Started Guide, IM WT1801R-03EN. 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.

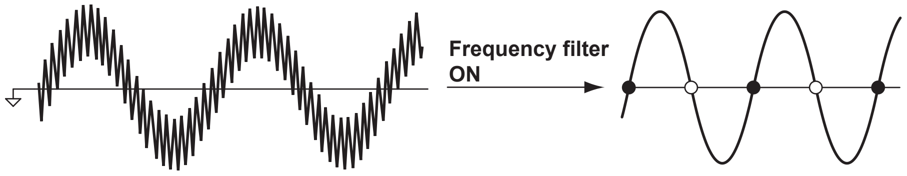


Because of the reasons described above, the measured voltage and current values may be unstable. If this happens, lower the data update rate so that more periods of the input signal fit within the data update interval.

When the waveform of the sync source is distorted

Change the sync 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.

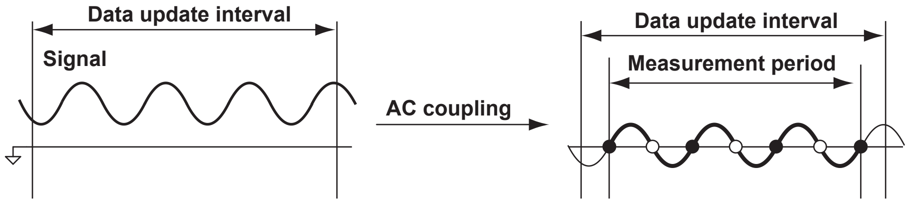
The instrument reduces the effects of noise by using hysteresis when it detects zero crossings. If the sync source is distorted or harmonics and noise are superposed on the signal to a level exceeding this hysteresis, harmonic components will cause zero crossing detection to occur frequently, and the 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 sync source's zero crossings, it is sometimes called the sync source filter or the zero-crossing filter.



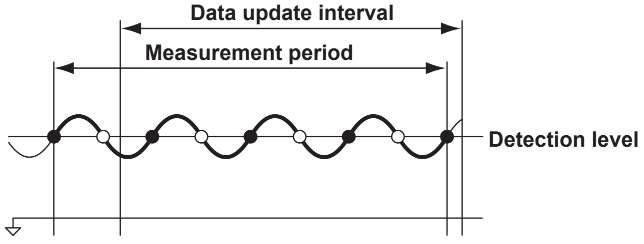
When measuring a signal that has no zero crossings because of a DC offset superposed on the AC signal

The measured values may be unstable if the period of the AC signal cannot be detected accurately. Change the sync source to a signal that allows for more stable detection of the period (switch from voltage to current or from current to voltage).

- When the data update interval is not Auto, 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.



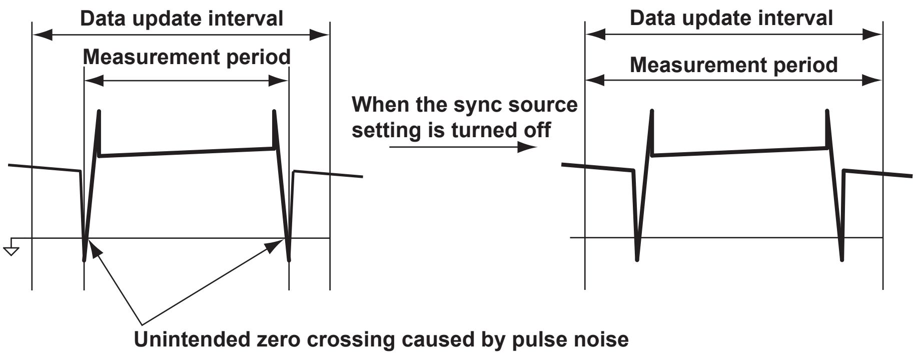
- When the data update interval is Auto, you can detect the period by setting the detection level to the center of the current amplitude.



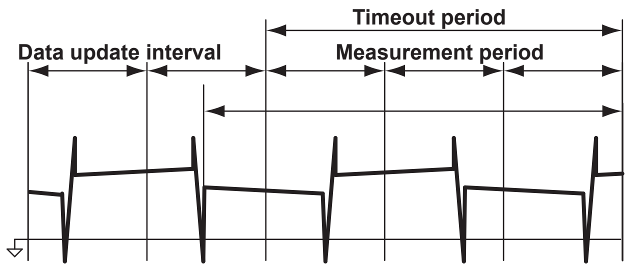
When measuring a DC signal

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 sync source to None.

- When the data update interval is not Auto, all the sampled data in the data update interval is used to determine measured values.



- When the data update interval is Auto, all the sampled data within the timeout period is used to determine measured values.



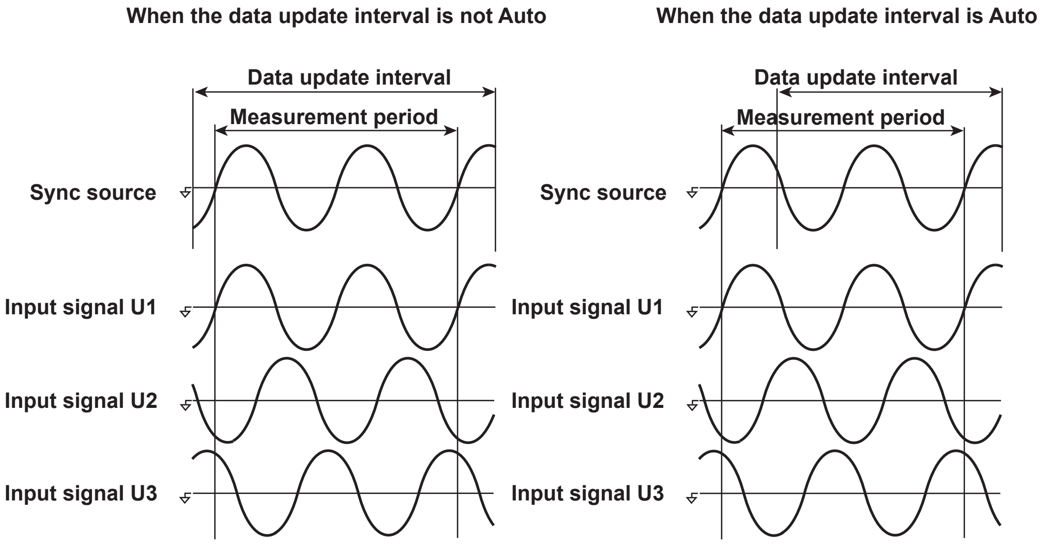
Set the sync source according to the signal under measurement and the measurement objective.

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 sync source of input elements 1 and 2 to the same signal. For example, set the sync 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 sync source of input elements 1, 2, and 3 to the same signal.

To facilitate this sort of configuration, the sync 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 sync source of each input element in the Σ wiring unit can be set independently.

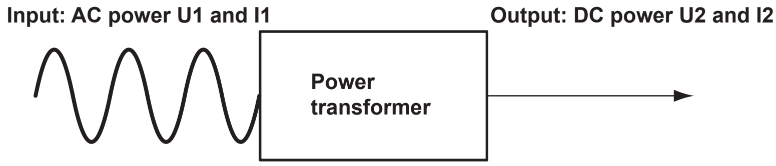


Synchronization Source Setup Example	
Input element 1	U1 (or I1)
Input element 2	
Input element 3	

Setting the synchronization period when measuring the efficiency of a power transformer

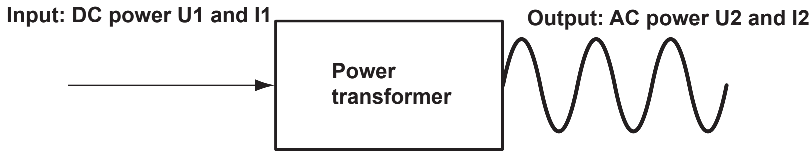
- **Power transformer with single-phase input and single-phase output**

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 sync 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 sync 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.



Sync 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 sync 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 sync source of input elements 1 and 2 to U2 (or I2).

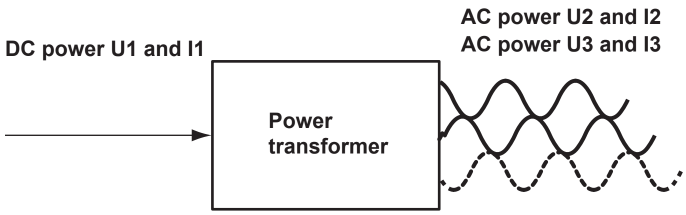


Sync Source Setup Example	
Input element 1	U2 (or I2)
Input element 2	

- **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 sync 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 sync 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.

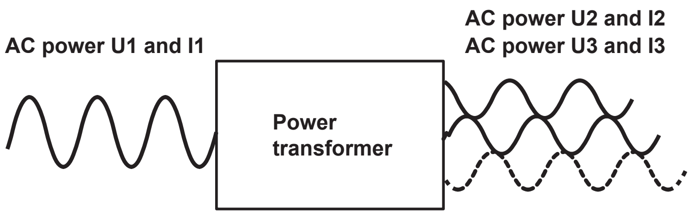


Sync Source Setup Example	
Input element 1	U2 (or I2, U3, or I3)
Input element 2	
Input element 3	

- **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 sync 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 sync source of input element 1 to U1 (or I1), and set the sync 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 sync 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.



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

- When the data update interval is not Auto, 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.
- When the data update interval is Auto, the measurement period for determining the numeric data of the maximum voltage and current (Peak) will be the measurement period specified earlier.
- For details on the measurement period for measurement functions related to harmonic measurement, see chapter 2, “Measurement Period.”

Appendix 5 User-Defined Function Operands

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

Measurement functions of normal measurement

Measurement Function	User-Defined Functions		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
Fundamental voltage component	UFND( )	UFND(E1)	Yes	Yes
Fundamental current component	IFND( )	IFND(E1)	Yes	Yes
Fundamental active power component	PFND( )	PFND(E1)	Yes	Yes
Fundamental apparent power component	SFND( )	SFND(E1)	Yes	Yes
Fundamental reactive power component	QFND( )	QFND(E1)	Yes	Yes
Fundamental power factor component	LAMBDAFND( )	LAMBDAFND(E1)	Yes	Yes
Fundamental power factor angle component	PHIFND( )	PHIFND(E1)	Yes	Yes

Integrated power (watt hours)

Measurement Function	User-Defined Functions		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 Functions		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 Functions		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 Functions		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 Functions		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 Functions		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 Functions		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 calculation

Measurement Function	User-Defined Functions		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 Functions		Left Parameter in (,) or Parameter in ( )		Right Parameter in (,)			
			Element	Wiring Unit	Harmonics			
					Total	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 6 USB Keyboard Key Assignments

104 keyboard (US)

Key	Pressed while Ctrl key held down on USB keyboard		Soft keyboard displayed on instrument		Other	
		Instrument shift state ON		USB keyboard shift state ON		Instrument shift state 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		m	M		
n	Execute NUMERIC		n	N		
o	OTHERS menu		o	O		
p	INPUT SET		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 cell) : No feature is assigned to the key.

Key	Pressed while Ctrl key held down on USB keyboard		Soft keyboard displayed on instrument		Other	
		Instrument shift state ON		USB keyboard shift state ON		Instrument shift state 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						
Scroll Lock	Execute IMAGE SAVE	IMAGE SAVE menu				
Pause	Execute LOCAL	Execute KEY LOCK				
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	Pressed while Ctrl key held down on USB keyboard		Soft keyboard displayed on instrument		Other	
		Instrument shift state ON		USB keyboard shift state ON		USB keyboard shift state ON
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.

109 keyboard (Japanese)

Key	Pressed while Ctrl key held down on USB keyboard		Soft keyboard displayed on instrument		Other	
		Instrument shift state ON		USB keyboard shift state ON		Instrument shift state 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		m	M		
n	Execute NUMERIC		n	N		
o	OTHERS menu		o	O		
p	INPUT SET		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 box) : No feature is assigned to the key.

Key	When the Ctrl Key Is Held Down on the USB Keyboard		When the Soft Keyboard Is Displayed on This Instrument		Other	
		When the Shift of This Instrument Is On		+Shift on the USB Keyboard		When the Shift of This Instrument 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						
Scroll Lock	Execute IMAGE SAVE	IMAGE SAVE menu				
Pause	Execute LOCAL	Execute KEY LOCK				
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	Pressed while Ctrl key held down on USB keyboard		Soft keyboard displayed on instrument		Other	
		When the Shift of This Instrument Is On		USB keyboard shift state ON		USB keyboard shift state ON
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.

Appendix 7 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				
ΔMeasure Type	-			
ΔMeasure Mode	rms			
All Elements Setup				
Sensor Preset	Others			
CT Preset	Others			
For other items, see RANGE, SENSOR RATIO, SCALING, LINE FILTER, FREQ FILTER, and SYNC SOURCE.				
SCALING				
Scaling	Off			
VT Scaling	1.0000			
CT Scaling	1.0000			
Scaling Factor	1.0000			
LINE FILTER	Normal measurement mode: Off (Cutoff 0.5 kHz) High speed data capturing mode: On (Cutoff 300 kHz)			
FREQ FILTER				
Freq Filter	Off			
Freq Filter at Update Rate Auto	Off			
Cutoff	100Hz			
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)

* Available on models with the external current sensor input option

Item	Setting					
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					
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					
SYNC SOURCE						
Element Object	Element1	Element2	Element3	Element4	Element5	Element6
Sync Source	I1	I2	I3	I4	I5	I6
Sync Source Settings						
Voltage Rectifier	Off					
Voltage Level	0.0 %					
Current Rectifier	Off					
Current Level	0.0 %					
Ext. Sensor Rectifier	Off					
Ext. Sensor Level	0.0 %					
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					
Hrm1 FFT Points	1024					
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			

* Available on models with the simultaneous dual harmonic measurement option

Item	Setting		
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		
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			
Auto	Off		
Update Rate	500ms		
Time Out at Update Rate Auto	1s		
HOLD			
Hold	Off		
INTEG			
Integrator Status	Reset condition		
Independent Control	Off		
Integ Set			
Mode	Normal		
Integ Timer	00000:00:00		
Integ Start	2024/01/01 00:00:00		
Integ End	2024/01/01 01:00:00		
Auto Cal	Off		
WP±Type			
Setting	Each		
Element1 to 6	Charge/Discharge		
q mode			
Setting	Each		
Element1 to 6	dc		
D/A Output Rated Time	00001:00:00 (Displayed on models with the D/A output option)		

Item	Setting		
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 %		
FORM (Wave)			
Format	Single		
Time/div	5ms		
Trigger Settings			
Mode	Off		
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[1]:0, Torque[1]:0 , Aux1[2]:0, Aux2[2]:0		
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		

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

2 Available on models with the auxiliary input option

Item	Setting	
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	
FORM (high speed data capturing)		
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)		
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
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
NULL	
Null	Off
NULL SET	
Target Element	All
On 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]	English			
Message Language[1]	English			
LCD				
Auto OFF[1, 2]	Off			
Auto OFF Time[1, 2]	5min			
Brightness	7			
Color Settings				
Graph Color	Default			
Grid Intensity	4			
Base Color	Gray			
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			
Integration Resume Action	Error			
Menu Font Size[1, 2]	Large			
Rounding to Zero	On			
Crest Factor	CF3			
Network				
TCP/IP				
DHCP[1, 2]	On			
DNS[1, 2]	Auto			
FTP/Web Server				
User Name[1, 2]	anonymous			
Time Out(s)[1, 2]	900			
Net Drive				
Login Name[1, 2]	anonymous			
FTP Passive[1, 2]	Off			
Time Out(s)[1, 2]	15			
SNTP				
Time Out(s)[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 item is not affected when the instrument is initialized (by pressing UTILITY and then Initialize Settings).
2 This item is not loaded when a setup parameter file is loaded (by pressing FILE and then Load Setup).

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**	**9**[2]	**10**[2]	**11**[2]	**12**[2]
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*3]	ΔI	Q(k)	Rs(k)	Ithf	ΦUi-Uk
λ	U+pk	I+pk	q+	F6	Ev6	Torque[*1*3]	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[4]			F10							
	P-pk[4]			F11							
				F12							
				F13							
				F14							
				F15							
				F16							
				F17							
				F18							
				F19							
				F20							

Left side of the single list screen[2] and dual list screen[2]

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 These appear on models with the motor evaluation option.
2 Electrical angle measurement is displayed on models with the harmonic measurement option or simultaneous dual harmonic measurement option.
3 On models with the auxiliary input option, Aux1 is displayed instead of Speed, and Aux2 is displayed instead of Torque.
4 Not displayed when the split display is in use.

Appendix 8 Limitations on Modifying Settings and Operations

During integration and storage, 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		
		Start/ Ready	Stop/ Timeup/ Error	Start/ Ready	Stop	Comp/ Error
Basic Measurement Conditions	Wiring	No	No	No	No	No
	η Formula	No	Yes	No	No	No
	Element Independent	No	No	No	No	No
	ΔMeasure Type	No	No	No	No	No
	ΔMeasure Mode	No	Yes	No	No	No
	Element ALL	No	No	No	No	No
	Voltage or Current Range	No	No	Yes	Yes	Yes
	Voltage or Current Auto Range	No	No	Yes	Yes	Yes
	Direct Current Input Or External Current Sensor	No	No	No	No	No
	Sensor Preset	No	No	No	No	No
	Sensor Ratio	No	No	No	No	No
	CT Preset	No	No	No	No	No
	VT/CT/SF Scaling	No	No	No	No	No
	Config(V)/Config(A)	No	No	No	No	No
	Crest Factor	No	No	No	No	No
	Sync Source	No	No	No	No	No
	Sync Source Settings	No	No	No	No	No
	Line Filter	No	No	No	No	No
	Freq Filter	No	No	No	No	No
	Update Rate	No	No	No	No	No
	Update Rate Auto	No	No	No	No	No
	Timeout at Update Rate Auto	No	No	No	No	No
	Average	No	No	No	No	No
Harmonics	PLL Source	No	No	No	No	No
	Min/Max Order	No	No	No	No	No
	Thd Formula	No	No	No	No	No
	Element Settings	No	No	No	No	No
Motor	Scaling	No	No	No	No	No
	Sense Type	No	No	No	No	No
	Auto Range	No	No	Yes	Yes	Yes
	Range	No	No	Yes	Yes	Yes
	Linear Scale A/B	No	No	No	No	No
	Linear Scale Calculate Execute	No	No	No	No	No
	Line Filter	No	No	No	No	No
	Motor	No	No	No	No	No
	Pulse Range Upper/Lower	No	No	No	No	No
	Torque Pulse	No	No	No	No	No
	Torque Pulse Rated Freq	No	No	No	No	No
	Pulse N	No	No	No	No	No
	Pole	No	No	No	No	No
	Sync Speed Source	No	No	No	No	No
	Electrical Angle Measurement ON/OFF	No	No	No	No	No
	Electrical Angle Correction	No	No	No	No	No
Auxiliary Signal	Scaling	No	No	No	No	No
	Auto Range	No	No	Yes	Yes	Yes
	Range	No	No	Yes	Yes	Yes
	Linear Scale A/B	No	No	No	No	No
	Linear Scale Calculate Execute	No	No	No	No	No
	Line Filter	No	No	No	No	No

Operation (changing settings or executing features)		Integration Status		Storage State		
		Start/ Ready	Stop/ Timeup/ Error	Start/ Ready	Stop	Comp/ Error
Computation	User-Defined Function Conditions	No	Yes	No	No	No
	Max Hold ON/OFF	No	No	Yes	Yes	Yes
	User-Defined Event Conditions	No	Yes	No	No	No
Computation	S Formula	No	No	No	No	No
	S, Q Formula	No	No	No	No	No
	Pc Formula	No	No	No	No	No
	Sampling Frequency	No	No	No	No	No
	Phase	No	No	No	No	No
	Sync Measure	No	No	No	No	No
Integration	Independent Control	No	No	×[1]	×[1]	×[1]
	D/A Rated Time	No	No	Yes	Yes	Yes
Waveform Display	Time/Div	No	No	No	No	No
	Trigger Mode	No	No	Yes	Yes	Yes
	Trigger Source	No	No	No	No	No
	Trigger Slope	No	No	No	No	No
	Trigger Level	No	No	No	No	No
Storage	STORE CSV Conversion	Yes	Yes	No	No	Yes
	STORE START	Yes	Yes	×[2]	Yes	No
	STORE STOP	Yes	Yes	Yes	Yes	Yes
	STORE RESET	Yes	Yes	Yes	Yes	Yes
File	File Auto Naming	Yes	Yes	No	No	Yes
	File Name	Yes	Yes	No	No	Yes
	Comment	Yes	Yes	No	No	Yes
	Setup File Save	No	No	No	No	No
	Setup File Load	No	No	No	No	No
	Numeric Save	No	Yes	No	No	Yes
	Numeric Save Item Settings	Yes	Yes	No	No	Yes
	Wave Save	No	Yes	No	No	Yes
	Custom File Save	No	Yes	No	No	Yes
	Custom File Load	No	No	No	No	No
	Change Drive	Yes	Yes	No	No	No
	Change Directory	Yes	Yes	No	No	No
	Delete	No	No	No	No	No
	Rename	No	No	No	No	No
	Make Directory	No	No	No	No	No
	Copy	No	No	No	No	No
	Move	No	No	No	No	No
	Save Images	No	Yes	No	No	Yes
Utility	Initialize Settings	Yes	Yes	No	No	No
	Date/Time	No	No	No	No	No
	Date/Time Type	No	No	No	No	No
	Menu Language	No	No	Yes	Yes	Yes
	Message Language	No	No	Yes	Yes	Yes
	Menu Font Size	No	No	Yes	Yes	Yes
	Freq Display at Frequency Low	No	No	No	No	No
	Motor Display at Pulse Freq Low	No	No	No	No	No
	SelfTest	No	No	No	No	No
Other Features	Manual Cal	No	No	Yes	Yes	Yes
	NULL	No	No	No	No	No

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 9 Limitations on the Features during High Speed Data Capturing

This instrument cannot change measurement conditions or calculation settings during high-speed data collection. Additionally, there are some functions that cannot be executed.

Item			Operation
High speed data capturing	Capture count		Yes[1, 2]
	Optimize count		Yes[1, 2]
	Capture control	Voltage/current measurement 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

High speed data capturing items cannot be set or executed in normal measurement.

Item		Operation
Switching the Display	Numeric	No[1]
	Waveform	No[1]
	Trend	No[1]
	Bar Graph	No[1]
	Vector	No[1]
	High Speed Data Capturing Mode	Yes
	Setup Parameter List Display	No
Basic Measurement Conditions	Wiring System[3, 4]	Yes[1]
	Efficiency Formula	No
	Independent Input Element Configuration[4]	Yes[1]
	Delta Calculation	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
	Other Basic Measurement Conditions	Yes[1]
Harmonic Measurement	Harmonic Measurement Conditions	No
Motor Evaluation	Input Signal Type[7]	No[1]
	Analog Auto Range	No
	Sync Source	No
	Sync Speed	No
	Electrical Angle Measurement	No
Auxiliary Input	Analog Auto Range	No
	Sync Source	No
Computation	User-Defined Functions	No
	MAX Hold	No
	User-Defined Events	No
	Formula for Apparent Power (S Formula)	No
	Apparent Power and Reactive Power Calculation Types (S,Q Formula)	No
	Formula for Corrected Power (Pc Formula)	No
	Sampling Frequency[8]	Yes[1]
	Phase Difference Display Format	No
	Master and Slave Synchronized Measurement	No

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

1 Cannot be set/executed when high speed data capturing is running (Start)
2 Cannot be set/executed when recording to a high speed data capturing file (Rec)
3 When the wiring system of a wiring unit is 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 if using this feature would cause the current input setting to change between direct input and external current sensor input, this feature cannot be set or executed. Set or execute in normal measurement mode.
5 When the NULL feature is enabled, the current input cannot be changed between direct input and external current sensor. Set it in normal measurement mode.
6 The line filter is always on. The setting range of the line filter is different from that of normal measurement. The line filter settings for high speed data capturing are not the same as those for normal measurement. The instrument retains both sets of settings.
7 When the NULL feature is enabled, you cannot change the motor input signal type. Set it in normal measurement mode.
8 You cannot turn it Auto. When the sampling frequency is set to Auto for normal measurement and you switch to high speed data capturing, this instrument operates according to the Clock C setting.
9 The NULL feature continues to use the settings (including on/off status) of normal measurement even when high speed data capturing is in progress. You cannot change the NULL feature settings. Set it in normal measurement mode.

Settings used in both normal measurement and high speed data capturing cannot be set or executed when high speed data capturing is running (Start).

Appendix 10 Limitations on Features When the Data Update Interval is Auto

When the data update interval is Auto, there are measurement conditions and computations whose settings you cannot change and features that you cannot execute.

Item	Limitation
Sampling Frequency	Setting the sampling frequency to Auto will set the sampling frequency to Clock C.
Single Measurement	This cannot be executed.
Trigger Mode	This is fixed to OFF.
Independent Input Element Configuration and Measurement Period (Sync Source)	The sync source cannot be set independently even when the independent input element configuration is on.
Independent Integration	When independent integration is on, integration cannot be started.
Integration Mode	This is fixed to “Normal.”
Watt-Hour Integration Method for Each Polarity (WP ± Type)	This is fixed to “Charge/Discharge.”
Integration Auto Calibration	This is fixed to OFF.
Auto Range during Integration	This is set to OFF. Fixed range is selected when integration is started.
Integration Resume Operation at Power Failure Recovery	The instrument recovers in an integration error state. Integration cannot be resumed.
Input Element Group during Harmonic Measurement	All elements are fixed to group Hrm1.
Storage Mode	Storage cannot be started in either of the following situations. • When the storage mode is integration-synchronized mode • When the storage interval is not 00:00:00
Self-Test	The test item “memory test (Memory)” cannot be executed.

Measurement function

When the data update interval is Auto, the following measurement functions are not measured and displayed as “-------” (no data). When data is stored or output via communication, data is NAN.

- fPLL2: PLL frequency of harmonic setting 2
- WS, WQ: Integrated value of apparent power and reactive power

Data update status

When the data update interval is set to Auto, storing data also stores the following data update status information.

The data update status information represents when the measured value of the detected measurement period was updated within the data update interval of 50 ms in 16-bit hexadecimal notation.

- When the bit is 1, the measured value is updated.
- When the bit is 0, the measured value is not updated, and the previous measured value is output.

However, if averaging is on, measured values are averaged every data update interval of 50 ms.

UpdateStsPwr[1]

Input element data update status for normal measurement

This bit is set to 1 when the measured value in the newly specified measurement period resulting from a “period detection of the sync source” or “timeout” is updated.

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
										EL6	EL5	EL4	EL3	EL2	EL1

EL1: input element 1 to EL6: input element 6

UpdateStsMtr[1]

Motor evaluation input data update status for normal measurement

This bit is set to 1 when the measured value in the newly specified measurement period resulting from a “period detection of the sync source” or “timeout” is updated.

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
														Trq	Spd

Spd: Speed input, Trq: Torque input

UpdateStsAux[1]

Auxiliary signal input data update status for normal measurement

This bit is set to 1 when the measured value in the newly specified measurement period resulting from a “period detection of the sync source” or “timeout” is updated.

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
														AUX2	AUX1

AUX1, AUX2: Auxiliary Input

UpdateStsHrm[1]

Input element data update status for harmonic measurement

- This bit is set to 1 when the new measured value resulting from a detection of the number of cycles of the PLL source is updated.
- This bit is also set to 1 when no harmonic measurement data [-------] is updated due to a timeout.

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
										EL6	EL5	EL4	EL3	EL2	EL1

EL1: input element 1 to EL6: input element 6

UpdateStsWave[2]

Data update status of waveform measurement

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
		Trq AUX2	Spd AUX1	I6	U6	I5	U5	I4	U4	I3	U3	I2	U2	I1	U1

U1 to 6: Voltage input of input elements 1 to 6

I1 to 6: Current input of input elements 1 to 6

Spd: Speed input, Trq: Torque input

AUX1, AUX2: Auxiliary signal input

1 This can be output using the :NUMeric[:NORMal]:VALue? communication function and storage feature.

2 This can be output using the :NUMeric[:NORMal]:VALue? communication function.

Communication Commands and Data Update Status

The aforementioned data update status corresponds to the following communication command functions.

- UpdateStsPwr: UNPower
- UpdateStsMtr: UNMotor
- UpdateStsAux: UNAux
- UpdateStsHrm: UHPower
- UpdateStsWave: UWCHannel

If the data update interval is not Auto and any of the functions above is substituted into <Function> in the following communication command, the return value for :NUMeric[:NORMal]:VALue? will be 0x0: "no update."

:NUMeric[:NORMal]:ITEM<x> {NONE|<Function>[,<Element>][,<Order>]}

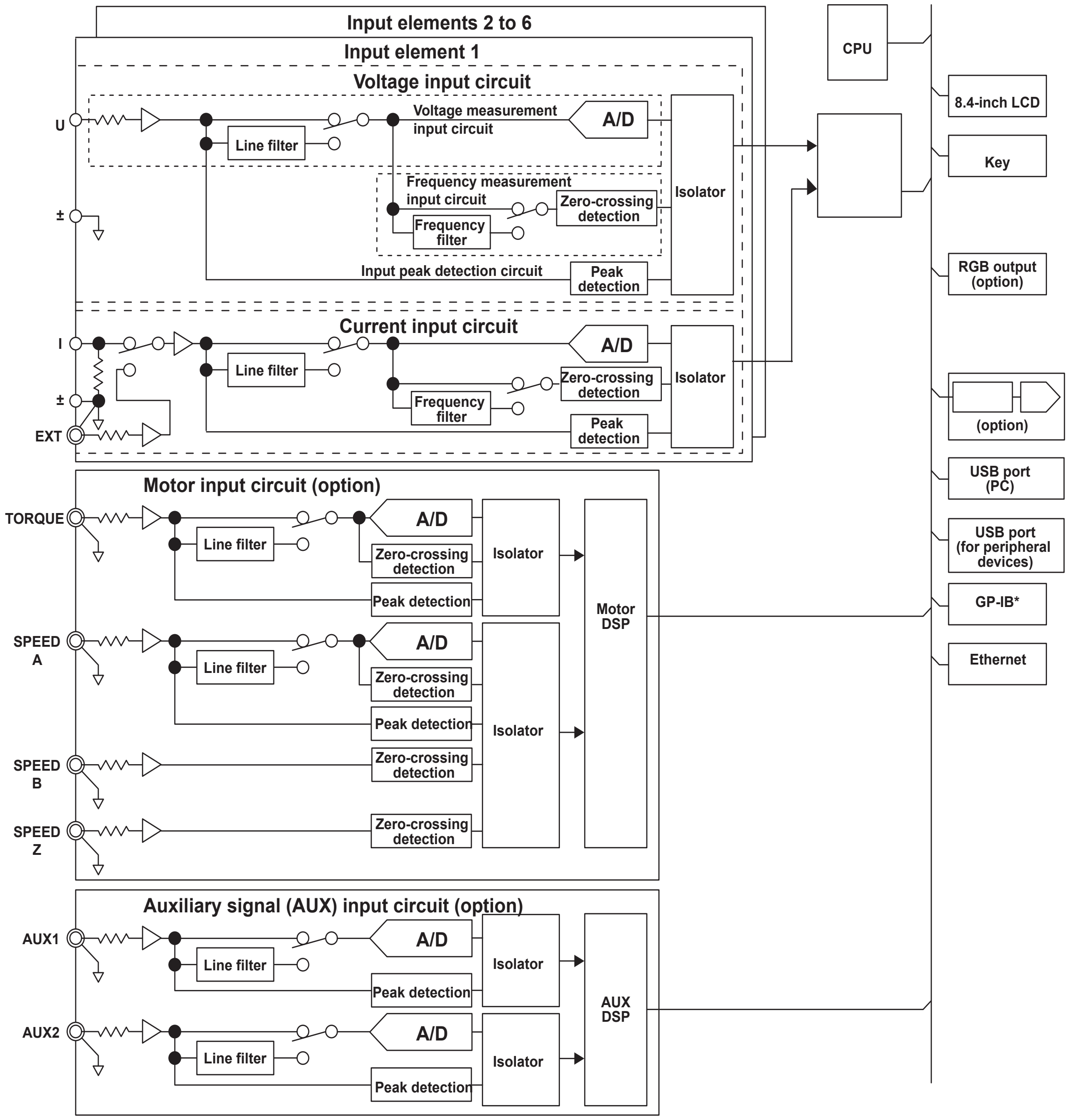
Appendix 11 Firmware Version

This manual covers WT1800R firmware versions 1.01 and later.

To view the firmware version, press Utility > System Overview, and check Version on the Overview screen that is displayed.

Appendix 12 Block Diagram

Block diagram



* Only models with the GP-IB interface option

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 terminal (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 terminal 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 calculated values are determined from the measured values. The measured values and calculated 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.

Index

T

Page

U

Page

V

Page

W

Page

X

Y

Z