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WT500

Power Analyzer

U S E R ' S M A N U A L

Thank you for purchasing the WT500 Power Analyzer. The WT500 is an instrument capable of measuring parameters such as voltage, current, and power with high precision.

This user's manual explains the features, operating procedures, and handling precautions of the WT500. To ensure correct use, please read this manual thoroughly before beginning operation. Keep this manual in a safe place for quick reference in the event that a question arises.

This manual is one of two WT500 manuals. Please read both manuals.

Manual Title	Manual No.	Description
WT500 Power Analyzer User's Manual	IM760201-01E	This manual. Explains all WT500 features, except for the communication features, and the operating procedures that relate to them.
WT500 Power Analyzer Communication Interface User's Manual (CD-ROM)	IM760201-17E	Explains the features related to using communication commands to control the WT500.

Notes

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

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Revisions

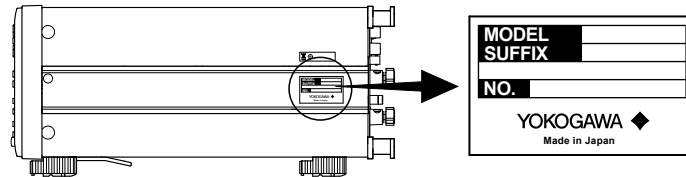
- 1st Edition: June 2008
- 2nd Edition: January 2009
- 3rd Edition: July 2012

Checking the Package Contents

After receiving the product and opening the package, check the items described below. If the wrong items have been delivered, if items are missing, or if there is a problem with the appearance of the items, contact your nearest YOKOGAWA dealer.

WT500

Check that the model name and suffix code given on the name plate on the side panel are the same as those on your order.



MODEL and SUFFIX Codes

Model/Item	Suffix Code	Description
760201		Number of installed input elements: 1
760202		Number of installed input elements: 2
760203		Number of installed input elements: 3
Power cord	-D	UL, CSA standard power cord
	-F	VDE standard power cord
	-Q	BS standard power cord
	-R	AS standard power cord
	-H	GB standard power cord (CCC-compatible)
Options	/C1	GP-IB interface
	/C7	Ethernet interface
	/EX1	External sensor input (only selectable with the 760201)
	/EX2	External sensor input (only selectable with the 760202)
	/EX3	External sensor input (only selectable with the 760203)
	/G5	Harmonic measurement
	/DT	Delta computation
	/FQ	Frequency measurement add-on (enables simultaneous measurement of all input elements)
	/V1	VGA output

Suffix Code Example

On a model with three input elements installed that comes with the GP-IB interface, external input sensor, and harmonic measurement options and a UL, CSA standard power cord, the suffix code is 760203-D/C1/EX3/G5.

NO. (Instrument number)

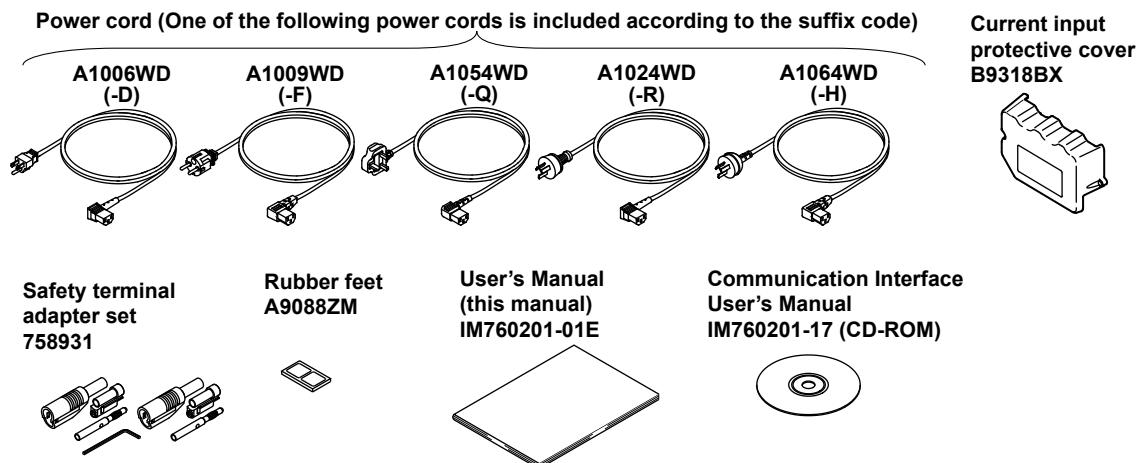
When contacting the dealer from which you purchased the instrument, please give them the instrument number.

Standard Accessories

The WT500 is shipped with the following accessories.

Item	Model/Part No.	Quantity	Note
Power cord	One of the following power cords is included according to the suffix code on the previous page.		
	A1006WD	1	UL, CSA standard power cord Maximum rated voltage: 125 V, Maximum rated current: 7 A
	A1009WD	1	VDE standard power cord Maximum rated voltage: 250 V, Maximum rated current: 10 A
	A1054WD	1	BS standard power cord Maximum rated voltage: 250 V, Maximum rated current: 10 A
	A1024WD	1	AS standard power cord Maximum rated voltage: 250 V, Maximum rated current: 10 A
	A1064WD	1	GB standard power cord (CCC-compatible) Maximum rated voltage: 250 V, Maximum rated current: 10 A
Rubber feet	A9088ZM	1	There are two feet in a pair.
Current input protective cover	B9319BX	1	Comes with two screws.
Safety terminal adapter set	758931	See the note on the right.	Same number of sets as the number of installed input elements
			760201: One set with one hexagonal socket wrench
			760202: Two sets with one hexagonal socket wrench 760203: Three sets with 1 hexagonal socket wrench
User's Manual	IM760201-01E	1	This manual
Communication Interface User's Manual	IM760201-17E	1	CD-ROM (CD-ROM part number: B9319ZZ)

(Printed manuals can be purchased separately. Contact your nearest YOKOGAWA dealer.)

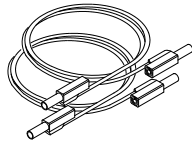


Optional Accessories (Sold separately)

The following optional accessories are available for purchase separately.

Item	Model/Part No.	Quantity Sold	Note
Measurement lead	758917	1	Two leads in one set. Used with the separately sold 758922 or 758929 adapter. Length: 0.75 m. Rated voltage: 1000 V.
Safety terminal adapter set	758923	1	Two pieces in one set. Rated voltage 600 V.
	758931	1	Two pieces in one set. Rated voltage 1000V.
Alligator clip adapter set	758922	1	Two pieces in one set. For the 758917 measurement lead. Rated voltage: 300 V.
	758929	1	Two pieces in one set. For the 758917 measurement lead. Rated voltage: 1000V.
Fork terminal adapter set	758921	1	Two pieces in one set. For the 758917 measurement lead. Rated voltage: 1000 V. Rated current: 25 A.
BNC-BNC	366924	1	42 V or less. Length: 1 m.
Measurement lead	366925	1	42 V or less. Length: 2 m.
External sensor cable	B9284LK	1	For connecting the current sensor input connector of the WT500. Length: 0.5 m.
Conversion adapter	758924	1	BNC-4 mm socket adapter. Rated voltage: 500 V.

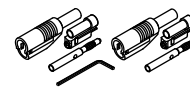
**Measurement lead
758917**



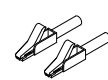
**Safety terminal
adapter set
758923**



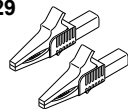
**Safety terminal
adapter set
758931**



**Alligator clip
adapter set
758922**



**Alligator clip
adapter set
758929**



**Fork terminal
adapter set
758921**



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



**External sensor
cable
B9284LK**



**Conversion adapter
758924**



Safety Precautions

This instrument is an IEC safety class 01 instrument (provided with a terminal for protective earth grounding).

The general safety precautions described herein must be observed during all phases of operation. If the instrument is used in a manner not specified in this manual, the protection provided by the instrument may be impaired. Yokogawa Electric Corporation assumes no liability for the customer's failure to comply with these requirements.

The following symbols are used on this instrument.



Handle with care. To protect the instrument and its users, refer to the explanation in the User's Manual or Service Manual.



Electric shock, danger



Alternating current



Both direct and alternating current



Power on



Power off



Power-on state



Power-off state



Grounding

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

WARNING

Use the Correct Power Supply

Make sure that the power supply voltage matches the WT500 rated supply voltage and that it does not exceed the maximum voltage range specified for the power cord.

Use the Correct Power Cord and Plug

To prevent fire and electric shock, use the power cord supplied by YOKOGAWA. The main power plug must be plugged into an outlet with a protective earth terminal. The earth protection will be nullified if you use an ungrounded extension cord.

Connect to a Protective Earth Terminal

To prevent electric shock, be sure to connect to a protective earth terminal before turning on the power. The power cord that comes with the instrument is a three-prong cord. Connect the power cord to a properly grounded three-prong outlet.

Do Not Impair the Protective Grounding

Never cut off the internal or external protective earth wire or disconnect the wiring to the protective earth terminal. Doing so may result in electric shock or damage to the instrument.

Do Not Operate with Defective Protective Grounding or Fuses

Do not operate the instrument if its protective grounding or one of its fuses might be defective. Check the grounding and the fuses before operating the instrument.

Do Not Operate in an Explosive Atmosphere

Do not operate the instrument in the presence of flammable gasses or vapors. Doing so is extremely dangerous.

Do Not Remove Covers

Only qualified YOKOGAWA personnel should remove the instrument's covers. The inside of the instrument is dangerous because parts of it have high voltages.

Ground the Instrument before Making External Connections

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

Operating Environment Limitations

CAUTION

This is a class A instrument designed for an industrial environment. Operation of this equipment in a residential area can cause radio interference, in which case users will be required to correct the interference.

Waste Electrical and Electronic Equipment



Waste Electrical and Electronic Equipment (WEEE), Directive 2002/96/EC
(This directive is valid only in the EU.)

This product complies with the WEEE Directive (2002/96/EC) marking requirement. This marking indicates that you must not discard this electrical/ electronic product in domestic household waste.

Product Category

With reference to the equipment types in the WEEE directive Annex 1, this product is classified as a “Monitoring and Control instrumentation” product.

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

New EU Battery Directive



New EU Battery Directive, DIRECTIVE 2006/66/EC (This directive is valid only in the EU.)

Batteries are included in this product. This marking indicates they shall be sorted out and collected as ordained in ANNEX II in DIRECTIVE 2006/66/EC.

Battery type

Lithium battery

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

Conventions Used in This Manual

Notes and Cautions

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



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

WARNING

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

CAUTION

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

Note

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

Symbols Used in Procedural Explanations

The procedural explanations in chapters 3 to 13 use the following symbols, characters, and words to identify their contents.

Procedure

Follow the order of the step numbers when carrying out procedures. Procedural explanations assume that the procedures are being performed for the first time. You may not need to perform every step in a procedure when you are altering settings that have already been made before.

Explanation

Limitations and settings related to the procedure are explained here. The feature itself is not usually explained here. For information about the features themselves, see chapter 2.

Characters and Terminology Used in Procedural Explanations

Panel Keys and Soft Keys

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

SHIFT+Panel Key

When *SHIFT+panel key* appears in a procedural explanation, it means to press the shift key so that it lights, and then to press the indicated panel key. The setup menu marked in purple below the panel key that you pressed appears on the screen.

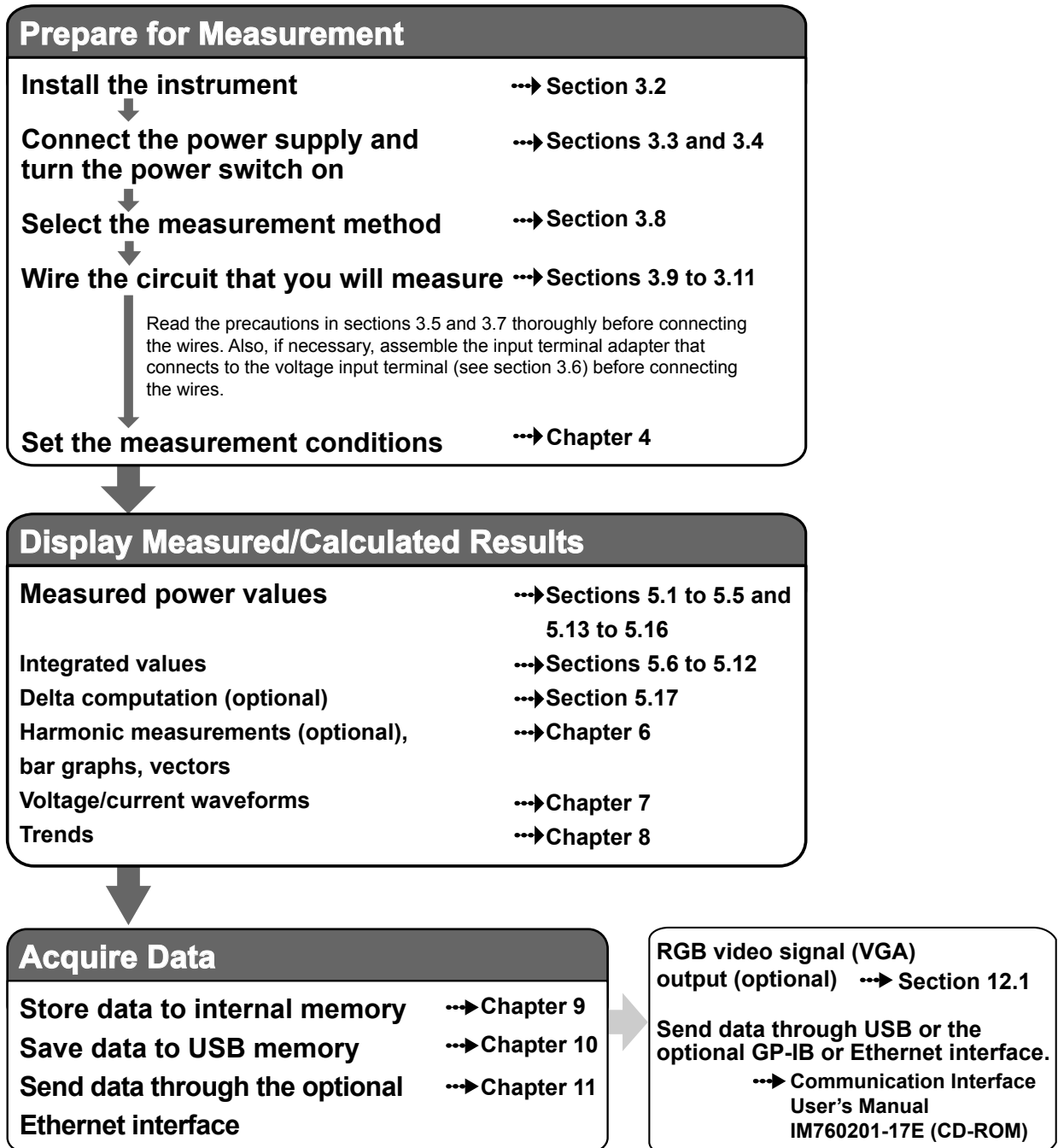
Units

k Denotes 1000. Example: 12 kg, 100 kHz

K Denotes 1024. Example: 459 KB (file size)

Workflow

The figure below is provided to familiarize the first-time user with the workflow of WT500 operation. For a description of an item, see the relevant section or chapter. In addition to the sections and chapters that are referenced in the figure below, this manual also contains safety precautions for handling the instrument and performing wiring work. Be sure to observe the precautions.



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Startup Guide

This guide presents an example of how to measure the efficiency of an inverter and explains the setup procedure that you must follow and the displays that appear throughout the entire process, from the wiring of circuits to measurement and computation. For detailed explanations of the various settings, see their corresponding references, which are indicated throughout the document.

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Circuit Wiring

<<For details, see section 3.5.>>

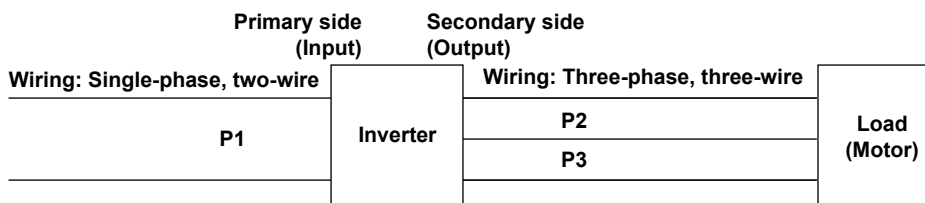
To avoid electric shock and damage to the instrument, follow the precautions below.

WARNING

- Ground the instrument before connecting measurement cables. The power cord that comes with the instrument is a three-prong cord. Insert the power cord into a grounded three-prong outlet.
- Turn off the power to the circuit under measurement when wiring it. Connecting or removing measurement cables while the power is on is dangerous.
- Do not include a voltage input terminal in a current measurement circuit or a current input terminal in a voltage measurement circuit.
- Strip the insulation covers of measurement cables so that when they are wired to the input terminals, the conductive parts (bare wires) do not protrude from the terminals. Also, make sure to fasten the input terminal screws securely so that cables do not come loose.
- Only connect cables that have safety terminals that cover the conductive parts to the voltage input terminals. Using a terminal with bare conductive parts (such as a banana plug) can be dangerous if the terminal comes loose.
- After connecting measurement cables, attach the current input protection cover (screw tightening torque: 0.6 N•m). Make sure that the conductive parts do not protrude from the protection cover.
- To make the protective measures effective, before applying the voltage or current from the circuit under measurement, check that:
 - The power cord provided with the instrument is being used to connect to the power supply and that the instrument is grounded.
 - The instrument's power switch is turned on.
 - The current input protection cover provided with the instrument is attached.

Section 3.3 lists other important precautions that should be followed when wiring. Read the precautions in section 3.3 thoroughly before you begin wiring.

This section presents an example of how to wire circuits for measuring the efficiency of an inverter with the WT500 Power Analyzer (three-phase, four-wire model 760203). To measure the efficiency of an inverter with the WT500 (three-phase, four-wire model 760203) when the inverter has a single-phase, two-wire primary circuit and a three-phase, three-wire secondary circuit, connect the single-phase, two-wire circuit to input element 1, and connect the three-phase, three-wire circuit to input elements 2 and 3.



P1: Active power measured by input element 1 of the WT500
 P2: Active power measured by input element 2 of the WT500
 P3: Active power measured by input element 3 of the WT500

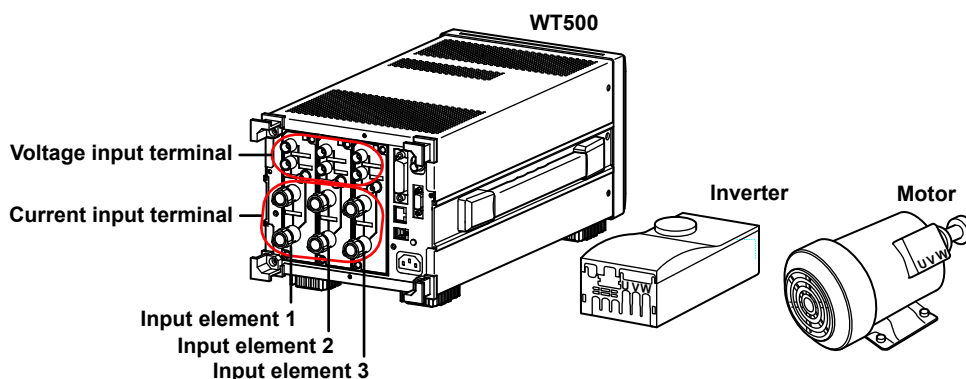
$$\text{Efficiency} = \frac{\text{Power consumed by the load (= P2 + P3)}}{\text{Power supplied by the source (= P1)}} \times 100(\%)$$

Preparing the WT500

<<For details, see section 3.2.>>

1. Prepare the WT500 (three-phase, four-wire model 760203).

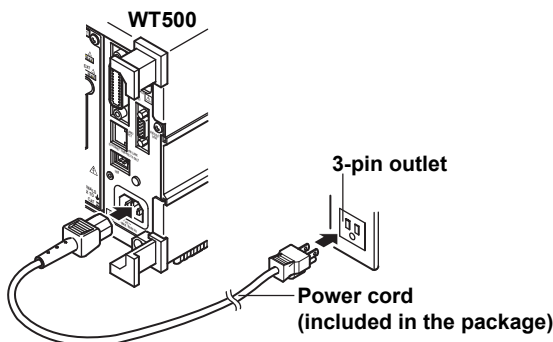
Also, prepare a motor and the inverter that you will be measuring.



Connecting the WT500 to a Power Source

<<For details, see section 3.3.>>

2. Make sure that the WT500 (three-phase, four-wire model 760203) power switch is off.
3. Connect the WT500 power cord to the power inlet on the rear panel.
4. Connect the other end of the power cord to a power outlet.

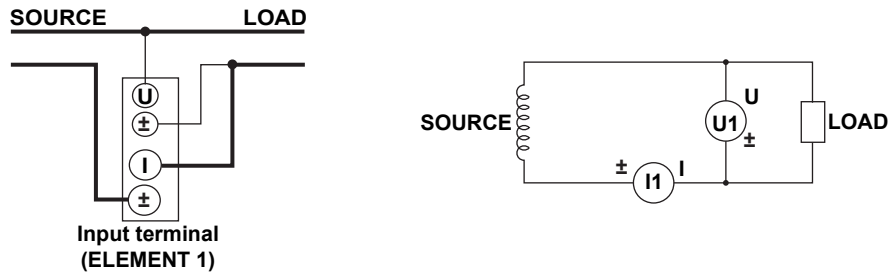


Wiring the Circuits for Measuring the Inverter's Single-Phase, Two-Wire Primary Circuit

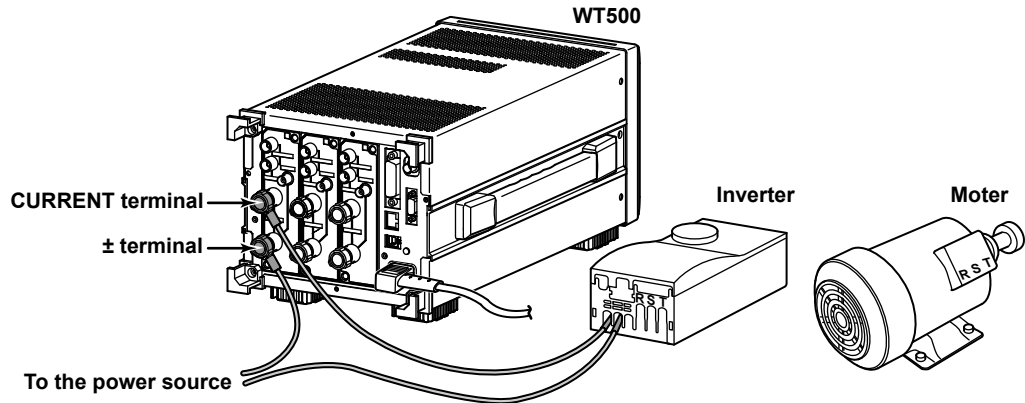
<<For details, see section 3.9.>>

- 5. Wire together the voltage and current input terminals of input element 1 on the rear of the WT500 (three-phase, four-wire model 760203) and the inverter's primary circuit to make a current and a voltage measurement circuit.

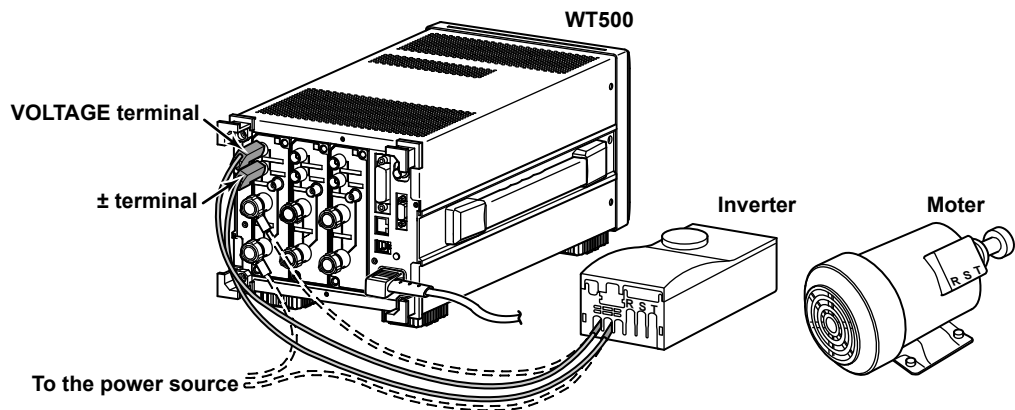
Wiring diagrams



Example of current measurement circuit wiring



Example of voltage measurement circuit wiring

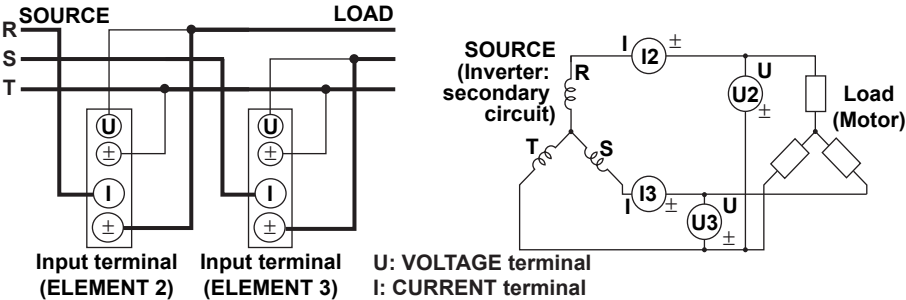


Wiring the Circuits for Measuring the Inverter's Three-Phase, Three-Wire Secondary Circuit

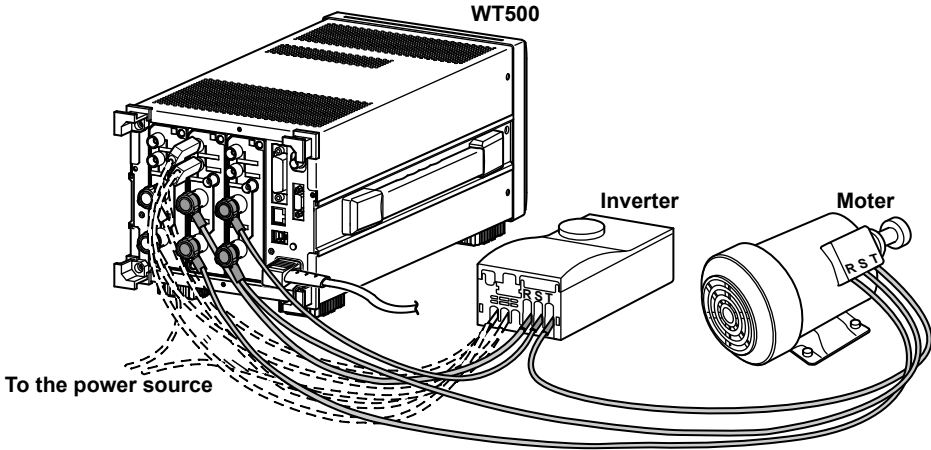
<<For details, see section 3.9.>>

- 6. Wire together the voltage and current terminals of input elements 2 and 3 on the rear of the WT500 (three-phase, four-wire model 760203), the inverter's secondary circuit, and the motor to make a voltage and current measurement circuit.

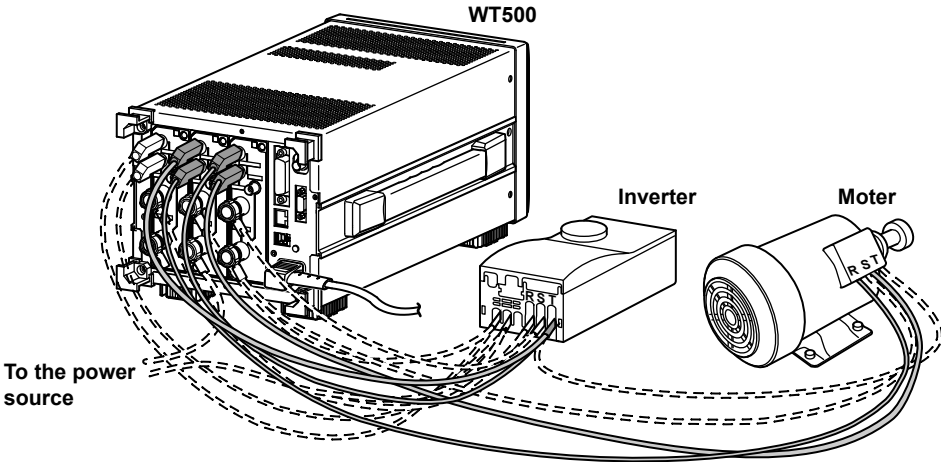
Wiring Diagram



Wiring Example of a Current Measurement Circuit

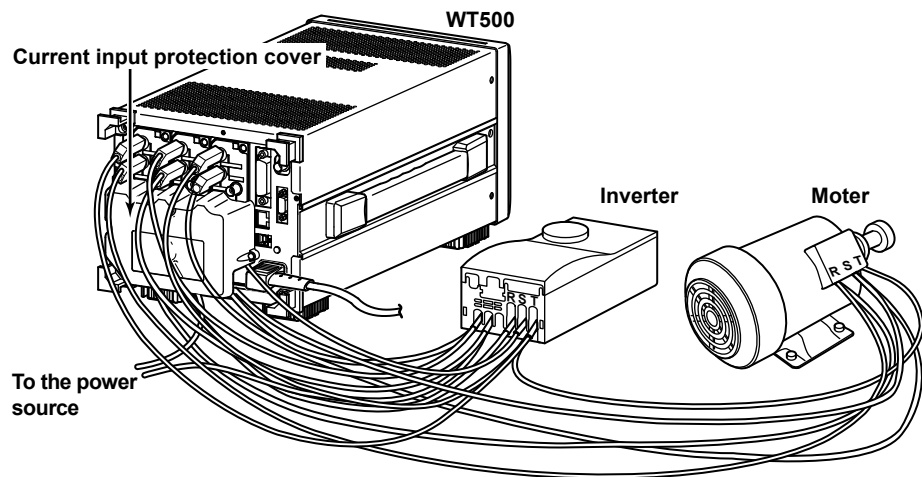


Wiring Example of a Voltage Measurement Circuit



7. Attach the current input protection cover (screw tightening torque: 0.6 N•m).

Before you attach the current input protection cover, make sure that the input terminal screws are tightened firmly.

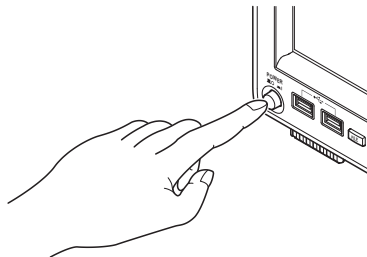


Turning On the WT500 Power Switch

<<For details, see section 3.4.>>

8. Press the power switch in the lower left of the front panel.

The test program starts when you turn the power switch on. You can begin making measurements after the WT500 displays the opening message. To reduce fluctuations in measured values that are based on the amount of time that has passed since the WT500 power switch has been turned on, give the WT500 approximately 30 minutes to warm up before you begin measuring.



Turning On the Power of the Circuit under Measurement

Before you turn on the power of the circuit under measurement, confirm that:

- The WT500 is connected to a power source.
- The input terminal screws are tightened firmly.
- The current input protection cover is attached.
- The WT500 power switch is on, and the WT500 is ready to measure.

9. Turn on the power of the circuit under measurement.

10. Use the inverter to turn the motor.

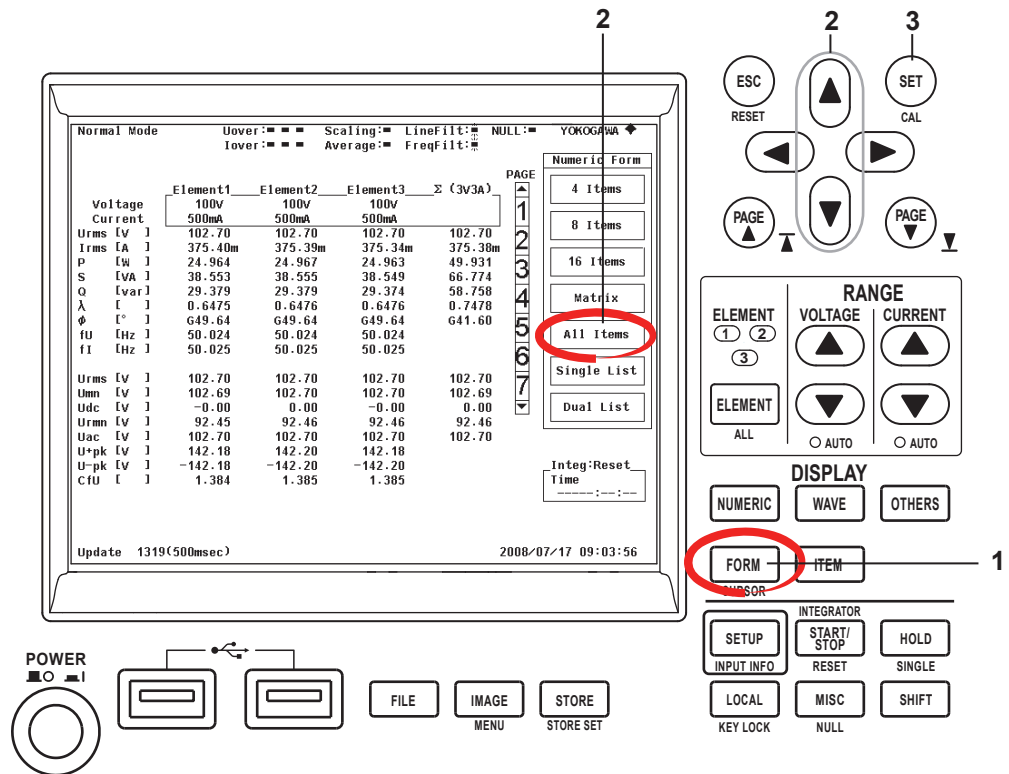
Display Switching

<<For details, see section 5.2.>>

When you use the WT500 for the first time, only four measured items (measurement functions) appear on the screen as numeric data. This section explains how to switch to the All Items display after turning on the power of the circuit under measurement. In the All Items display, you can display the efficiencies and all of the measured values (voltage, current, and active power) of both the primary and secondary inverter circuits. In the All Items display, a table of numeric data is displayed with measurement functions listed vertically and elements and wiring units (Σ) listed horizontally.

Switching to the All Items Display

In the figure below, all of the menus that are necessary for this operation are open. The numbers in the figure indicate the order of the steps in this operation.



1. Press FORM to display the Numeric Form menu.
2. Use the cursor keys to select All Items.
3. Press SET to confirm the selection.

You can also change the number of displayed items by pressing NUMERIC. Each time you press NUMERIC, the number of displayed items switches in this order: 4 Items > 8 Items > 16 Items > Matrix > All Items > Single List* > Dual List* > 4 Items > and so on.

* Only appears on models with the harmonic measurement option

Tips

- For information on how to select which measured items to display, see page S-15.
- The WT500 can display data using more than just numbers. For information about the other kinds of displays that are available, see page S-17.

Wiring System Selection

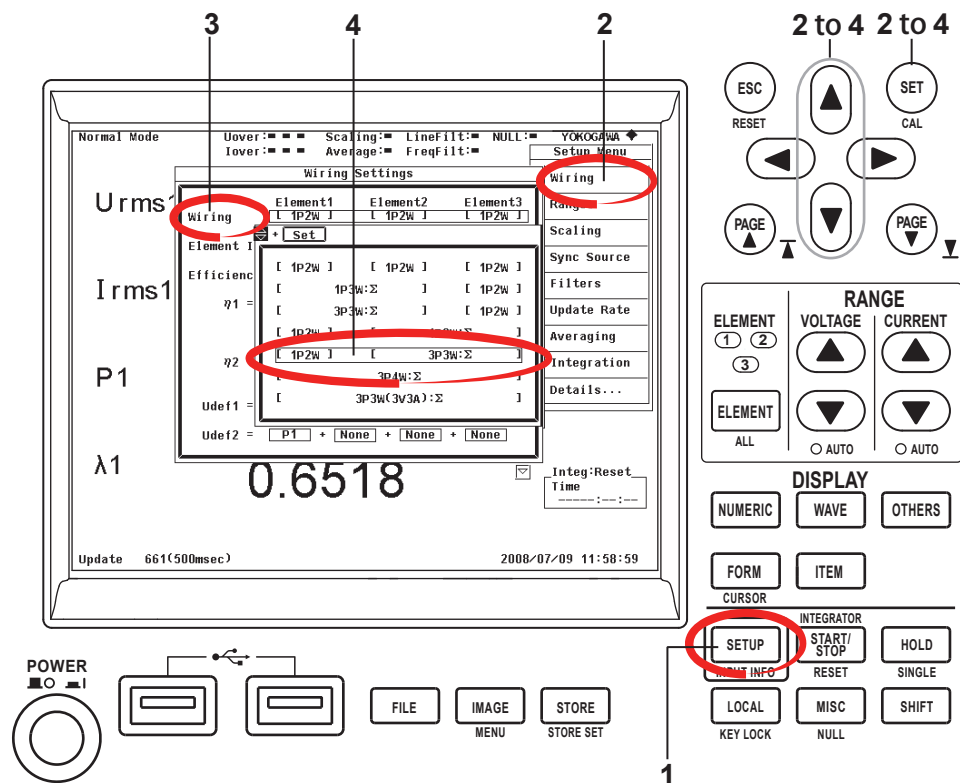
<<For details, see section 4.2.>>

Select wiring systems that match the measuring circuits that you have connected. If you select input element Σ , the average of the voltages and currents of all of the specified wiring systems and the sum of the powers of each input element (this value does not have physical meaning when a three-phase, three-wire system is used) are displayed.

- For information about how power sums are computed, see section 16.3.
- For information on how to select input element Σ , see pages S-15 to S-17.

Setting the wiring system pattern to [1P2W] [3P3W:Σ]

To set the wiring system pattern, press the **SETUP** key shown in the figure below to display the Setup Menu, which contains the Wiring menu. In the figure below, all of the menus that are necessary for this operation are open. The numbers in the figure indicate the order of the steps in this operation.



1. Press **SETUP** to display the Setup Menu.
2. Use the up and down cursor keys (\blacktriangle and \blacktriangledown) to select the Wiring menu, and then press **SET**.
3. Use the up and down cursor keys (\blacktriangle and \blacktriangledown) to select Wiring, and then press **SET**.
4. Use the up and down cursor keys (\blacktriangle and \blacktriangledown) to select [1P2W] [3P3W:Σ], and then press **SET**.

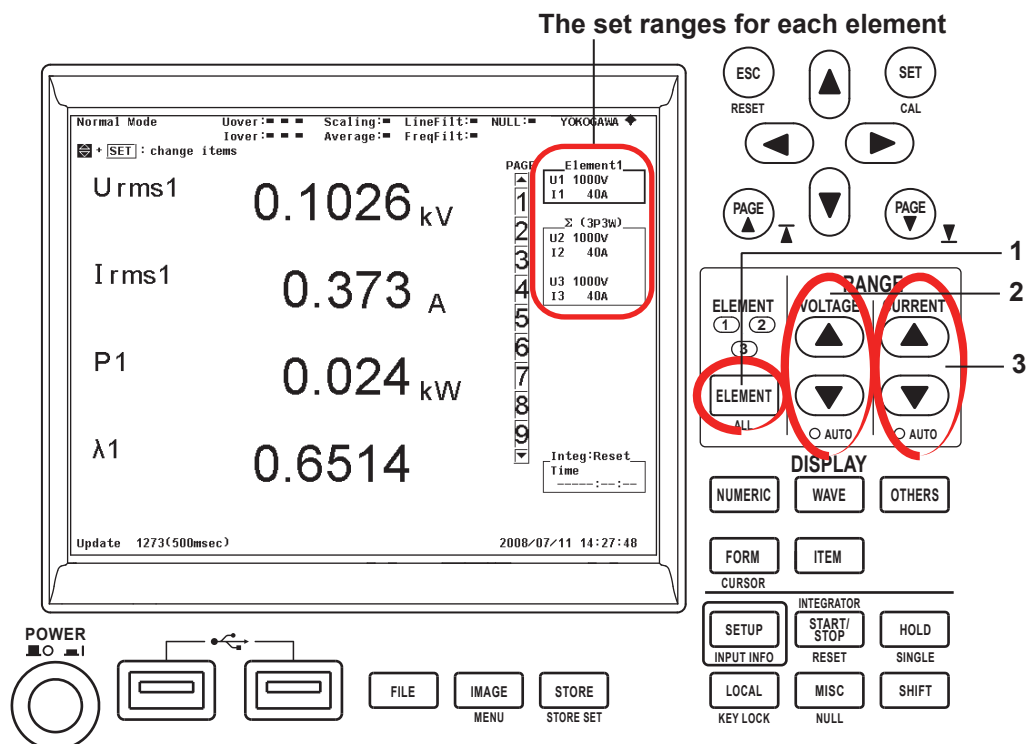
Measurement Range Selection

<<For details, see section 4.4.>>

After you select the wiring system of each circuit, you need to set the measurement ranges (the voltage and the current ranges) for each input element. The measurement ranges that are currently set for each input element appear on the right of the screen.

Selecting an Input Element, Voltage Range, and Current Range

You can select input elements, voltage ranges, and current ranges by pressing the **ELEMENT** and **range setting keys** (▲ and ▼) shown in the figure below. The numbers in the figure indicate the order of the steps in this operation.



1. Press **ELEMENT** to select the element whose ranges you want to configure. The indicator that corresponds to the currently selected element number lights. To set the measurement ranges of all elements, press **SHIFT+ELEMENT (ALL)**.
2. Press the ▲ or ▼ key under **VOLTAGE**. The measured values for the selected voltage range appear.
If you press **SHIFT+▼**, the voltage range is set automatically based on the measured voltage values, and the **AUTO** indicator lights.
3. Press the ▲ or ▼ key under **CURRENT**. The measured values for the selected current range appear.
If you press **SHIFT+▲**, the current range is set automatically based on the measured current values, and the **AUTO** indicator lights.

Tips

- You can also set the ranges from the Range menu, which is found in the Setup Menu that appears when you press **SETUP**. It is convenient to set ranges from the Range menu when you are using an external current sensor. For instructions on how to set ranges from the Range menu, see section 4.5.
- The measurement ranges that you can set vary depending on the specified crest factor. For instructions on how to set the crest factor, see section 4.11.

Measurement Period Configuration

<<For details, see section 4.7 and appendix 5.>>

To make correct measurements on the WT500, you must set its measurement periods properly.

The input signal used to define a measurement period is called a synchronization source. A measurement period is automatically set inside the WT500 when you specify a synchronization source.

The synchronization source options are U1, I1, U2, U3, I3, Ext Clk (external clock), and None. The options that you can select vary depending on what elements are installed. If the synchronization source for input element 1 is set to I1, an integer multiple of the period of I1 becomes the measurement period. By averaging the sampled data in this measurement period, the WT500 computes the measured values for input element 1, such as U1, I1, and P1.

Synchronization Source

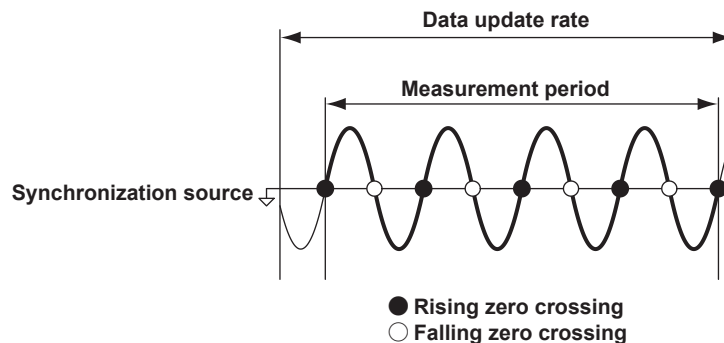
Select input signals with stable input levels and frequencies (with little distortion) as synchronization sources. Correct measured values can only be obtained if the period of the synchronization source signal is detected accurately. For example, if a switching power supply is being measured and the voltage waveform distortion is smaller than the current waveform distortion, set the synchronization source to the voltage signal.

Tips

To see whether the frequency of a synchronization source signal is being measured correctly, follow the procedure in section 5.16, "Selecting What Frequency to Measure," to display the frequency of the selected input signal (fU or fI) on the WT500. The most suitable synchronization source is the input signal whose measurement results are the most accurate and stable.

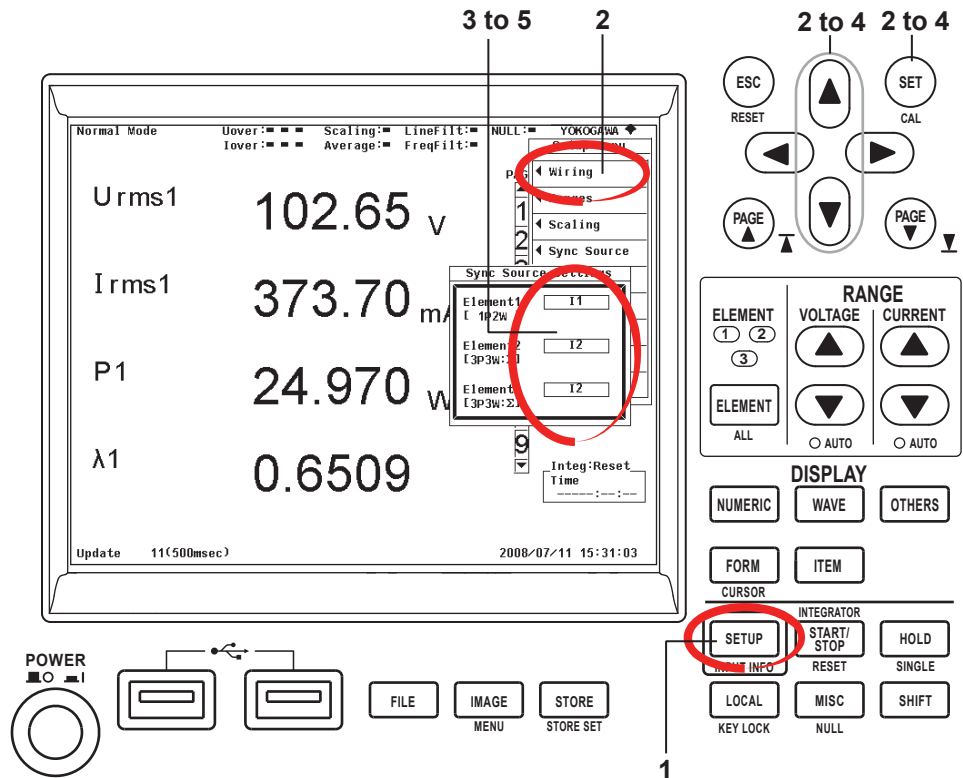
Zero Crossing

Zero crossing refers to the time at which the synchronization source passes through level zero (the center of the amplitude) on a rising or falling slope. The WT500 sets the measurement period to the time between the first zero crossing and the last zero crossing within a single data update period. There are two kinds of zero crossings, rising and falling. The WT500 selects the zero crossing that results in the longest measurement period.



Selecting Synchronization Sources

To select synchronization sources, press the SETUP key shown in the figure below to display the Setup Menu, which contains the Sync Source menu. In the figure below, all of the menus that are necessary for this operation are open. The numbers in the figure indicate the order of the steps in this operation.



1. Press SETUP to display the Setup Menu.
2. Use the up and down cursor keys (▲ and ▼) to select the Sync Source menu, and then press SET.
3. Use the up and down cursor keys (▲ and ▼) to select the sync source entry box for Element1, and then press SET.
4. Use the up and down cursor keys (▲ and ▼) to select the synchronization source for Element1, and then press SET.
5. Repeat steps 3 to 4 to select the synchronization sources for Element2 and Element3.

Input Filter Selection

<<For details, see section 4.8.>>

There are two types of input filters: line filters and frequency filters. Because the WT500 synchronizes with input signals when it measures, it is important that the WT500 measure the frequencies of the signals correctly.

Line Filter

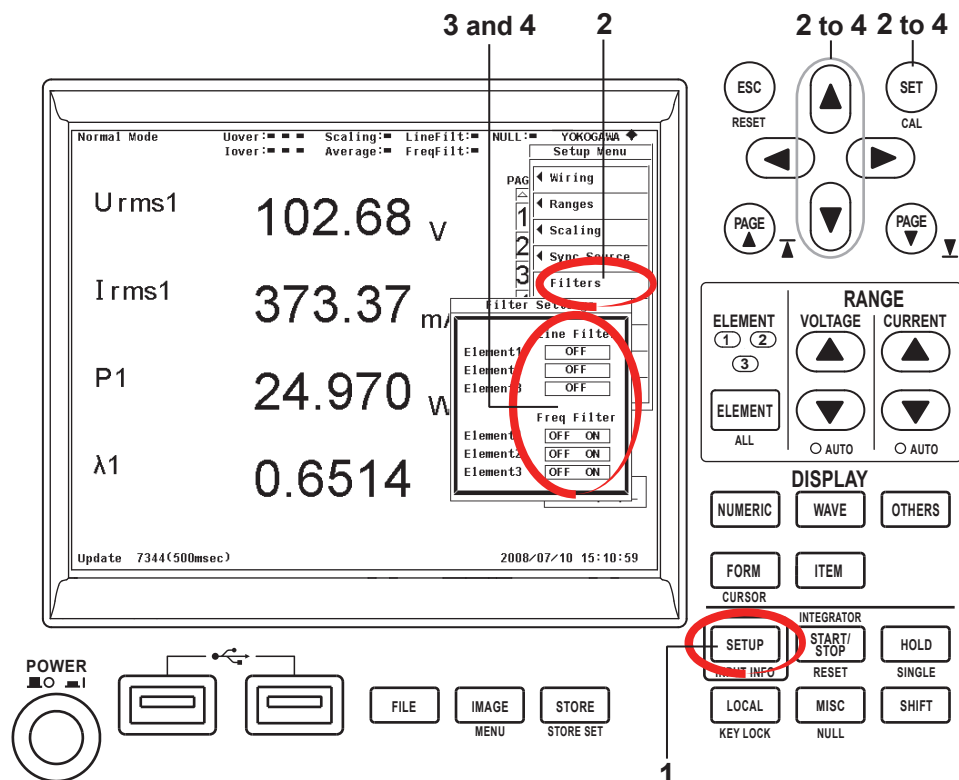
When the line filter is on, the voltage, current, and power of inverter waveforms, strain waveforms, etc., can be measured with their high frequency components eliminated. You can set the cutoff frequency. The frequency filter is turned on when the cutoff frequency is set to 500 Hz. This filter affects measured values directly.

Frequency Filter

The frequency filter enables the stable measurement of low-frequency voltage, current, and power waveforms that contain high-frequency components (see section 4.7 and appendix 5 for details). The high frequency components of measured signals are not removed. This filter does not directly affect measured voltage or current values. This filter can also be used to increase the accuracy of the detection of zero crossings (see section 2.2 and appendix 5 for details).

Selecting Input Filters

To select input filters, press the **SETUP** key shown in the figure below to display the Setup Menu, which contains the Filters menu. In the figure below, all of the menus that are necessary for this operation are open. The numbers in the figure indicate the order of the steps in this operation.



1. Press **SETUP** to display the Setup Menu.
2. Use the up and down cursor keys (**▲** and **▼**) to select the Filters menu, and press **SET**.
3. Use the up and down cursor keys (**▲** and **▼**) to select the input element whose line filter you want to set, press **SET**, and select a cutoff frequency. The WT500 automatically turns on the frequency filter of an element whose cutoff frequency is set to 500 Hz.
4. Use the up and down cursor keys (**▲** and **▼**) to select the input element whose frequency filter you want to turn on, and press **SET**.

Tips

You can use the following methods to stabilize the measurements of the WT500.

- Change the measurement time by changing the data update rate (see section 4.9, "Selecting the Data Update Rate," for details).
 - Use the averaging feature to display the exponential or moving averages of the measured values (see section 4.10, "Selecting an Averaging Method," for details).
-

Efficiency Equation Configuration

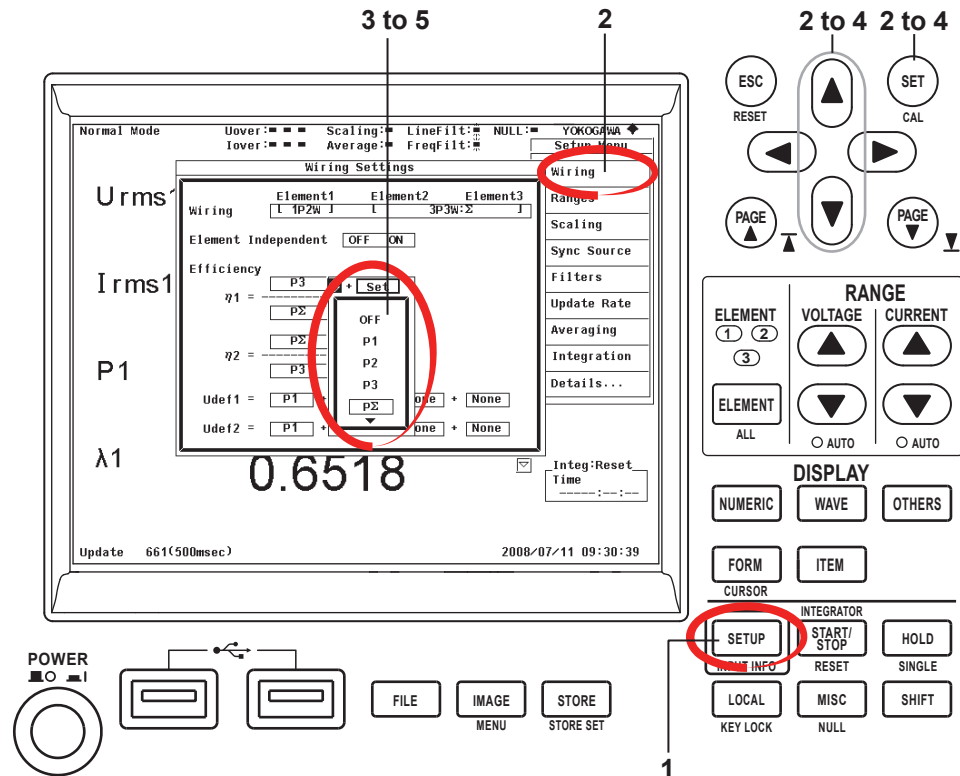
<<For details, see section 5.3.>>

Set the efficiency equation after you have wired circuits, selected the wiring systems, selected the measurement ranges (the voltage and current ranges), set the measurement periods, and selected input filters.

In efficiency computation, the value that is displayed as the active power of the inverter's secondary circuit is divided by the value that is displayed as the active power of the inverter's primary circuit, and the result is returned as a percentage.

Setting the Efficiency Equation

To configure the efficiency equation, press the SETUP key shown in the figure below to display the Setup Menu, which contains the Wiring menu. In the figure below, all of the menus that are necessary for this operation are open. The numbers in the figure indicate the order of the steps in this operation.



1. Press SETUP to display the Setup Menu.
2. Use the up and down cursor keys (\blacktriangle and \blacktriangledown) to select the Wiring menu, and then press SET .
3. Use the up and down cursor keys (\blacktriangle and \blacktriangledown) to select the parameter entry box of the numerator of η_1 in the efficiency equation, and then press !!!.
4. Use the up and down cursor keys (\blacktriangle and \blacktriangledown) to select $P\Sigma$ as the numerator of η_1 , and then press SET .
5. Repeat steps 3 to 4 to select P1 as the denominator of η_1 , and press SET .

This is the end of the setup process that includes wiring circuits, switching the display, selecting the wiring systems, selecting the measurement ranges, setting the measurement periods, selecting input filters, and configuring the efficiency equation.

Display of Measured Results

<<For details, see section 5.2.>>

The All Items display can contain up to seven pages. The number of pages varies depending on the installed options. You can scroll through the pages of the display to show the measured values of various measurement functions.

Scrolling through Pages

You can switch to the measured values for measurement functions that are on pages 3 and later by scrolling through the pages. However, page 1 is always displayed.

Measured values from the inverter's primary circuit

Measured values from the inverter's secondary circuit

Averages of values from the inverter's primary and secondary circuits

	Element1	Element2	Element3	Σ (3P3W)
Voltage	100V	100V	100V	
Current	500mA	500mA	500mA	
Urms [V]	102.70	102.70	102.70	102.70
Irms [A]	375.40m	375.39m	375.34m	375.38m
P [W]	24.964	24.967	24.963	49.931
S [VA]	38.553	38.555	38.549	66.774
Q [var]	29.379	29.379	29.374	58.758
λ []	0.6475	0.6476	0.6476	0.7478
φ [°]	649.64	649.64	649.64	641.60
f0 [Hz]	50.024	50.024	50.024	
f1 [Hz]	50.025	50.025	50.025	

The currently displayed page is highlighted.

1. Press to scroll to the next page.
Press to scroll to the previous page.

Display of Measured Results

Displaying Voltage and Current RMS Values and Active Power Values

Voltage and current rms values and active power values are always displayed on the first page.

	Element1	Element2	Element3	Σ (3P3A)
Voltage	100V	100V	100V	
Current	500mA	500mA	500mA	
Urms [V]	102.70	102.70	102.70	102.70
Irms [A]	375.40m	375.39m	375.34m	375.38m
P [W]	24.964	24.967	24.963	49.931
S [VA]	38.553	38.555	38.549	66.774
Q [var]	29.379	29.379	29.374	58.758
λ []	0.6475	0.6476	0.6476	0.7478
φ [°]	649.64	649.64	649.64	641.60
fU [Hz]	50.024	50.024	50.024	
fI [Hz]	50.025	50.025	50.025	
.
.
.

Tips

For information about the measurement functions that appear on the display, see section 2.2, "Measurement Functions and Periods," and appendix 1, "Symbols and Determination of Measurement Functions."

Displaying the Efficiency Values

To display the efficiency values, scroll to page 5.

The screenshot shows the main display area with the following data:

	Element1	Element2	Element3	Σ (3P3A)
Voltage	100V	100V	100V	
Current	500mA	500mA	500mA	
Urms [V]	102.70	102.70	102.70	102.70
Irms [A]	375.40m	375.39m	375.34m	375.38m
P [W]	24.964	24.967	24.963	49.931
S [VA]	38.553	38.555	38.549	66.774
Q [var]	29.379	29.379	29.374	58.758
λ []	0.6475	0.6476	0.6476	0.7478
φ [°]	649.64	649.64	649.64	641.60
fU [Hz]	50.024	50.024	50.024	
fI [Hz]	50.025	50.025	50.025	

User Function	[W]	[A]	[]
F1	[W]	[A]	[]
F2	[V]	[]	[]
F3	[A]	[]	[]
F4	[W]	[]	[]
F5	[V]	[]	[]
F6	[V]	[]	[]
F7	[A]	[]	[]
F8	[A]	[]	[]

η1	η2
92.238 [%]	93.503 [%]

The 'Efficiency' section is highlighted with a red box. The display also shows a 'Data Measure' table with values for dF1rms, dF2rms, dF3rms, and dF4rms.

Efficiency values

2. Press or to scroll to page 5.

Displays

The WT500 has the following five displays. How you can change the displays depends on what kind of measurement is being performed.

Numeric Data Display

<<For details, see sections 3.16, 5.2, and 6.2.>>

This display shows measured data, such as voltage, current, and power values, in numeric form.

U _{rms1}	102.64 V
I _{rms1}	373.18 mA
P1	24.966 W
λ1	0.6518

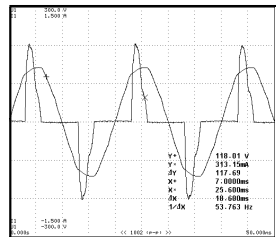
Numeric data can be displayed in the following ways.

- 4 Items: Four numeric data values are displayed in one column.
- 8 Items: Eight numeric data values are displayed in one column.
- 16 Items: 16 numeric data values are displayed in two columns.
- All Items, Matrix: The numeric data is displayed using the set format. The displayed items (measurement functions) cannot be changed in the All Items display, but they can be changed in the Matrix display.
- Single List, Dual List: The numeric data is displayed in list format. This item only appears on models with the harmonic measurement option.

Waveform Display

<<For details, see section 3.16 and chapter 7.>>

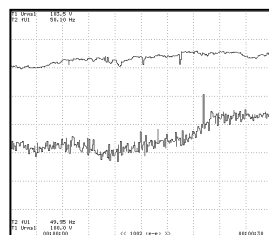
This display shows voltage and current waveforms for each element that are based on the sampled data that has been acquired within the data update period (see section 4.9 for details). You can assign up to six waveforms to any of up to four split screens.



Trend Display

<<For details, see chapter 8 and sections 3.16 and 2.8.>>

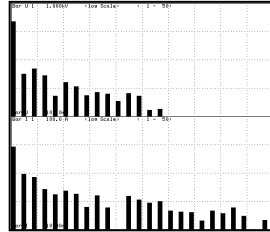
This display shows the trends (graphs of how numeric data changes over time) of measurement functions. You can assign up to eight trends to any of up to four split screens.



Bar Graph Display (Only on models with the harmonic measurement option)

<<For details, see sections 3.16, 2.8, and 6.7.>>

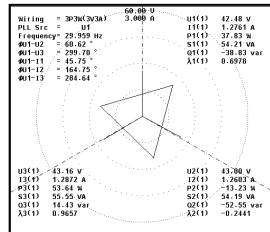
This display shows harmonic amplitudes using bar graphs. The harmonic orders are lined up on the horizontal axis, and the vertical axis represents the amplitude of each harmonic. You can assign up to three bar graphs to up to three split screens.



Vector Display (Only on models with the harmonic measurement option)

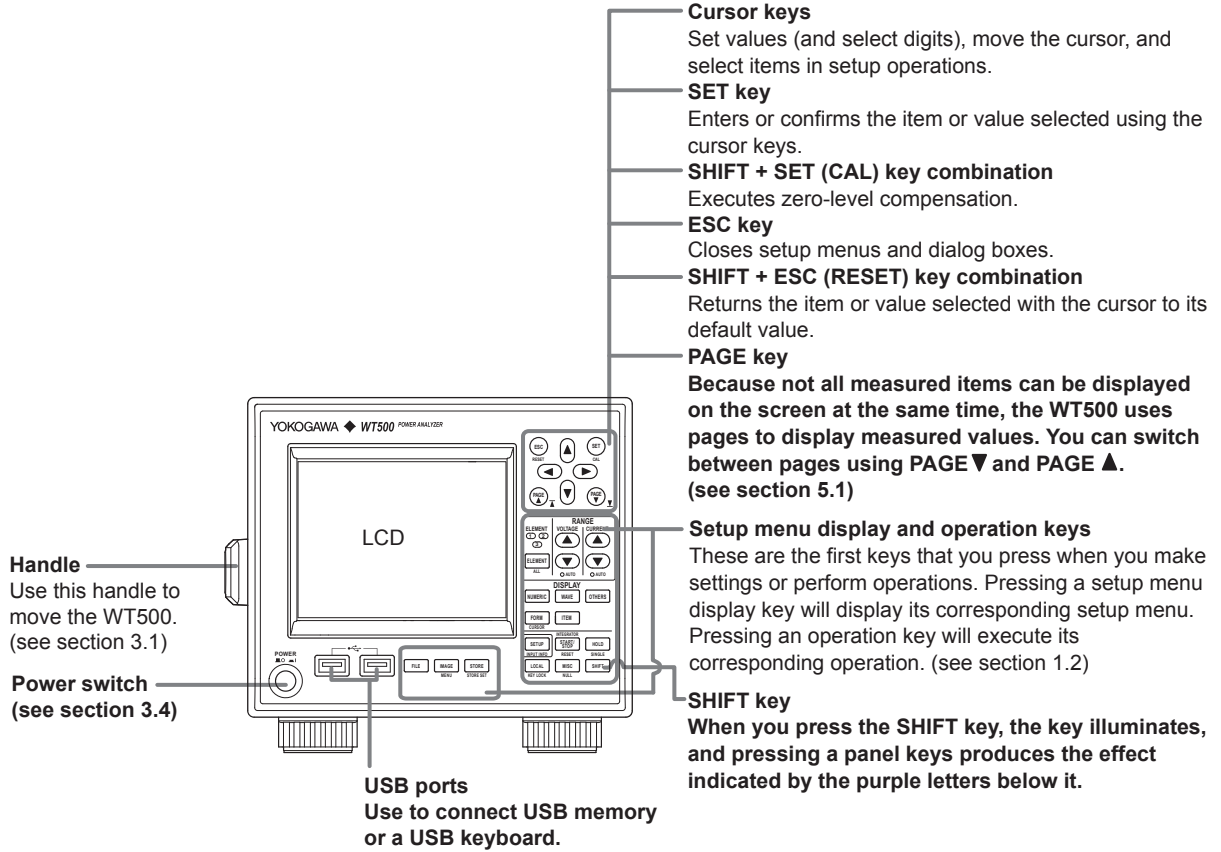
<<For details, see sections 3.16, 2.8, and 6.8.>>

In this display, 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.

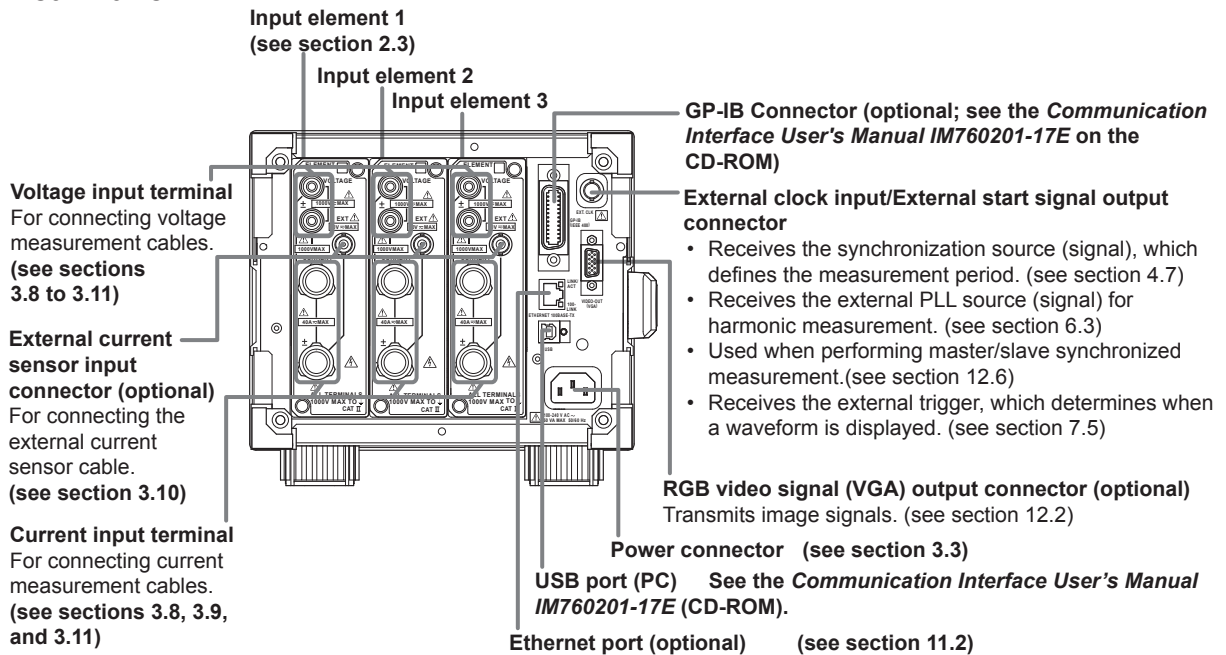


1.1 Front Panel, Rear Panel, and Top Panel

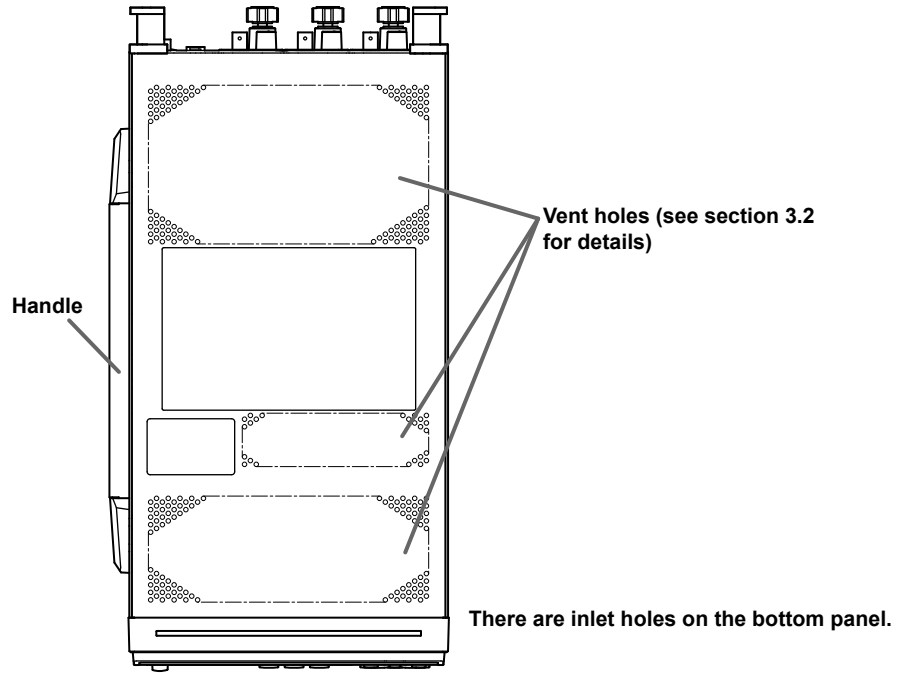
Front Panel



Rear Panel

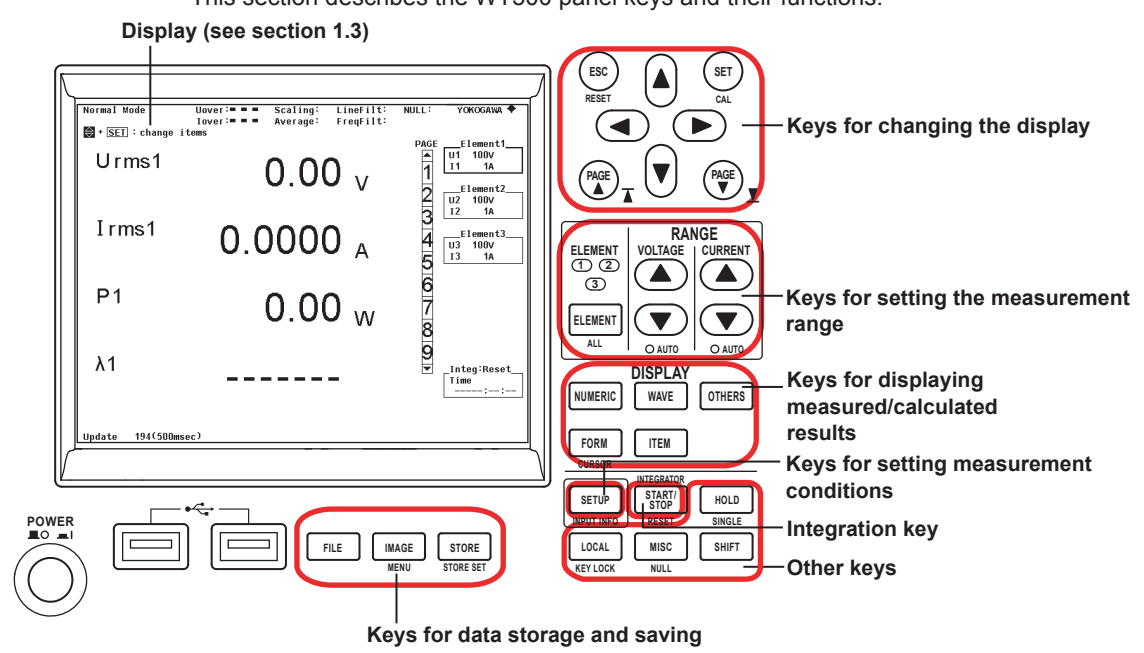


Top Panel

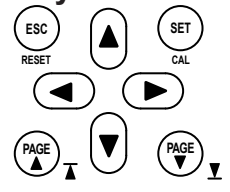


1.2 Setup Menu Display and Operation Keys

This section describes the WT500 panel keys and their functions.



Keys for Changing the Display



Cursor Keys (▲▼◀▶)

Use these keys to move the cursor in setup menus and dialog boxes, to set values, to select digits when setting numbers, and to select menu items.

SET

Use this key to display menus that you select with the cursor keys, confirm items and values, and open a menu for changing displayed items when the menu display is turned off in a numeric data display.

ESC

Use this key to close setup menus and dialog boxes, and to move up a level in a menu.

SHIFT+ESC (RESET) Key Combination

Use this key combination to return the item or value selected with the cursor to its default value.

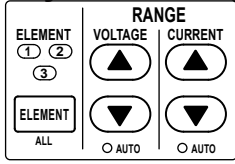
PAGE▲ and PAGE▼

Use these keys in numeric value displays and other displays, when all of the measured items do not fit into a single page, to change the displayed page. You can go to the first page by pressing SHIFT+PAGE▲ and to the last page by pressing SHIFT+PAGE▼.

SHIFT+SET (CAL) Key Combination

Use this key combination to execute zero-level compensation. When zero level compensation is executed, the WT500 creates a zero input condition in its internal circuitry and sets the level at that point to the zero level.

Keys for Setting the Measurement Range



ELEMENT

- Use this key to select the input element that you want to set the measurement range for. The selected input element will change each time you press ELEMENT.
- When selecting a wiring system, the input elements that are part of the same wiring system will be selected together.

SHIFT+ELEMENT (ALL) Key Combination

Use this key combination to set the voltage and current ranges of all elements at the same time. Press ELEMENT again to make settings for individual elements.

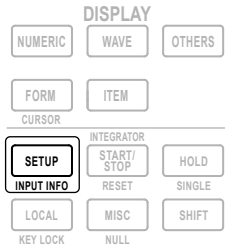
▲ and ▼ (See sections 4.3 and 4.4)

Use these keys to select the voltage, current, and current sensor ranges. The ranges selected with these keys are valid when the AUTO indicators described below are not lighted (when the manual range feature is being used).

SHIFT+▼ (AUTO) Key Combination

Use this key combination to activate the auto range feature (the AUTO indicator will light when this feature is activated). This feature automatically sets the voltage, current, or current sensor range depending on the amplitude of the received electrical signal. Press SHIFT+▼ (AUTO) again to activate the manual range feature (the AUTO indicator light will turn off).

Keys for Setting Measurement Conditions



SETUP

Use this key to display the Setup menu for setting measurement conditions. The following items appear in the Setup menu:

- **Wiring (See sections 4.1, 4.2, 5.7, and 5.8)**
Select this item to display a menu for selecting the wiring system, configuring individual input element settings, setting the efficiency equation, etc.
- **Ranges (See sections 4.3 and 4.4)**
You can select this item to set the voltage, current, or current sensor range, just as you can with the panel RANGE keys. If you select AUTO, the auto feature will be activated and the AUTO indicators underneath the RANGE keys will light.
- **Scaling (See section 4.5)**
Select this item to display a menu for setting the VT and CT ratios and the power factor for each input element. The power coefficients are used to convert the VT/CT output or the power derived from measuring the VT and CT outputs to the voltage, current, and power of the object being measured.
- **Sync Source (See section 4.7)**
Select this item to display a menu for setting the synchronization source for each wiring unit. The synchronization source defines the period (measurement period) over which sampled data, which is used to produce numeric data (i.e., measured values such as voltage, current, and power), is acquired.
- **Filters (See section 4.8)**
Select this item to display a menu for setting the line filter (which is inserted into the measurement circuit) and the frequency filter (which is inserted into the frequency measurement circuit) for each element.
- **Update Rate (See section 4.9)**
Select this item to display a menu for selecting the period (data update rate) at which sampled data, which is used to produce numeric data (i.e., measured values such as voltage, current, and power), is acquired.
- **Averaging (See section 4.10)**
Select this item to display a menu for setting the measured value averaging feature.

- **Integration (See sections 5.6 to 5.12)**
Select this item to display a menu for setting the integration mode, integration auto calibration, the integration timer, the reservation time, the watt hour integration method for each polarity, and the ampere hour integration mode.
- **Details.../Hide Details**
Select this item to switch between displaying all menu items and only displaying a portion of the menu items.
- **Measure (See sections 5.3 to 5.5 and 12.6)**
Select this item to display a menu for setting master/slave synchronized measurement and for selecting the equation for apparent/reactive power and the format for phase difference display.
- **User Function (See sections 5.13 and 5.14)**
Select this item to display a menu for setting user-defined functions and the MAX hold feature.
- **Freq Items (See section 5.16)**
This item only appears on models without the frequency measurement option. Select this item to display a menu for selecting which frequencies to measure. Because models with the frequency measurement option measure all voltages and currents, this menu will not appear.
- **Harmonics (See sections 6.3 to 6.5)**
This item only appears on models with the harmonic measurement option. Select this item to display a menu for setting the PLL source, the measured harmonic orders, and the equation for the harmonic distortion factor, in harmonic measurement.
- **Delta Measure (See section 5.17)**
This item only appears on models with the delta computation option. Select this item to display a menu for selecting the delta computation type and the voltage or current mode that will be the object of delta computation.

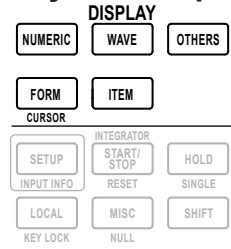
Note

While displaying any submenu in the Setup menu, you can press PAGE▲ or PAGE▼ to display the previous or next menu. This feature is useful when you want to check the measurement conditions set in each menu.

SHIFT+SETUP (INPUT INFO) Key Combination

Use this key combination to display a list of the conditions for acquiring the data from a measured voltage or current signal, such as the wiring system for each element, the wiring unit, the measurement range, the scaling, the synchronization source, and the input filter.

Keys for Displaying Measured/Computed Results



NUMERIC (See sections 3.16, 5.1, and 6.2)

Use this key to display numeric data.

- Each time you press NUMERIC, the number of displayed items switches in this order: 4 Items > 8 Items > 16 Items > Matrix > All Items > Single List* > Dual List* > 4 Items > and so on.
 - * Only appears on models with the harmonic measurement option.
- When you are displaying numeric data, you can press FORM, which is described later in this section, to display a menu for changing the number of displayed items.
- When you are displaying numeric data, you can press ITEM, which is described later in this section, to display a menu for changing the displayed items.

WAVE (See sections 3.16, 6.7, and 7.2)

Use this key to display waveforms.

- Each time you press WAVE, the waveform display split screen setting switches in this order: Single > Dual > Triad > Quad > Single > and so on.
- When you are displaying waveforms, you can press FORM, which is described later in this section, to display a menu for setting the time-axis of the displayed waveforms, the trigger for waveform display, the number of waveform display split screens, and the assignment of waveforms to split screens.
- When you are displaying waveforms, you can press ITEM, which is described later in this section, to display a menu for selecting and zooming in on the displayed waveforms.

OTHERS (See sections 3.16, 6.7, 6.8, 7.2, and 8.2)

Use this key to switch between the Trend, Bar Graph*, and Vector* displays.

Each time you press OTHERS, the display switches in this order: Trend > Bar* > Vector* > Trend > and so on.

* Only appears on models with the harmonic measurement option.

FORM (See sections 5.2, 6.2, 6.7, 6.8, 7.4, 7.5, 7.7, 7.8, and 8.6 to 8.9)

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

SHIFT+FORM (CURSOR) Key Combination (See sections 7.9 and 8.10)

Use this key when you are displaying waveforms, trends, or bar graphs* to display a menu for using cursors to measure waveform and graph values.

* Only appears on models with the harmonic measurement option.

ITEM Key (See sections 5.2, 6.2, 6.7, 6.8, 7.3, 7.6, and 8.3 to 8.5)

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

Keys for Data Storage/Saving



FILE

Use this key to display a menu for saving and loading setup parameters, saving measured data, deleting files, copying files, and so on.

IMAGE

Use this key to save the screen image data.

SHIFT+IMAGE (MENU) Key Combination

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

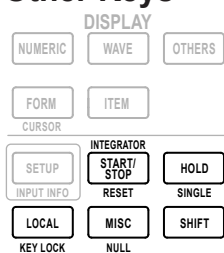
STORE

Use this key to execute, stop, or reset a storage operation.

SHIFT+STORE (STORE SET) Key Combination

Use this key to display a setup menu for the storage feature.

Other Keys



START/STOP Key

Use this key to start or end integration. You can view the integration condition in the integration setup/condition display (see section 1.3).

SHIFT+START/STOP (RESET) Key Combination

Use this key combination to reset the integrated value.

HOLD (See section 4.12)

Press HOLD to stop data measurement and display operations and to hold the numeric display (the HOLD key illuminates when the numeric display is held). During integration, the numeric display is held but measurement is not stopped. Press HOLD again to allow the numeric data display to be updated (the HOLD key will no longer be illuminated).

SHIFT+HOLD (SINGLE) Key Combination (See section 4.12)

Use this key combination while the display is held to measure the signal once at the set data update rate, and then to re-hold the display.

LOCAL

Use this key to switch from remote mode (the REMOTE indicator will appear at the upper right of the screen) to local mode (in which front panel key operations are valid). This key is invalid when the WT500 is in local lockout mode.

SHIFT+LOCAL (KEY LOCK) Key Combination

Use this key combination to turn the key lock on or off. When the key lock is on, no keys or key combinations other than SHIFT+LOCAL are valid, and LOCK appears in the upper right of the screen.

MISC

Use this key to display a menu for viewing the system status, initializing setup parameters, configuring or viewing the settings of remote control through communication commands (using the USB, GP-IB, or Ethernet interface option), setting the date/time, selecting the message and menu languages, selecting the crest factor, setting the USB peripheral interface, setting the optional Ethernet interface, setting the self test, etc.

SHIFT+MISC (NULL) Key Combination

Use this key combination to activate the NULL feature, which removes the DC component from the sampled data (the NULL indicator appears on the screen when the NULL feature is activated). Press SHIFT+MISC (NULL) again to deactivate the NULL feature (the NULL indicator will no longer appear).

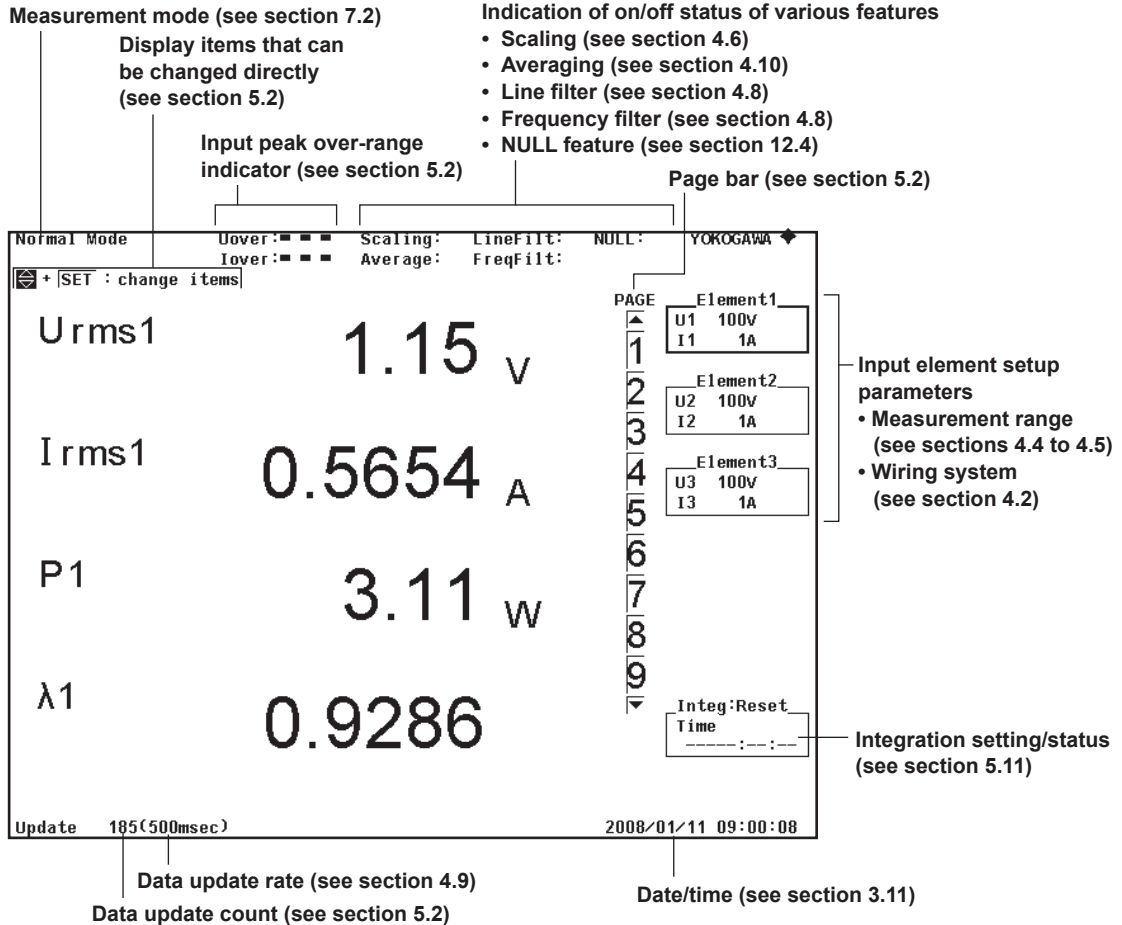
SHIFT

When you press the SHIFT key, the key illuminates, and pressing a panel key produces the effect indicated by the purple letters below it. Holding down SHIFT for 2 seconds or more will lock the WT500 into the shifted state. Pressing SHIFT again will release the shifted state (and the SHIFT key will no longer be illuminated).

1.3 Screen Display

Display Example When Measuring Power (Numeric display) in Normal Measurement Mode

For a description of the screens in other display modes, see the chapters that cover those modes.



Non-Numeric Displays

--OL--

Overload

Displayed if the measured value exceeds 140% of the measurement range.

--OF--

Overflow

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

No data

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

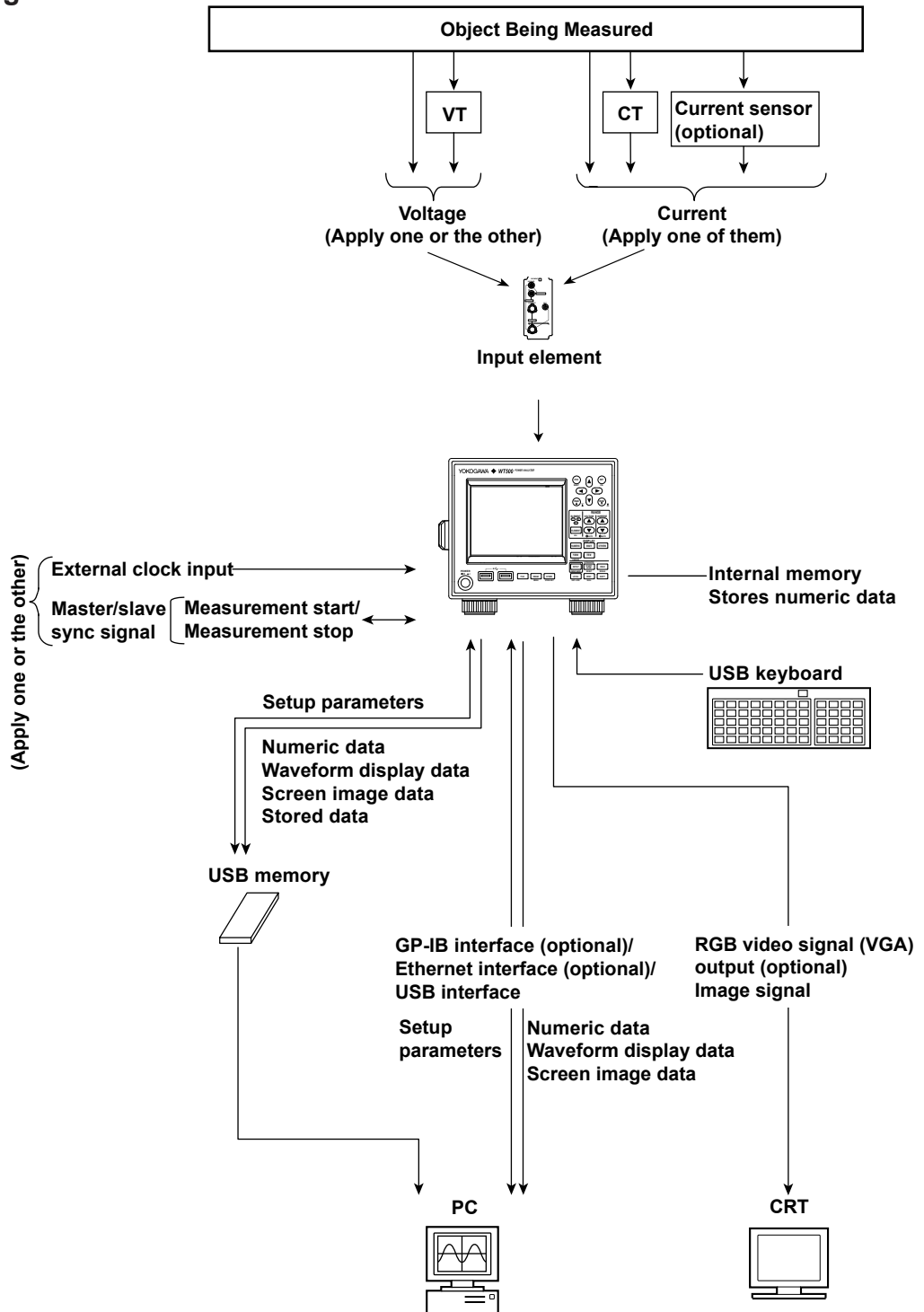
Error

Error

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

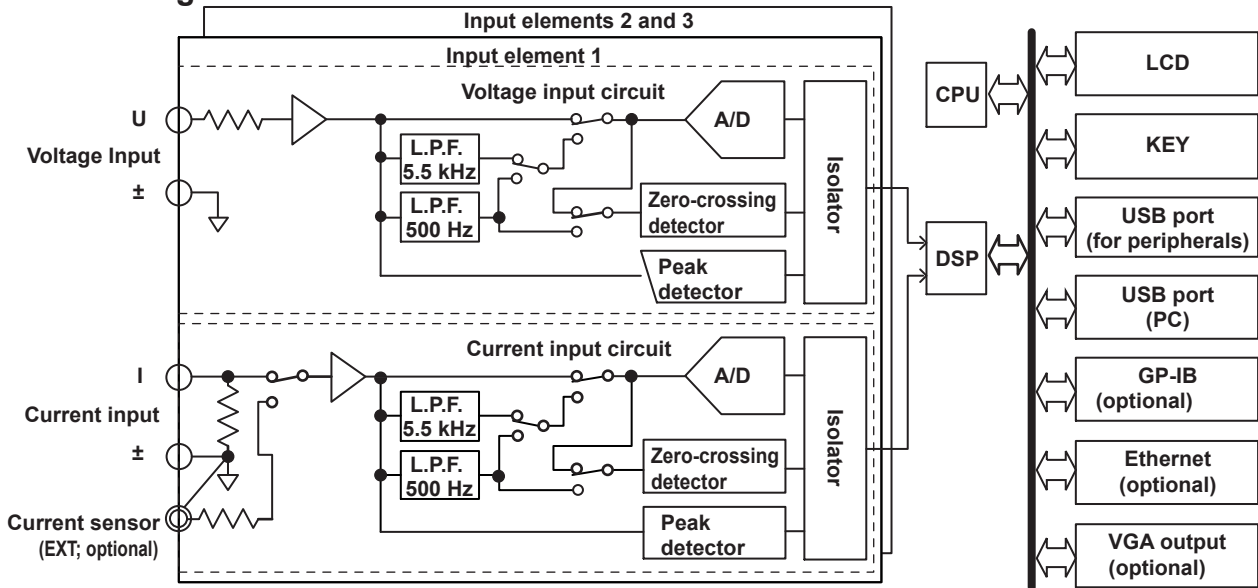
2.1 System Configuration and Block Diagram

System Configuration



2.1 System Configuration and Block Diagram

Block Diagram



Input Signal Flow and Process

Input elements 1 through 3 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, \pm) 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, \pm) and an optional current sensor input connector (EXT). Only one can be used at any given time. The voltage signal from the current sensor that is received at the current sensor input connector is normalized using the voltage divider and the operational amplifier (op-amp). It is then sent to a current A/D converter. The current signal that is applied to the current input terminal is converted to a voltage signal by a shunt. Then, it is sent to the current A/D converter in the same fashion as the voltage signal from the current sensor.

The voltage signal that is applied to the voltage A/D converter and current A/D converter is converted to digital values at an interval of approximately 10 μ s. 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. The measured values and computed values are displayed and transmitted as measurement functions of normal measurement.

The harmonic measurement functions are derived in the following manner (harmonic measurement is an option). 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.

2.2 Measurement Functions and Periods

Measurement Functions

The physical values (such as rms voltage, average current, power, and phase difference) that the WT500 measures and displays are called measurement functions. Each measurement function is displayed using symbols that correspond to its physical value. For example, “Urms” corresponds to the true rms voltage.

Types of Measurement Functions Used in Normal Measurement

The data of measurement functions (numeric data) is measured or computed from the sampled data that is described in “Measurement Period” on page 2-9.¹

- 1 The WT500 samples the instantaneous values of the voltage and current signals at the specified sample rate. The sampled data is processed as numeric data or data used to display waveforms on the screen (waveform display data).

The sample rate is the number of data points that are sampled within 1 s. For example, at a sample rate of 100 kS/s, 100000 data points are sampled every second.

Types of Measurement Functions

• Input Element Measurement Functions

The following 23 measurement functions are available. For details about the determination of measurement function data, see appendix 1.

U (voltage Urms, Umn, Udc, Urmn, Uac), I (current Irms, Imn, Idc, Irmn, Iac), P (active power), S (apparent power), Q (reactive power), λ (power factor), ϕ (phase difference), fU/fl (also expressed as FreqU/FreqI; measures the frequencies of up to two voltage/current signals),² U+pk/U-pk (maximum/minimum voltage values), I+pk/I-pk (maximum/minimum current values), and CfU/CfI (crest factor of voltage/current; peak-to-rms ratio)

- 2 The voltage and current frequencies of all input elements can be measured on models with the frequency measurement add-on option.

• Wiring Unit Σ Measurement Functions (Σ Functions)

The following 15 measurement functions are available. For details about the determination of measurement function data, see appendix 1.

U Σ (voltage average Urms Σ , Umn Σ , Udc Σ , Urmn Σ , Uac Σ), I Σ (current average Irms Σ , Imn Σ , Idc Σ , Irmn Σ , Iac Σ), P Σ (sum of active powers), S Σ (sum of apparent powers), Q Σ (sum of reactive powers), $\lambda\Sigma$ (power factor average), and $\phi\Sigma$ (phase difference average)

• Efficiency (Σ functions) and User-Defined Functions

There are two efficiency functions, η_1 and η_2 . The available user-defined functions are F1 to F8. For details, see section 2.5.

• Integration Functions

See section 2.6.

• Delta Computation (Optional)

There are four delta functions, $\Delta F1$ to $\Delta F4$. For details, see section 5.17.

Determining Voltage and Current

The following five types of voltage (U) and current (I) measurement functions are available.

- **Urms and Irms (True rms value)**

These values are the true rms values of the voltage and current. The instantaneous values over one period are squared and averaged. Then, the square root of the average is determined. $f(t)$ is the input signal as a function of time. T is the period of the input signal.

$$\text{Urms or Irms} = \sqrt{\frac{1}{T} \int_0^T f(t)^2 dt}$$

- **Umn and Imn (Rectified mean value calibrated to the rms value)**

This function rectifies one period of the voltage or current signal, determines the average, and multiplies the result by a coefficient. The coefficient is a value that when applied to a sinusoidal input signal, gives the true rms value. When the input signal is a distorted or DC waveform, these values will differ from the true rms values. $f(t)$ is the input signal as a function of time. T is the period of the input signal.

$$\text{Umn or Imn} = \frac{\pi}{2\sqrt{2}} \cdot \frac{1}{T} \int_0^T |f(t)| dt$$

- **Udc and Idc (Simple average, DC)**

These are the average values of the voltage and current signal over one period. This function is useful when determining the average value of a DC input signal or the DC component that is superimposed on an AC input signal.

$$\text{Udc or Idc} = \frac{1}{T} \int_0^T f(t) dt$$

- **Uac and Iac (AC component)**

This function determines the AC component of the voltage or current. The function calculates the square root of the square of the true rms value minus the square of the DC component.

$$\text{Uac} = \sqrt{\text{Urms}^2 - \text{Udc}^2}, \text{ or } \text{Iac} = \sqrt{\text{Irms}^2 - \text{Idc}^2}$$

- **Urmn and Irmn (Rectified mean value)**

This function rectifies one period of the voltage or current signal and determines the average.

$$\text{Urmn or Irmn} = \frac{1}{T} \int_0^T |f(t)| dt$$

Elements

Element refers to a set of input terminals that can receive a single phase of voltage and current to be measured. The WT500 can contain up to three elements, numbered from 1 to 3. An element number is appended to the measurement function symbol for the measured data that the WT500 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 Systems

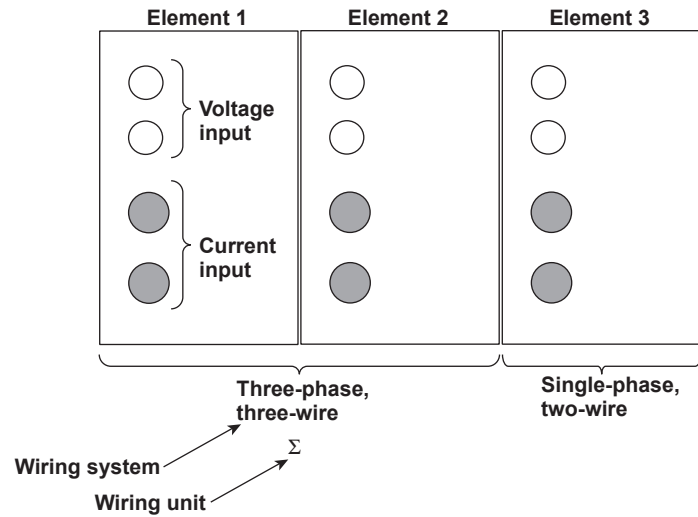
You can specify five wiring systems on the WT500 to measure the power of various single-phase and three-phase power transmission systems: single-phase, two-wire; single-phase, three-wire; three-phase, three-wire; three-phase, four-wire; and three-phase, three-wire with three-voltage, three-current method. For details, see section 2.3.

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. The wiring unit is represented by Σ . The measurement function of a wiring unit is called a Σ function.

For example, "Urms Σ " corresponds to the average of the voltages of the input elements that are assigned to the wiring unit. The average represents the true rms value.

- **Wiring System and Wiring Unit Configuration Example**



Types of Measurement Functions Used in Harmonic Measurement (Optional)

The data of harmonic measurement functions (numeric data) is measured or computed from the sampled data that is described later in “Measurement Period.”*

* For information about sampled data, see the explanation under “Types of Measurement Functions Used in Normal Measurement,” earlier in this section.

Types of Harmonic Measurement Functions

- **Input Element Harmonic Measurement Functions**

The following 15 harmonic measurement functions are available. For details about the determination of measurement function data, see appendix 1.

Measurement Function	Characters or Numbers in Parentheses				All No parentheses
	Total	dc	1	k	
U()	Yes	Yes	Yes	Yes	No
I()	Yes	Yes	Yes	Yes	No
P()	Yes	Yes	Yes	Yes	No
S()	Yes	Yes	Yes	Yes	No
Q()	Yes	Always 0	Yes	Yes	No
λ ()	Yes	Yes	Yes	Yes	No
ϕ ()	Yes	No	Yes	Yes	No
ϕ U()	Yes	No	No	Yes	No
ϕ I()	Yes	No	No	Yes	No
Uhdf()	Yes	Yes	Yes	Yes	No
lhdf()	Yes	Yes	Yes	Yes	No
Phdf()	Yes	Yes	Yes	Yes	No
Uthd	No	No	No	No	Yes
lthd	No	No	No	No	Yes
Pthd	No	No	No	No	Yes

Yes: Numeric data available

No: No numeric data available

- Functions with parentheses will produce different values depending on which of the following is contained in their parentheses.
 - total: The total value is displayed.
 - dc: The dc component numeric data is displayed.
 - 1: The numeric data of the fundamental signal is displayed.
 - k: The numeric data from harmonic orders 2 to N is displayed. N is the upper limit of harmonic order analysis (see section 17.6 for details). The upper limit of harmonic analysis is either set to an automatically determined value or to the value that you set, whichever is smaller. It can go up to the 50th harmonic order.
- All: Functions without parentheses display numeric data.
- Functions Uhdf to Pthd are measurement functions that express values that are unique to harmonics. For details about how the values are determined, see appendix 1.

- **Harmonic Measurement Functions That Express the Voltage and Current Phase Differences (ϕ) between and within Input Elements**

There are five kinds of harmonic measurement functions that express phase differences:

ϕU_i-U_j , ϕU_i-U_k , ϕU_i-I_i , ϕU_i-I_j , ϕU_i-I_k

(i, j, and k are input element numbers)

The following explanation of the five kinds of harmonic measurement functions is for the case when the number of input elements in wiring unit Σ is three and their common wiring system is three phase, four wire. Also, i = 1, j = 2, and k = 3.

In this case, the following numeric data for the phase differences between elements 1, 2, and 3 is calculated.

- $\phi U1-U2$

The phase difference between the fundamental voltage of element 1, $U1(1)$, and the fundamental voltage of element 2, $U2(1)$.

- $\phi U1-U3$

The phase difference between the fundamental voltage of element 1, $U1(1)$, and the fundamental voltage of element 3, $U3(1)$.

- $\phi U1-I1$

The phase difference between the fundamental voltage of element 1, $U1(1)$, and the fundamental current of element 1, $I1(1)$.

- $\phi U1-I2$

The phase difference between the fundamental voltage of element 1, $U1(1)$, and the fundamental current of element 2, $I2(1)$.

- $\phi U1-I3$

The phase difference between the fundamental voltage of element 1, $U1(1)$, and the fundamental current of element 3, $I3(1)$.

- **Functions for Averaging and Summing Input Elements (Σ functions)**

The following six harmonic measurement functions are available. For details about how the measurement function values are determined, see appendix 1.

Measurement Function	Characters or number in parentheses	
	Total	1
$U\Sigma()$	Yes	Yes
$I\Sigma()$	Yes	Yes
$P\Sigma()$	Yes	Yes
$S\Sigma()$	Yes	Yes
$Q\Sigma()$	Yes	Yes
$\lambda\Sigma()$	Yes	Yes

Yes: Numeric data available

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

- total: The total value is displayed.
- 1: The numeric data of the fundamental signal is displayed.

2.2 Measurement Functions and Periods

Elements

Element refers to a set of input terminals that can receive a single phase of voltage and current to be measured. The WT500 can contain up to three elements, numbered from 1 to 3. The element number follows the function symbols discussed in “Input Element Harmonic Measurement Functions” earlier in this section. For example, “U1(2)” corresponds to the voltage of the second harmonic of element 1.

Wiring Systems

The selectable wiring system patterns vary depending on the number of input elements that are installed in the WT500.

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. The wiring unit is represented by Σ . The measurement function of a wiring unit is called a Σ function.

For example, “U Σ (1)” corresponds to the average of the fundamental voltages of the input elements that are assigned to the wiring unit.

PLL Source (See section 6.3 for operating instructions)

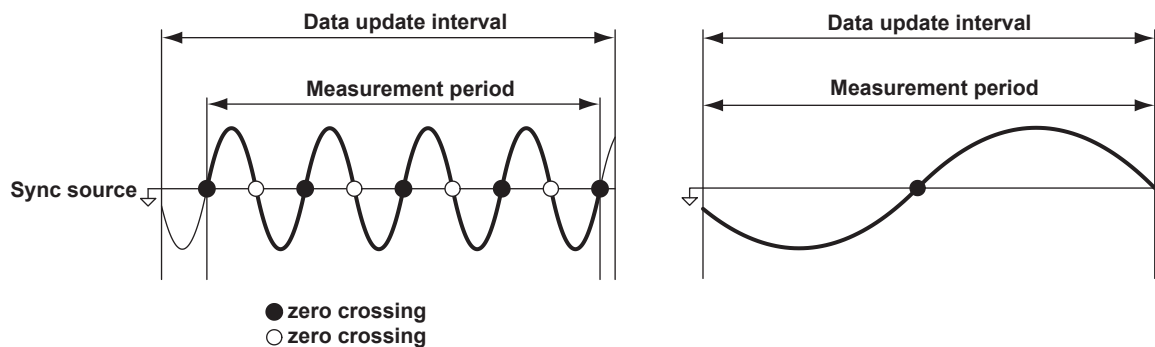
To measure harmonics, the fundamental period (the period of the fundamental signal) that will be used to analyze the harmonics must be determined. The signal for determining the fundamental period is the PLL (phase locked loop) source. For stable harmonic measurement, choose an input signal for the PLL source that has as little distortion and fluctuation as possible. The ideal signal when the crest factor is set to 3 (see section 5.11 for details) is a rectangular wave with an amplitude that is 50% or more of the measurement range (see section 1.3 for details). When the crest factor is set to 6, the ideal signal is a rectangular wave with an amplitude that is 100% or more of the measurement range.

Also, applying a clock signal (Ext Clk) with the same period as the waveform whose harmonics are being measured makes stable harmonic measurement possible.

Measurement Period (See section 4.7 for operating instructions)

Measurement Functions Used in Normal Measurement

- The measurement period is set within the data update interval between the first point where the reference input signal (synchronization source) crosses the level zero point (center of the amplitude) on the rising trigger slope (or falling trigger slope) and the last point where the synchronization source crosses the level zero point (center of the amplitude) on the rising slope (or falling slope).^{1, 2} However, the measurement period for determining the numeric data of the peak voltage or peak current is the entire span of the data update interval. 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 Cfl) is also the entire span of the data update interval.
- The WT500 determines whether to define the measurement period using the rising or falling edge automatically by choosing the method that will result in the longest measurement period.
- If there is not more than one rising or falling slope within the data update interval, the entire data update interval is set as the measurement period.
- You can select which input signal will be the synchronization source (synchronized to the zero-crossing point of the input signal) for each element. You can set the synchronization source signal to the voltage, current, or external clock input signal.
- For details, see appendix 6.
 - 1 *Trigger 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).
 - 2 The *data update interval* is the interval at which the data that is used in measurement functions is sampled. For details on how to set the interval, see section 2.3, "Data Update Rate."



Measurement Functions Used in Harmonic Measurement

The measurement period is the first 1024 points from the beginning of the data update interval at the harmonic sampling frequency. The WT500 determines the harmonic sampling frequency automatically based on the period of the signal that is set as the PLL source. The sampled data and the measurement period used for computation may differ from the sampled data and the measurement period used for measurement functions.

2.3 Measurement Conditions

Number of Installed Input Elements and Wiring Systems (See sections 4.2 and 4.3 for operating instructions)

Wiring Systems

- There are five wiring systems available on the WT500.
 - 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
- * In this manual, "3P3W" is used to indicate a three-phase, three-wire system and a three-phase, three-wire system with a three-voltage, three-current method. Since the two types of wiring systems cannot be distinguished if only 3P3W is written, "3P3W (3V3A)" is used to indicate the three-voltage, three-current method.
- The selectable wiring systems vary depending on the number of installed elements.

Wiring Unit

The *wiring unit* is a set of two or three input elements of the same wiring system that are grouped together. The wiring unit is represented by Σ .

For example, "Urms Σ " corresponds to the average of the voltages of the input elements that are assigned to the wiring unit. The average value represents the true rms value.

Wiring System Patterns

- The following table shows the relationship between the number of installed input elements, the selectable wiring system patterns, and the assignment of input elements to wiring unit Σ .
For example, there are four wiring system patterns on a WT500 that has three input elements installed.
- The input element assignment to wiring unit Σ and how Σ functions (such as voltage, current, active power, apparent power, reactive power, power factor, and phase difference) are determined are based on the wiring system pattern. For details about the relationship between the wiring system and how Σ functions data is determined, see Appendix 1.

Number of installed input elements	1		
Wiring system Pattern 1	1P2W		
Number of installed input elements	1	2	
Wiring system Pattern 1	1P2W	1P2W	
Wiring system Pattern 2	1P3W: Σ or 3P3W: Σ		
Number of installed input elements	1	2	3
Wiring system Pattern 1	1P2W	1P2W	1P2W
Wiring system Pattern 2	1P3W: Σ or 3P3W: Σ		1P2W
Wiring system Pattern 3	1P2W	1P3W: Σ or 3P3W: Σ	
Wiring system Pattern 4	3P4W: Σ or 3P3W (3V3A): Σ		

Measurement Range (See section 4.4 for operating instructions)

Set the measurement range using an rms value. When directly applying voltage or current signals to an input element, two types of measurement ranges are available: fixed range and auto range. When waveforms are displayed and the crest factor (see section 4.6 for details) is set to 3, the vertical display range corresponds to 3 times the measurement range. When the crest factor is set to 6, the vertical display range corresponds to 6 times the measurement range. For details about waveform display, see section 2.7, "Waveform Display."

Fixed Range

Select each range from the given choices. The selected range does not change even if the amplitude of the input signal changes. For voltage, the maximum and minimum selectable ranges when the crest factor is set to 3 are 1000 V and 15 V. When the crest factor is set to 6, the maximum and minimum selectable ranges are 500 V and 7.5 V.

Auto Range

The measurement range is switched automatically depending on the amplitude of the input signal. The different ranges used in the auto range are the same as those available for the fixed range.

• Range Increase

- The measurement range is increased when the data of measurement function U_{rms} or I_{rms} exceeds 110% of the currently set measurement range.
- The measurement range is increased when the crest factor is set to 3 and the peak value of the input signal exceeds 330% of the currently set measurement range, or when the crest factor is set to 6 and the peak value of the input signal exceeds 660% of the currently set measurement range.

• Range Decrease

The measurement range is decreased when the data of the measurement function U_{rms} or I_{rms} is less than or equal to 30% of the measurement range and Upk^* and Ipk^* are less than or equal to 300% of the next lower range when the crest factor is set to 3, or 600% of the next lower range when the crest factor is set to 6.

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

Power Range

The measurement ranges (power ranges) of active power, apparent power, and reactive power are determined by the wiring system, voltage range, and current range as shown below. For the actual power range values, see section 4.3, "Setting the Measurement Range during Direct Input."

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

Scaling (See sections 4.5 and 4.6 for operating instructions)

When applying current signals through an external current sensor or applying voltage or current signals through an external VT (voltage transformer) or CT (current transformer), the conversion ratio or coefficient can be specified.

When Applying Current Signals through an External Current Sensor

The output of current sensors that output voltage, such as shunts and clamps, can be applied to the current sensor connector (EXT) and measured. Set how many millivolts the current sensor transmits 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 input terminals.

Measurement Function	Conversion Ratio	Data before Transformation	Transformation 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 value Ipk	E	I_{pk_s} (current sensor output)	I_{pk_s}/E

When Applying Voltage or Current Signals through an External VT or CT

• **VT ratio and CT ratio**

You can convert the input signal into the numeric data or waveform display data of the voltage or current before transformation by setting the VT ratio, CT ratio, and power factor (coefficient multiplied to the power determined from the voltage and current).

• **Power factor**

By setting the power factor (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 Transformation	Transformation Result	
Voltage U	U_2 (secondary output voltage of the VT)	$U_2 \times V$	V: VT ratio
Current I	I_2 (secondary output of the CT)	$I_2 \times C$	C: CT ratio
Active power P	P_2	$P_2 \times V \times C \times SF$	SF: Power factor
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 value Upk	U_{pk_2} (secondary output of the VT)	$U_{pk_2} \times V$	
Max./Min. current value Ipk	I_{pk_2} (secondary output of the CT)	$I_{pk_2} \times C$	

Input Filter (See section 4.8 for operating instructions)

There are two types of input filters. The WT500 makes measurements by synchronizing to the input signal. Therefore, the frequency of the input signal must be measured accurately.

Line Filter

The line filter is inserted into the voltage, current, and power measurement input circuits and directly affects the voltage, current, and power measurements (see the block diagram in section 2.1). When the line filter is turned on, the measured value does not contain high frequency components. The voltage, current, and power of inverter waveforms, strain waveforms, etc., can be measured with their high frequency components eliminated. You can select the cutoff frequency.

Frequency Filter

The frequency filter is inserted into the frequency measurement input circuit and affects frequency measurements. It affects the detection of the measurement period for voltage, current, and power measurements (see section 4.7 and appendix 5). The frequency filter is also used to accurately detect the zero crossing (see section 2.2 and appendix 5). The frequency filter is not inserted into the voltage, current, and power measurement input circuit. Therefore, the measured values include high frequency components even when the frequency filter is turned on.

Note

The frequency filter is turned on when the line filter is set to 500 Hz.

Data Update Rate (See section 4.9 for operating instructions)

You can select an update interval from 100 ms, 200 ms, 500 ms, 1 s, 2 s, and 5 s.

The numeric data is updated at the selected interval. To capture relatively fast load fluctuations in the power system, select a fast data update rate. To capture relatively low frequency signals, select a slow data update rate.

Averaging (See section 4.10 for operating instructions)

The averaging function is effective when reading of the numeric display is difficult 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.

During Normal Measurement

Two types of averages are available: exponential averages and moving averages.

- **Exponential Average**

Numeric data can be exponentially averaged using a specified attenuation constant. Averaging is performed according to the following equation.

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

- D_n: Displayed value that has been exponentially averaged n times. (The first displayed value D₁ is equal to M₁.)
- D_{n-1}: Displayed value that has been exponentially averaged n-1 times.
- M_n: Measured data at the nth time.
- K: Attenuation constant (can be selected from 2, 4, 8, 16, 32, and 64)

- **Moving Average**

Numeric data can be linearly averaged using a specified average count. Averaging is performed according to the following equation.

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

- D_n: Displayed value obtained by linearly averaging m points of numeric data from the n-(m-1)th to the nth time
- M_{n-(m-1)}: Measured data at the n-(m-1)th time.
.....
.....
- M_{n-2}: Measured data at the n-2th time.
- M_{n-1}: Measured data at the n-1st time.
- M_n: Measured data at the nth time.
- m: Average count (can be selected from 8, 16, 32, 64, 128, and 256)

During Harmonic Measurement

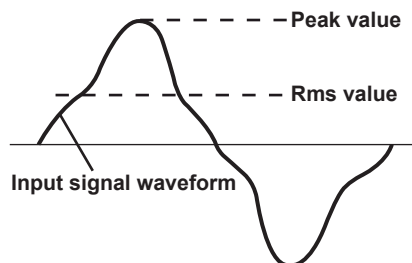
When exponential averaging is specified, the harmonic measurement functions are averaged.

When averaging is set to moving average, averaging is only performed on normal measurement functions, not on harmonic measurement functions.

Crest Factor (See section 4.11 for operating instructions)

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

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



The crest factor on the WT500 is determined by the ratio of the maximum peak value that can be applied for rated input to the measurement range.

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

The crest factor can be set to 3 or 6. 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 measured signal is greater than the specifications of the measurement instrument (the crest factor defined at the rated input), the signal can be measured 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 at CF = 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 chapter 14, "Specifications."

Hold (See section 4.12 for operating instructions)

The data display of each measurement function can be held. The communication output data while the display is held is the same as the held numeric data.

Single Measurement (See section 4.12 for operating instructions)

While the display is held, the signal is measured once at the set data update rate, and then the display is re-held.

2.4 Power Measurement

When the screen is set to numeric display, measured data such as voltage, current, and power can be displayed.

Display Resolution

The display resolution for voltage, current, active power, apparent power, reactive power, and so on is 60000. When the range rating (rated value of the specified measurement range) is specified, the Σ functions of the voltage, current, active power, apparent power, reactive power, and so on are set to the decimal place and unit of the element with the lowest display resolution of the target elements. For information about the display resolution for integration, see section 5.8.

Numeric Display during Normal Power Measurement (See section 5.1 for operating instructions)

Selecting the Number of Displayed Items

The number of items can be selected from 4, 8, 16, Matrix, and All Items. Not all of the data will fit onto a single screen. You can scroll through the displayed items to view data that is not on the screen.

• Eight-Item Display Example

Measurement function	Value	Unit
U _{rms1}	102.70	v
I _{rms1}	373.44	mA
P ₁	24.73	w
S ₁	38.35	VA
Q ₁	29.32	var
λ ₁	0.6447	
ϕ ₁	G49.86	°
f _{U1}	50.021	Hz

• Matrix Display Example

Element and wiring system

Measurement function	Element and wiring system		
	Element1 U1 100v I1 500mA	Element2 U2 100v I2 500mA	Element3 U3 100v I3 500mA
U _{rms} [V]	102.69	102.69	102.69
I _{rms} [A]	375.19 _m	375.18 _m	375.14 _m
P [W]	24.951	24.953	24.949
S [VA]	38.527	38.529	38.524
Q [var]	29.356	29.357	29.353
λ []	0.6476	0.6476	0.6476
ϕ [°]	G49.64	G49.64	G49.64
f _U [Hz]	50.031	50.031	50.031
f _I [Hz]	50.030	50.029	50.030

• All-Item Display Example

Element and wiring system

Measurement function	Element and wiring system			
	Element1 100v 500mA	Element2 100v 500mA	Element3 100v 500mA	Σ (3V3A)
U _{rms} [V]	102.70	102.70	102.70	102.70
I _{rms} [A]	375.40 _m	375.39 _m	375.34 _m	375.38 _m
P [W]	24.964	24.967	24.963	49.931
S [VA]	38.553	38.555	38.549	66.774
Q [var]	29.379	29.379	29.374	58.758
λ []	0.6475	0.6476	0.6476	0.7470
ϕ [°]	G49.64	G49.64	G49.64	G41.60
f _U [Hz]	50.024	50.024	50.024	
f _I [Hz]	50.025	50.025	50.025	
U _{rms} [V]	102.70	102.70	102.70	102.70
U _{mn} [V]	102.69	102.70	102.70	102.69
U _{dc} [V]	-0.00	0.00	-0.00	0.00
U _{rms} [V]	92.45	92.46	92.46	92.46
U _{ac} [V]	102.70	102.70	102.70	102.70
U _{pk} [V]	142.18	142.20	142.18	
U _{pk} [V]	-142.18	-142.20	-142.20	
c _{fU} []	1.384	1.385	1.385	

Changing the Displayed Items

You can select a displayed item to change the numeric data that is displayed at that item's position.

U rms1	102.70 v		U rms1	102.49 v
I rms1	373.44 mA	Change the measurement function of the third item →	I rms1	371.50 mA
P 1	24.73 W		λ1	0.6447
S 1	38.35 VA	Change the element of the third item ↘	S 1	38.21 VA
			U rms1	102.86 v
			I rms1	379.32 mA
			P 2	20.02 W
			S 1	39.85 VA

Scrolling through Pages

The numeric display consists of up to nine pages. The number of pages varies depending on the installed options and the number of displayed items. You can set the displayed items on each page. The page can be scrolled to switch the page, and the displayed items can be changed collectively.

Display example
Displays the voltage, current, power, and power factor of elements 1 to 3 on pages 1 to 3. Displays the voltage, current, power, and power factor of wiring unit Σ on pages 4.

Page bar
The current page is highlighted.

Resetting the Numeric Display

If the number of displayed items is set 4, 8, 16, or matrix, the display order of measurement functions can be reset to the factory default configuration.

Numeric Display during Harmonic Measurement (See section 6.1 for operating instructions)

In addition to the 4, 8, 16, matrix, and All displays, list displays (the single list and double list displays) are also available.

Selecting the Number of Displayed Items

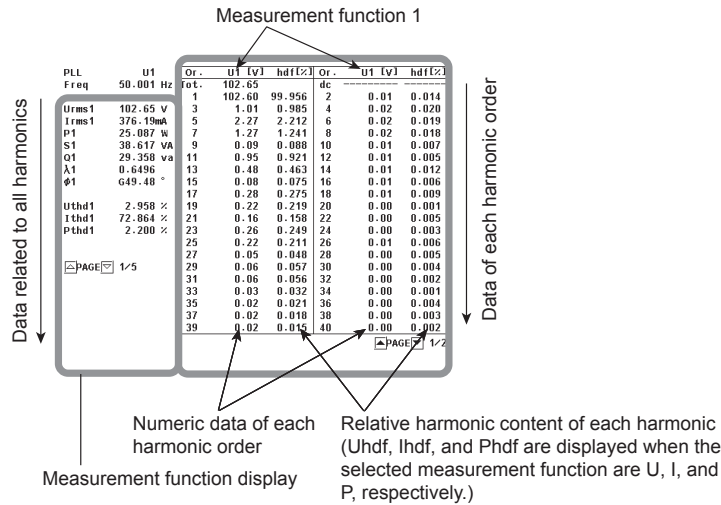
Just as in ordinary measurement, the number of items can be selected from 4, 8, 16, Matrix, and All Items.

List Display

For each measurement function, the numeric data for each harmonic can be displayed in two columns.

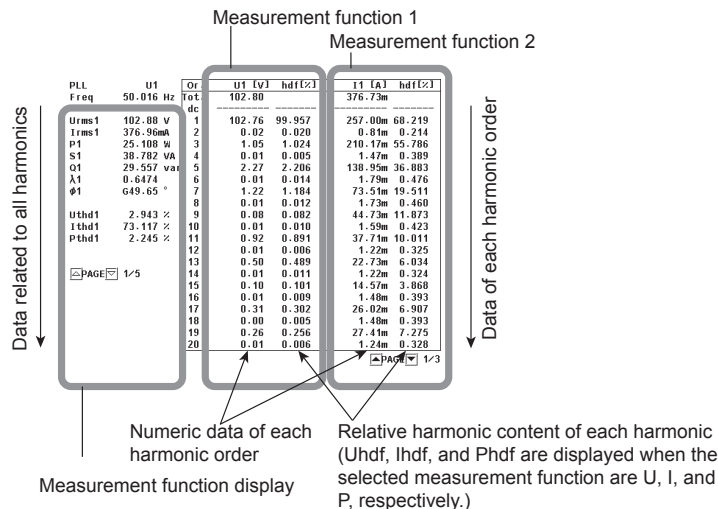
- **Single List**

The data of a single measurement function can be divided into even and odd harmonics and displayed. The selectable measurement functions are U, I, P, S, Q, λ , ϕ , ϕU , and ϕI .



- **Dual List**

The data from two different measurement functions can be displayed in two separate columns. The selectable measurement functions are U, I, P, S, Q, λ , ϕ , ϕU , and ϕI .



Scrolling through Pages

Just as in ordinary measurement, you can scroll through pages one page at a time.

Resetting the Numeric Display

If the number of displayed items is set 4, 8, 16, or matrix, the display order of measurement functions can be reset to the factory default configuration.

2.5 Computation

The following computations can be performed with the data of measurement functions. In addition, there is a function that allows you to select the equation used to determine the measurement function data.

Setting the Equation for Computing Efficiency (See section 5.3 for operating instructions)

To measure the input/output efficiency of a device, set the equations for η_1 and η_2 . For example, if the input power to a device is P_1 and the output power is P_Σ , you can compute the power conversion efficiency of the device by setting the equation to $\eta = (P_\Sigma)/(P_1) \times 100$.

Setting the Equation for Computing Apparent Power (See section 5.4 for operating instructions)

Apparent power is the product of voltage times current. The voltage and current used to determine the apparent power can be selected from (1) the true rms values explained under "Determining Voltage and Current" in section 2.2, "Measurement Functions and Periods"; (2) the rectified mean values calibrated to the rms values; (3) the linear averages; (4) the rectified mean value calibrated to the rms value of the voltage and the rms value of the current; and (5) the rms values.

Selecting the Computing Equation for Apparent Power and Reactive Power (See section 5.4 for operating instructions)

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

$$\text{Active power } P = UI\cos\phi \dots\dots\dots(1)$$

$$\text{Reactive power } Q = UI\sin\phi \dots\dots\dots(2)$$

$$\text{Apparent power } S = UI\dots\dots\dots(3)$$

U = rms voltage; I = rms current; ϕ = Phase difference between voltage and current

The power values are related as follows:

$$(\text{Apparent power } S)^2 = (\text{Active power } P)^2 + (\text{Reactive power } Q)^2 \dots\dots(4)$$

The three-phase power is the sum of the power of each phase.

These definitions only apply for 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 computation. Because the equations for deriving the power for distorted waveforms are not defined, none of the equations can be said to be more correct than the other. Therefore, the WT500 provides three equations for determining the apparent power and reactive power.

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)

The apparent power of each phase is calculated using equation 3, and the reactive power of each phase is calculated using equation 2. The results are summed to derive the power.

$$\text{Active power for a three-phase, four-wire system} \quad P_\Sigma = P_1 + P_2 + P_3$$

$$\text{Apparent power for a three-phase, four-wire system} \quad S_\Sigma = S_1 + S_2 + S_3 (= U_1 \times I_1 + U_2 \times I_2 + U_3 \times I_3)$$

$$\text{Reactive power for a three-phase, four-wire system} \quad Q_\Sigma = Q_1 + Q_2 + Q_3$$

$$(= s_1 \times \sqrt{(U_1 \times I_1)^2 - P_1^2} + s_2 \times \sqrt{(U_2 \times I_2)^2 - P_2^2} + s_3 \times \sqrt{(U_3 \times I_3)^2 - P_3^2})$$

The sign for s_1 , s_2 , and s_3 is negative when the current leads the voltage and positive when the current lags the voltage.

Type 2

The apparent power of each phase is determined from equation 3, and the results are added to derive the three-phase apparent power. The three-phase reactive power is calculated from the three-phase apparent power and the three-phase active power using equation 4.

$$\begin{aligned} \text{Active power for a three-phase, four-wire system} & P_{\Sigma} = P_1 + P_2 + P_3 \\ \text{Apparent power for a three-phase, four-wire system} & S_{\Sigma} = S_1 + S_2 + S_3 (= U_1 \times I_1 + \\ & U_2 \times I_2 + U_3 \times I_3) \\ \text{Reactive power for a three-phase, four-wire system} & Q_{\Sigma} = \sqrt{S_{\Sigma}^2 - P_{\Sigma}^2} \end{aligned}$$

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

The reactive power of each phase is calculated directly using equation 2. The three-phase apparent power is calculated using equation 4. This equation can be selected on models with the harmonic measurement option.

$$\begin{aligned} \text{Active power for a three-phase, four-wire system} & P_{\Sigma} = P_1 + P_2 + P_3 \\ \text{Apparent power for a three-phase, four-wire system} & S_{\Sigma} = \sqrt{P_{\Sigma}^2 + Q_{\Sigma}^2} \\ \text{Reactive power for three-phase, four-wire system} & Q_{\Sigma} = Q_1 + Q_2 + Q_3 \end{aligned}$$

Phase Difference (See section 5.5 for operating instructions)

You can select the format for displaying the voltage and current phase differences between and within each element. With the voltage of each element as a reference, one format displays the phase difference using 360° in the clockwise direction, and the other format displays lead up to 180° in the counterclockwise direction (D) and lag up to 180° in the clockwise direction (G). In harmonic measurement (optional), the phase differences between harmonics 1 to 50 of the voltage and current signals are displayed using a 360° format or a 180° format with a negative sign for lead and no sign for lag.

User-Defined Functions (See section 5.13 for operating instructions)

Equations can be created (defined) by combining the measurement function symbols and operators. The numeric data that corresponds to the equation can then be determined. The combination of a measurement function and an element number, "Urms1:URMS(E1)" for example, constitutes an operand. Eight equations (F1 through F8) can be defined.

Operators

There are 11 operators: +, -, *, /, ABS (absolute value), SQR (square), SQRT (square root), LOG (logarithm), LOG10 (common logarithm), EXP (exponent), and NEG (negation).

Number of Operands

There can be up to 16 operands in one equation.

MAX Hold (See section 5.14 for operating instructions)

The maximum value of a type of numeric data can be held. The measurement functions that the MAX hold is applied to are selected from the user-defined functions.

Setting the Average Active Power (See section 5.15 for operating instructions)

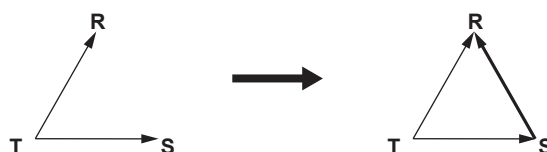
The average active power can be computed for devices, such as intermittent control devices, whose power fluctuates. The equation for computing the average active power is specified using a user-defined function.

Delta Computation (Optional; See section 5.17 for operating instructions)

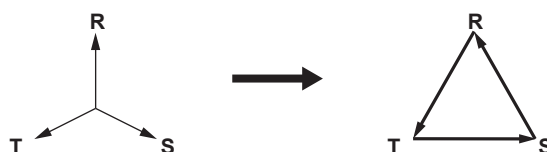
The sum or difference of the instantaneous voltage or current values (sampled data) between the elements in a wiring unit can be used to determine various types of data such as the differential voltage and phase voltage. This operation is called *delta computation*.

Delta computation can be applied in the following ways:

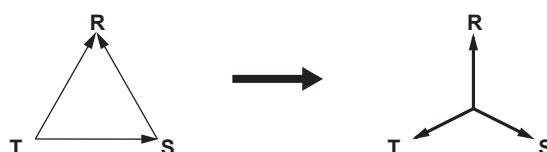
- The differential voltage and differential current between two elements can be computed on a single-phase, three-wire system or on a three-phase, three-wire system (when using two elements).
- The line voltage and phase current that are not measured can be computed on a single-phase, three-wire system or on a three-phase, three-wire system (when using 2 elements).



- Using the data from a three-phase, four-wire system, the data of a delta connection can be computed from the data of a star connection (star-delta transformation).



- Using the data from a three-phase, three-wire system (three-voltage, three-current method), the data of a star connection can be computed from the data of a delta connection (delta-star transformation). This function is useful when you wish to observe the phase voltage of an object that has no neutral line.



Equations for Computing the Distortion Factor (See section 6.5 for operating instructions)

Models with the harmonic measurement option can compute distortion factors. There are two equations for computing the distortion factor, each with different denominators. For information about these equations, see appendix 1.

2.6 Integration

The WT500 can integrate the active power (watt hour), the current (ampere hour), the apparent power (volt-ampere hour), and the reactive power (var hour) values. During integration, the measured and computed values of normal measurements can be displayed in addition to the watt hour, ampere hour, volt-ampere hour, var hour, and integration time values.

Integration Functions

Input Element Measurement Functions

The following nine types of numeric data can be determined. For details about the determination of measurement function data, see appendix 1.

(1) WP: watt hours, i.e., the sum of positive and negative watt hours, (2) WP+: positive watt hours consumed, (3) WP-: negative watt hours returned to the power supply, (4) q: ampere hours, i.e., the sum of positive and negative ampere hours, (5) q+: positive ampere hours consumed, (6) q-: negative ampere hours returned to the power supply, (7) WS: volt-ampere hours, (8) WQ: var hours, and (9) Time: integration time.

- **Watt Hour Integration Method for Each Polarity (See section 5.11 for operating instructions)**

For positive and negative watt hours, WP+ and WP-, you can set the integration equation to determine the DC or AC watt hours. (DC watt hours are computed by integrating each sampled data item. AC watt hours are computed by integrating the values at each data update interval.)

- **Current Integration Modes (See section 5.12 for operating instructions)**

You can select the type of current whose values will be integrated.

Wiring Unit Σ Measurement Functions (Σ Functions)

The following eight types of numeric data can be determined. For details about the determination of measurement function data, see appendix 1.

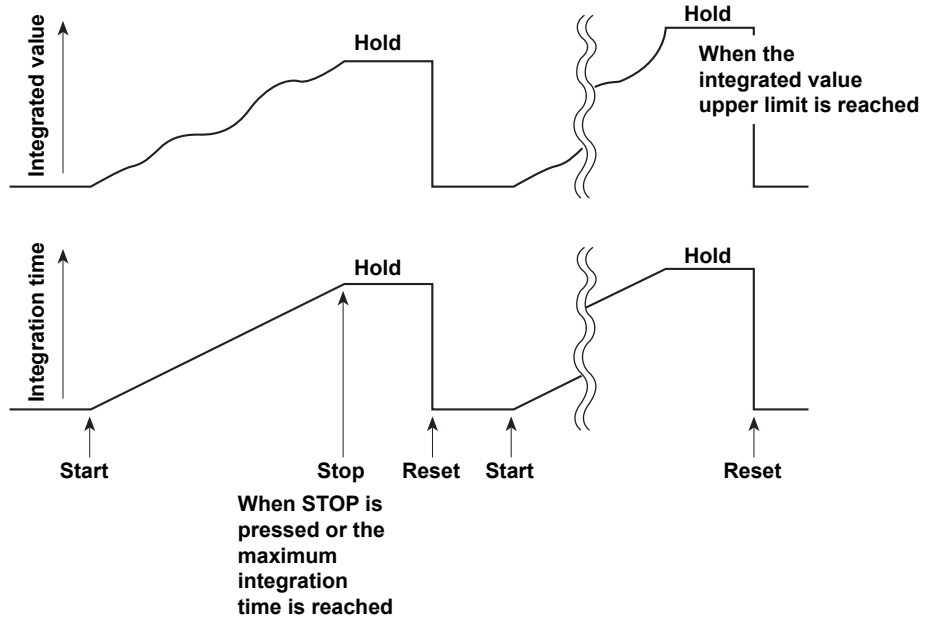
(1) WP Σ : sum of WP values, (2) WP+ Σ : sum of WP+ values, (3) WP- Σ : sum of WP- values, (4) q Σ : sum of q values, (5) q+ Σ : sum of q+ values, (6) q- Σ : sum of q- values, (7) WS Σ : sum of S Σ values, and (8) WQ Σ : sum of Q Σ values.

Integration Mode (See sections 5.6 and 5.7 for operating instructions)

The integration feature has five modes: manual integration mode, normal integration mode, continuous integration mode, real-time integration mode, and real-time continuous integration mode.

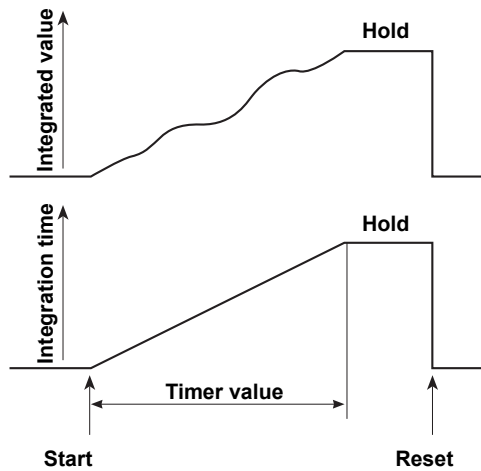
Manual Integration Mode

Integration continues from when you start it until you stop it. However, when the integration time reaches its maximum (10000 hours) or the integrated value reaches its maximum or minimum displayable value (see section 5.6 for details), integration is stopped, and the integration time and integrated value at that point are held.



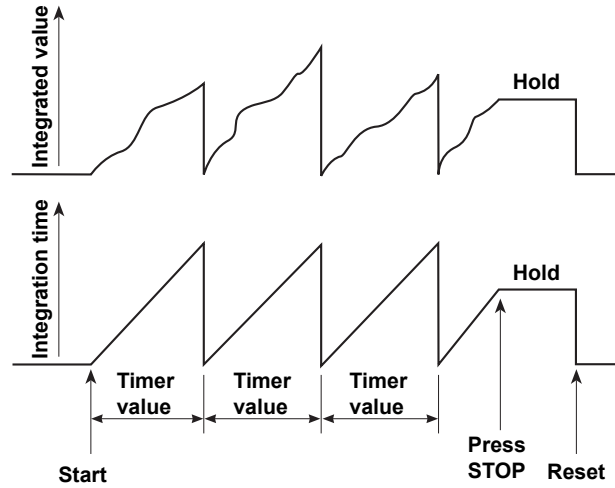
Normal Integration Mode

Integration continues for a specified amount of time (which is determined by the timer setting), and then stops. However, if the integrated value reaches its maximum or minimum displayable value before the specified amount of time has elapsed, integration is stopped, and the integration time and integrated value at that point are held.



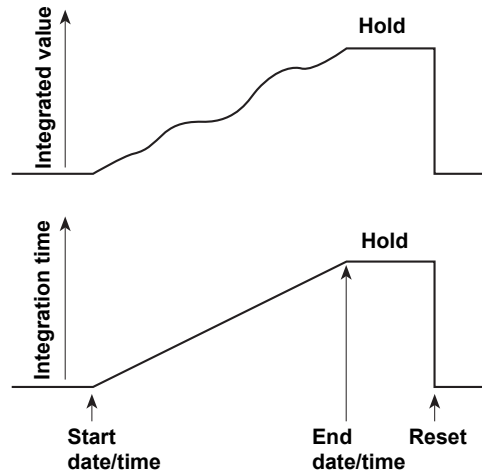
Continuous Integration Mode

Integration continues for a specified amount of time, and then resets and starts again. Integration repeats until you press STOP. If the integrated value reaches its maximum or minimum displayable value before the specified amount of time has elapsed, integration is stopped, and the integration time and integrated value at that point are held.



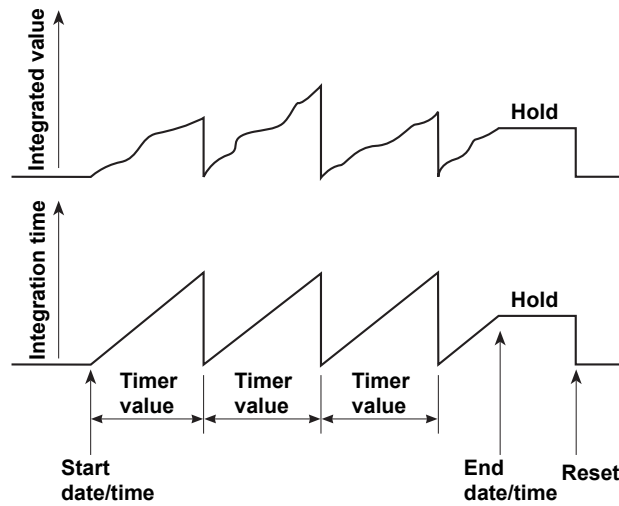
Real-Time Normal Integration Mode

You specify the dates and times when integration will start and end. When the specified stop time is reached, or when the integrated value reaches its maximum or minimum displayable value, integration is stopped, and the integration time and integrated value at that point are held.



Real-Time Continuous Integration Mode (Continuous integration)

You specify the dates and times when integration will start and end, and integration repeats within the start and end times at the interval specified by the timer. When the amount of time specified by the timer elapses, integration resets and starts again. When the specified stop time is reached, or when the integrated value reaches its maximum or minimum displayable value, integration is stopped, and the integration time and integrated value at that point are held.



2.7 Waveform Display

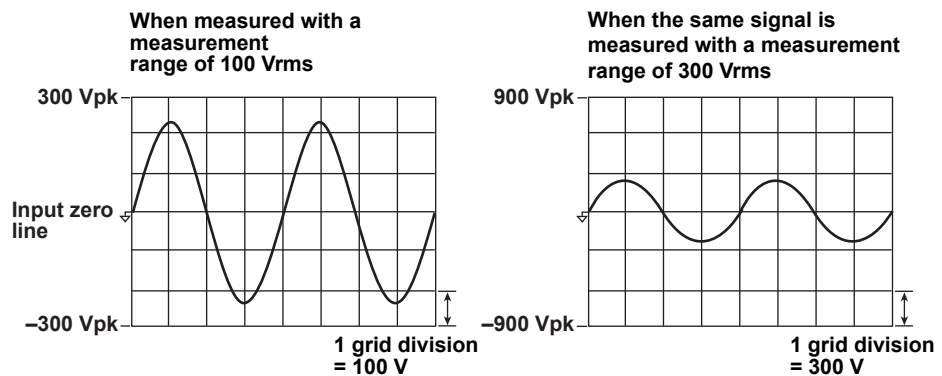
The WT500 displays waveforms based on the data sampled within the data update rate.

Selecting the Waveform to Display (See section 3.7 for operating instructions)

You can select whether to show or hide the voltage and current waveforms of each input element. This makes waveforms easier to see by allowing you to only show the waveforms that you want to examine.

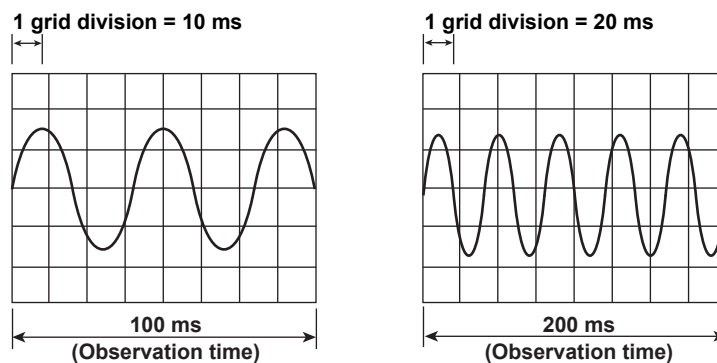
Vertical (Amplitude) Axis

The range of the vertical display is based on the specified measurement range. For example, if the crest factor is set to 3 and the voltage measurement range is set to 100 Vrms, the display range is set so that the top of the screen is 300 Vpk ($100 \text{ Vrms} \times 3$) and so that the bottom is -300 Vpk ($-100 \text{ Vrms} \times 3$), with the zero input line at the center. If the crest factor is set to 6 and the voltage measurement range is set to 50 Vrms, the display range is set so that the top of the screen is 300 Vpk ($50 \text{ Vrms} \times 6$) and so that the bottom is -300 Vpk ($-50 \text{ Vrms} \times 6$), with the zero input line at the center. The waveform is clipped if this range is exceeded.



Horizontal (Time) Axis (See section 7.4 for operating instructions)

Set the length of the horizontal axis by specifying the time per grid division. The time axis can be set up to the point in which the time corresponding to one screen is equal to the data update rate, in 1, 2, 5 steps. For example, if the data update rate is 500 ms, the time per division can be changed in this order: 1 ms > 2 ms > 5 ms > 10 ms > 20 ms > 50 ms. In this case, the time corresponding to one screen changes in this order: 10 ms > 20 ms > 50 ms > 100 ms > 200 ms > 500 ms.



Note

- **Waveform sampling data and waveform display data (the number of displayed points on the screen)**

Waveform sampling data and waveform display data are both measured waveform data, but they differ as described below.

Waveform sampling data: Data derived through A/D conversion of the input signal

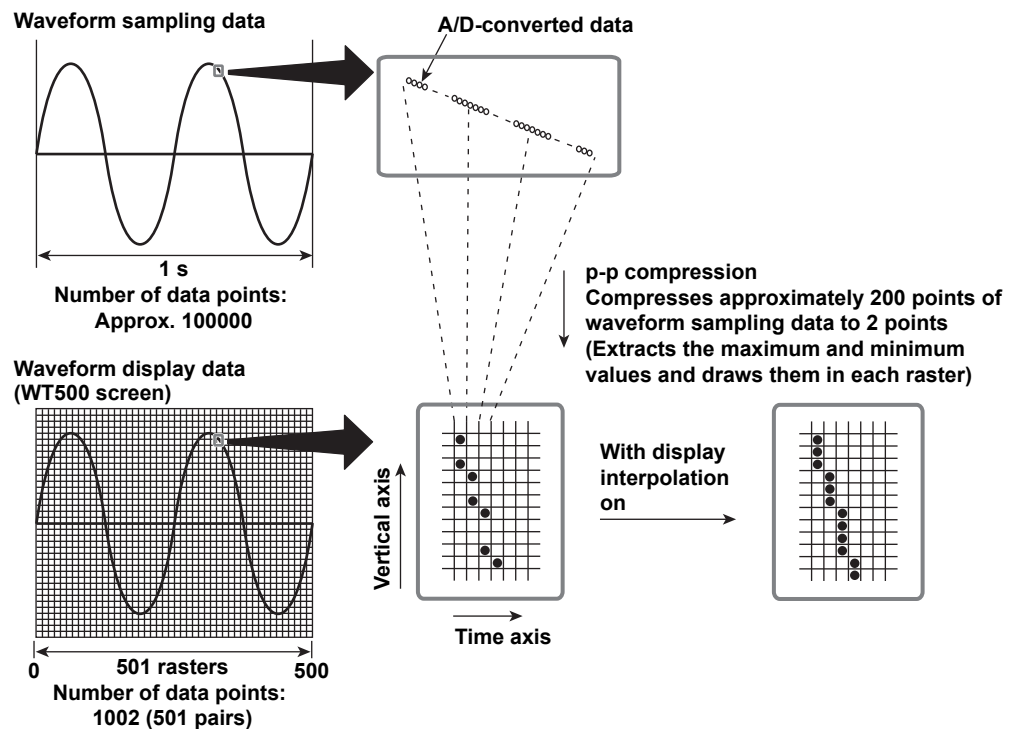
The WT500 A/D conversion rate is approximately 100 kS/s. Therefore, if the data update rate is set to 1 s, the number of data points sampled from a single input signal in a single measurement is approximately 100000 (see the figure below). Waveform sampling data is also called acquisition data or raw wave data.

Waveform display data: Waveform data displayed on the WT500 screen (1002 points)

When displaying waveforms on the WT500, data points are displayed in horizontal rasters (along the time axis). The number of rasters is 501. 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 1002.

Extraction of waveform display data from waveform sampling data (p-p compression)

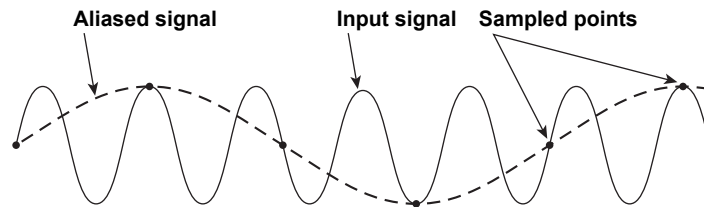
This example assumes that a 2-Hz sine wave is measured at a data update rate of 1 s. To display this waveform on the WT500 screen, the number of data points is converted from approximately 100000 to 1002 (501 pairs of maximum and minimum values). Thus, two points (a pair) of waveform display data are derived from approximately 200 points of waveform sampling data. This conversion is called p-p (peak-peak) compression. The compression rate of p-p compression varies depending on the data update rate and the horizontal scale (time axis) of the WT500 waveform display.



2.7 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 is called aliasing.



- **Sampling of waveform display data**

The WT500 samples waveform display data and stores it to memory at a rate of approximately 100 kS/s. The WT500 can accurately display the waveforms of signals with frequencies up to approximately 5 kHz.

Trigger (See section 7.5 for operating instructions)

A trigger is said to have "occurred" when the specified trigger condition is met and a waveform is displayed on the screen.

Trigger Mode

The trigger mode specifies the conditions for updating the display.

- **Auto Mode**

If a trigger occurs within a set amount of time (about 100 ms), which is referred to as the timeout period, the waveform display is updated. If the timeout period elapses without a trigger occurring, the display will be updated automatically.

- **Normal Mode**

The display is only updated when the trigger occurs. If the trigger does not occur, the display will not be updated.

Trigger Source

The trigger source is the signal that is used to check for the trigger condition.

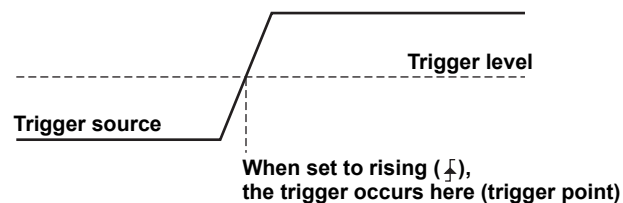
Trigger Slope

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.

Trigger Level

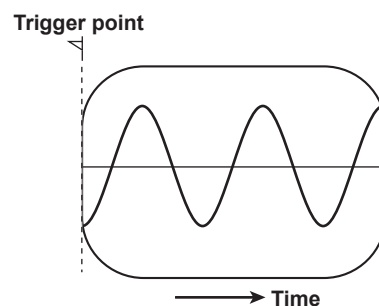
The trigger level is the level at which the trigger slope is determined.

When the trigger source passes through the specified trigger level on a rising or falling edge, a trigger occurs. You can select the input signal from any element or from the external clock signal as the trigger source.



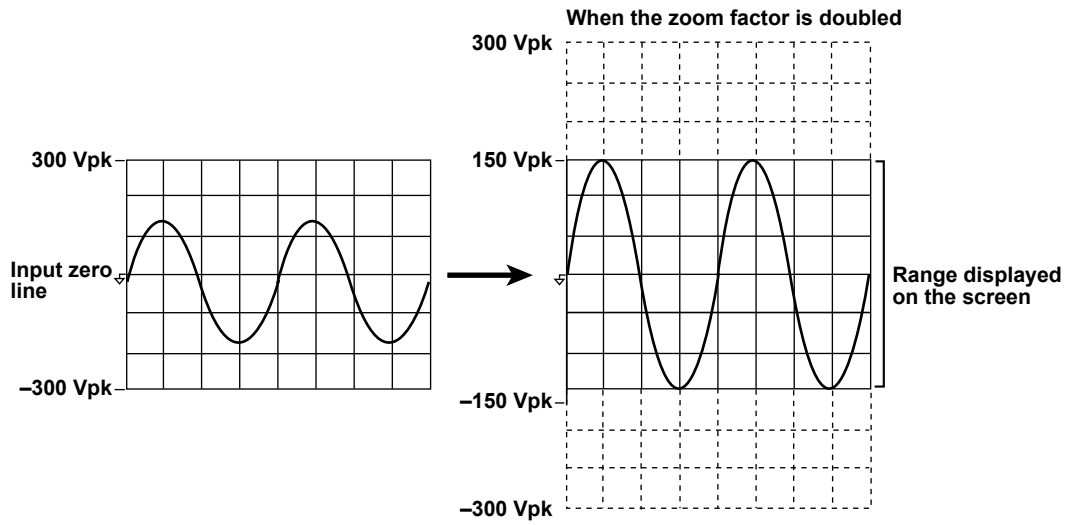
Trigger Point

The trigger point is the point at which a trigger occurs. The trigger point is always displayed at the left end 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.



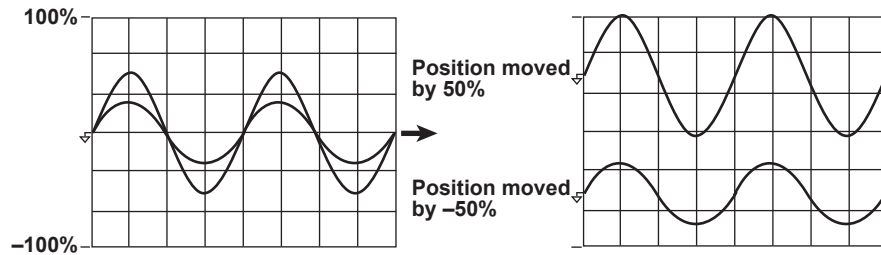
Vertical Waveform Zoom (See section 7.6 for operating instructions)

Each displayed waveform can be scaled vertically by a zoom factor of 0.1 to 100. The waveform is scaled around the zero-input line.



Vertical Waveform Position (See section 7.6 for operating instructions)

You can vertically shift the displayed position of a waveform. This is useful 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.



Split Waveform Display and Assignment (See section 7.7 for operating instructions)

The screen can be divided into windows, and waveforms can be assigned to those windows. The screen can be divided into up to four windows. This function is useful when there are many waveforms and it is difficult to view them all in a single display. Waveforms can be assigned to windows in one of the following three ways.

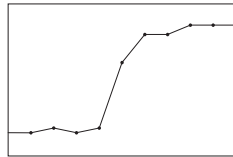
- Auto
The waveforms whose displays are turned on are assigned in order according to their element numbers, with an element's voltage waveform coming before its current waveform.
- Fixed
Regardless of whether their displays are on or off, waveforms are assigned in order according to their element numbers, with an element's voltage waveform coming before its current waveform.
- User
Waveforms can be assigned to windows by the user, regardless of whether their displays are on or off.

Waveform Display Interpolation (See section 7.8 for operating instructions)

The waveform display data can be connected linearly to display the waveform smoothly.

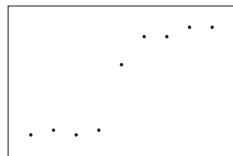
Linear Interpolation

Fills in the space between two data points with a straight line.



Interpolation OFF

No interpolation is performed. Only the data points are displayed.



Graticule (See section 7.8 for operating instructions)

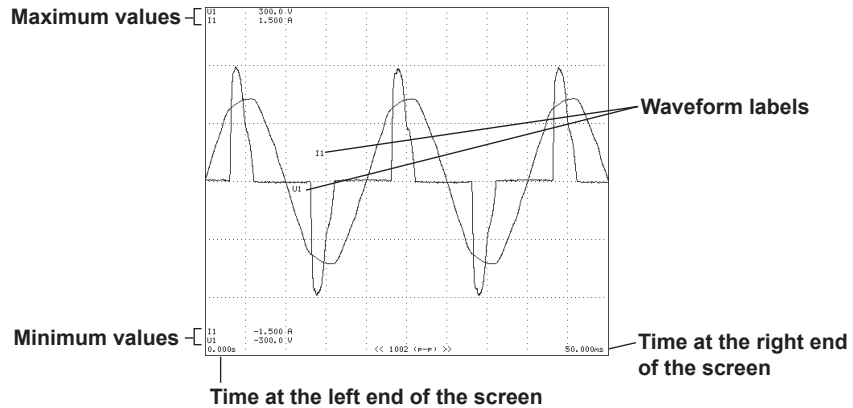
A grid or cross-hair can be displayed on the screen. You can also choose to not display a grid or cross-hair.

Scale Value Display (See section 7.8 for operating instructions)

You can turn on or off the display of the upper and lower limits of the vertical axis and the values at the left and right ends of the horizontal axis (time axis) of each waveform.

Waveform Label Display (See section 7.8 for operating instructions)

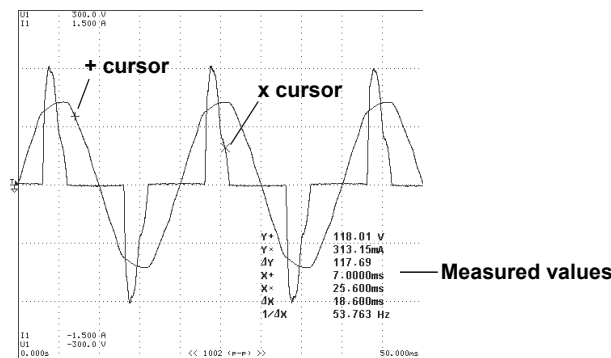
You can turn the display of waveform labels on or off.



Cursor Measurement (See sections 7.9 and 8.10 for operating instructions)

The value at the crossing point of the waveform and cursor can be measured and displayed. The voltage or current at specific sections of the waveform and the data on the horizontal axis (X-axis) can be measured. Cursor measurements are performed on the data that is displayed on the screen.

Two cursors, marked by a plus sign and an x, appear on the screen. For each cursor, the vertical value can be measured, and the X-axis value relative to the left end of the screen can be measured. The differences between the cursor's vertical values and X-axis values can also be measured.

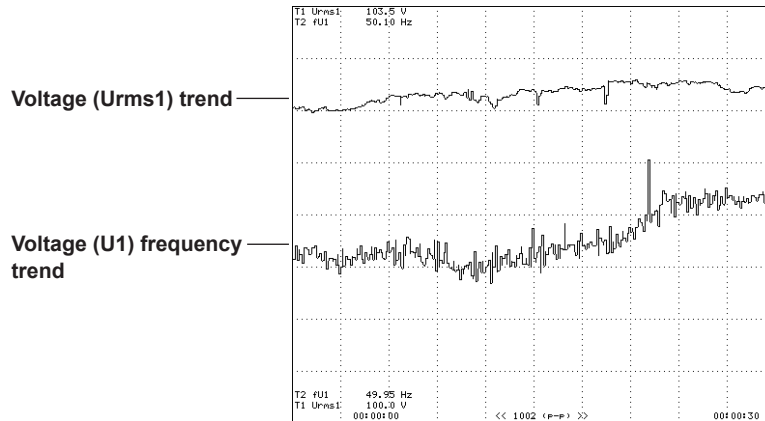


2.8 Trend, Bar Graph, and Vector Displays

Trends of each measurement function, bar graphs of each harmonic, and vectors of the fundamental signals of each element (when using the harmonic measurement option) can be displayed.

Trend Display

The trends of all measurement functions that are measured during normal measurement and harmonic measurement are displayed.



Trend Display Data

When the sampling of waveform display data is off during normal measurement, the numeric data of measurement functions that are determined at each data update interval is P-P compressed for each display segment (raster) and made into trend display data.* When the sampling of waveform display data is on during normal measurement, the numeric data of measurement functions that are determined whenever a trigger occurs is P-P compressed for each display segment (raster) and made into trend display data.*

* In some cases, P-P compression is not performed.

Scale Settings (See section 8.5 for operating instructions)

The WT500 can automatically set the values at the top and bottom of the screen based on the maximum and minimum values of the trend display data (this is referred to as auto scaling). The values at the top and bottom of the screen can also be set manually (manual scaling).

Horizontal (Time) Axis (See section 8.6 for operating instructions)

The time per division can be set in the range of 3 s to 1 day.

Split Display and Window Assignment (See section 8.7 for operating instructions)

Up to eight trends, T1 to T8, can be displayed. You can set trends T1 to T8 to any measurement function for any element. In harmonic measurement, you can also set the trends to harmonic orders.

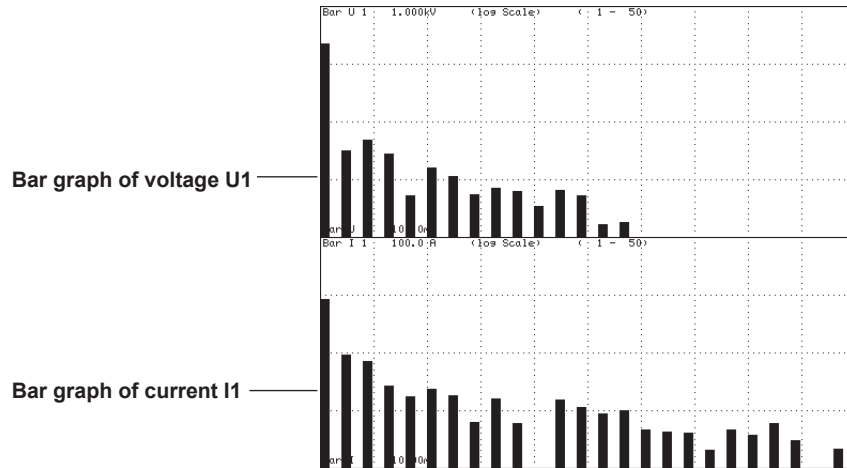
You can also divide the screen into as many as four windows, and each trend whose display is turned on will be assigned in numeric order to one of these windows.

Display Interpolation, Graticule, Scale Value Display, and Label Display (See section 8.8 for operating instructions)

The settings specified for waveform display are used.

Bar Graph Display of Harmonic Data (See section 6.7 for operating instructions)

On models with the 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 choose which harmonic function, element, and orders to display. The selectable harmonic measurement functions are U, I, P, S, Q, λ , ϕ , ϕU , and ϕI .



Vector Display of Harmonic Data (See section 6.8 for operating instructions)

On models with the 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. You can also zoom in on vectors or display amplitude values and the phase difference values between signals simultaneously.

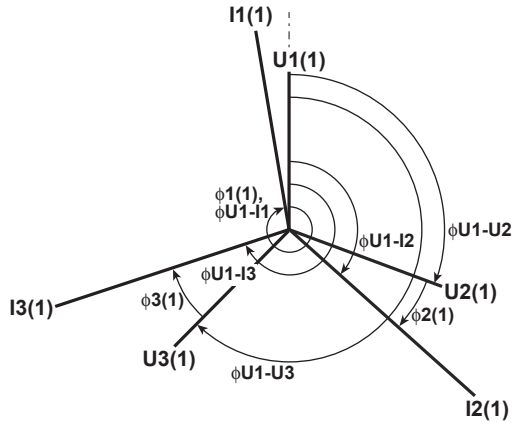
The vector display is shown on the next page.

The elements whose vectors are displayed vary depending on the number of installed input elements and the selected wiring pattern.

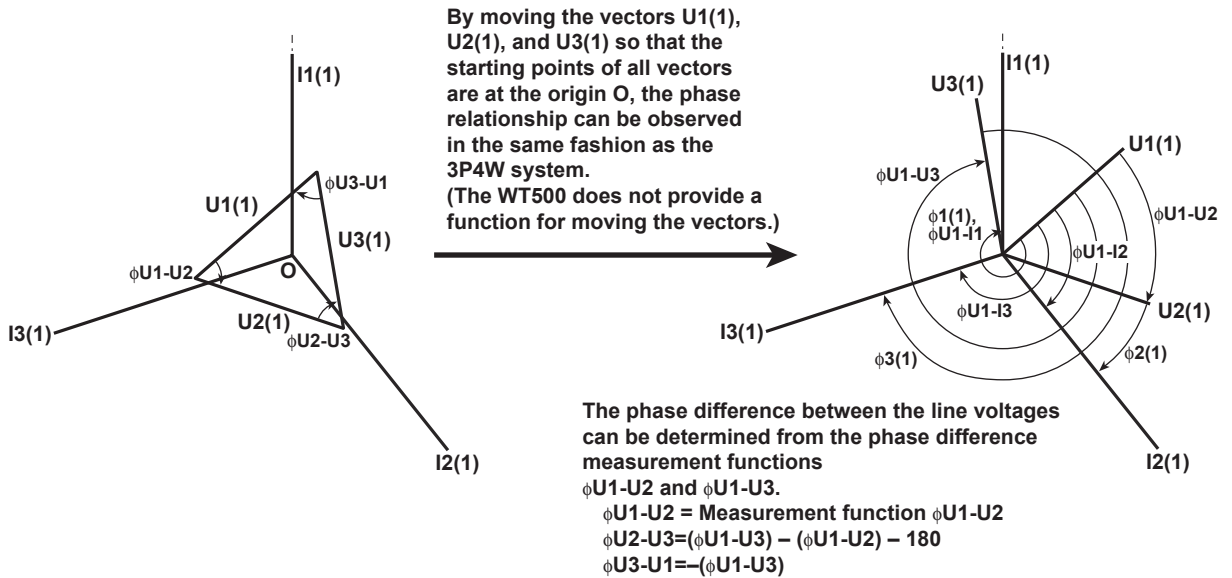
The following explanation is of the vector assignments when the number of input elements is three and when the wiring system of wiring unit Σ is set to three-phase, four-wire.

The vectors of elements 1, 2, and 3 are displayed. Vectors 1, 2, and 3 correspond to elements 1, 2, and 3, respectively. The relationships between the phase differences and amplitudes of U1(1), U2(1), U3(1), I1(1), I2(1), and I3(1) are displayed as vectors.

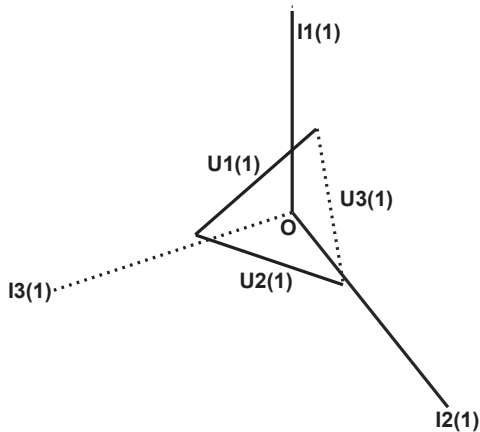
- **Vector Display When the Wiring System Is 3P4W (Three-phase, four-wire)**
 $U1(1)$, $U2(1)$, and $U3(1)$ are phase voltages. $I1(1)$, $I2(1)$, and $I3(1)$ are line currents.



- **Vector Display When the Wiring System Is 3P3W (3V3A; Three-voltage, three-current)**
 $U1(1)$, $U2(1)$, and $U3(1)$ are line voltages. $I1(1)$, $I2(1)$, and $I3(1)$ are line currents.



- **Vector Display When the Wiring System Is 3P3W (Three-phase, three-wire)**
 $U1(1)$, $U2(1)$, and $U3(1)$ are line voltages. $I1(1)$, $I2(1)$, and $I3(1)$ are line currents. However, $U3(1)$ and $I3(1)$ are not actually measured for the 3P3W system. The vectors are displayed through computation.



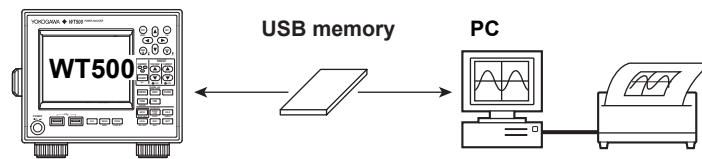
2.9 Saving and Loading Data, and Other Miscellaneous Functions

Storage (See chapter 9 for operating instructions)

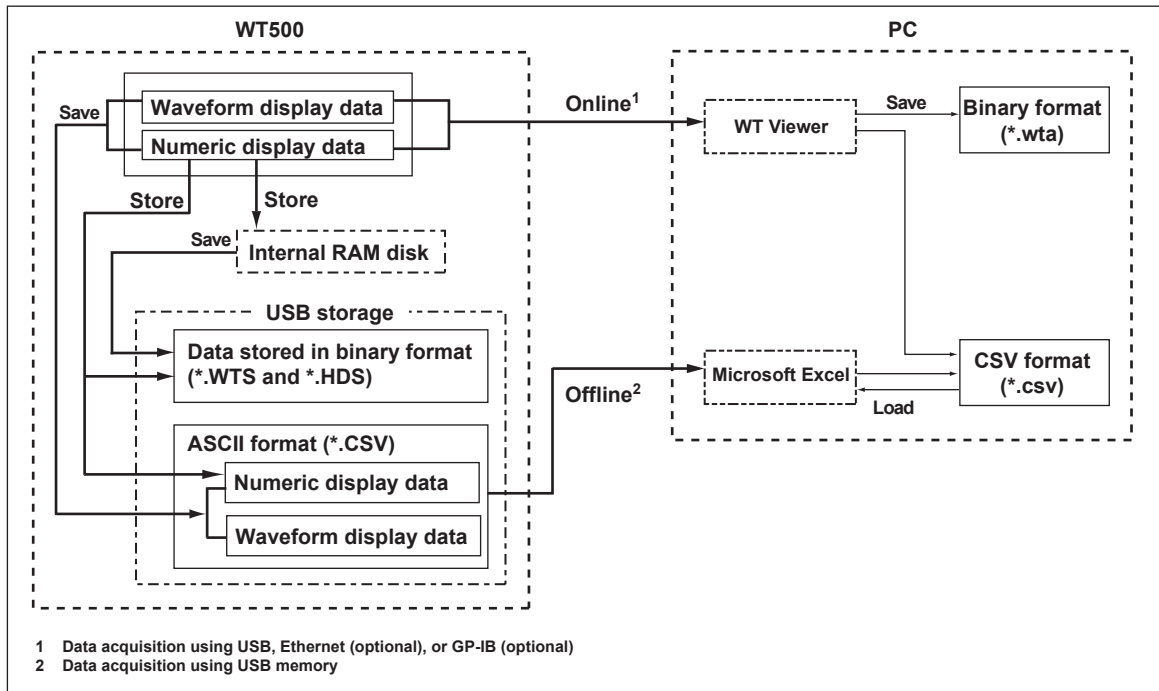
Numeric data can be stored to the WT500 internal memory or USB memory. The data is stored at the data update rate or at a specified time interval.

Saving and Loading from the Storage Medium (See chapter 10 for operating instructions)

The WT500 has USB ports (for peripheral devices). You can save numeric data, waveform display data, screen image data, and setup parameters to USB memory. You can load saved setup parameters as necessary. Also, you can insert image data into documents in a word-processing application.



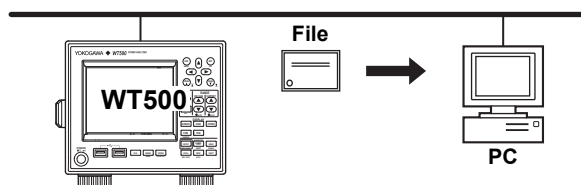
How WT500 Numeric Data and Waveform Display Data Can Be Transferred to a Personal Computer



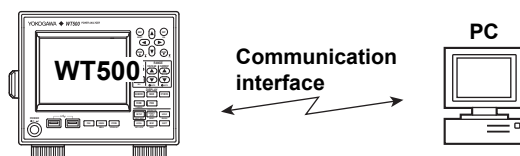
Ethernet Interface (Optional) (See chapter 11 for operating instructions)

Using the FTP server function, you can access the WT500 from an FTP client* on the network and retrieve files from the WT500 internal memory or USB storage.

* PC or workstation with FTP client features.

**USB, GP-IB (Optional), and Ethernet (Optional) Communication (See the Communication Interface User's Manual IM760201-17E)**

You can transfer measured data to a PC through a standard-equipped USB port, the optional GP-IB interface, or the optional Ethernet interface and analyze it on the PC. You can also make measurements by using an external controller to control the WT500.

**Entering Values and Strings on a USB Keyboard (See section 3.15 for operating instructions)**

You can connect a USB keyboard to a USB port and enter file names, comments, and so on.

**Initialization (See section 3.13 for operating instructions)**

All setting made using panel keys and soft keys can be restored to their factory default settings. For information about the initial settings, see appendix 2, "List of Initial Settings and Numeric Data Display Order."

Selecting the Message Language (See section 3.18 for operating instructions)

You can set the language of the error messages displayed on the screen during operation to English or Japanese.

Selecting the Menu Language (See section 3.18 for operating instructions)

You can set the language of the menus displayed on the screen to English or Japanese.

RGB Video Signal (VGA) Output (Optional) (See section 12.2 for operating instructions)

The RGB video signal (VGA, Video Graphics Array) can be output to an external monitor. This allows values and waveforms to be displayed on a large screen.

Zero-Level Compensation (See section 12.3 for operating instructions)

Zero-level compensation is when the WT500 creates a zero input condition in its internal circuitry and sets the level at that point to the zero level. Zero-level compensation must be performed to satisfy the specifications of this instrument (see chapter 14). Zero level compensation is automatically performed when the measurement range or input filter is changed. However, when the measurement range and input filter are not changed over an extended time, the zero level may change due to the changes in the environment surrounding the instrument. In such cases, you can manually perform zero-level compensation. There is also a function that automatically performs zero-level compensation during integration.

NULL Feature (See section 12.4 for operating instructions)

When the NULL feature is turned on, the Udc and Idc values (numeric data of the simple average of the voltage and current) are set as NULL values. The NULL values are subtracted from the sampled voltage and current values. All measurement functions are affected by the NULL values.

Setting the Key Lock or Shift Lock (See section 12.5 for operating instructions)

The key lock can be used to prevent inadvertent operation errors. The shift lock can be used to reduce the number of times you press SHIFT.

Master/Slave Synchronized Measurement (See section 12.6 for operating instructions)

The measurement of two WT500s can be synchronized by making one WT500 the master and the other WT500 the slave. The master outputs a measurement start signal, and the slave receives the signal.

System Condition Check (See section 13.4 for operating instructions)

You can view information about the WT500, such as the model, firmware version (ROM version), input element configuration, and installed options.

Self-Test Feature (See section 13.3 for operating instructions)

The WT500 can evaluate its internal memory (RAM) and panel keys to determine if they are working properly.

3.1 Handling Precautions

Safety Precautions

If you are using this instrument for the first time, make sure to thoroughly read “Safety Precautions,” on pages vi and vii.

Do Not Remove the Case

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

Unplug If Abnormal Behavior Occurs

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

Do Not Damage the Power Cord

Nothing should be placed on top of the power cord, and it should be kept away from any heat sources. When removing the plug from the power outlet, do not pull on the cord. Pull from the plug. If the power cord is damaged, purchase a replacement with the same part number as the one indicated on page iv.

General Handling Precautions

Do Not Place Objects on Top of the Instrument

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

Keep Electrically Charged Objects Away from the Instrument

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

Do Not Damage the LCD

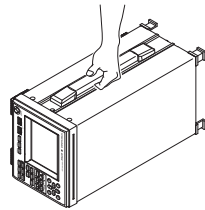
Because the LCD is very vulnerable and can be easily scratched, do not allow any sharp objects near it. Also, do not apply vibration or shock to it.

Unplug during Extended Non-Use

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

Carry the Instrument Properly

First, turn off the circuit under measurement and remove the measurement cables. Then, turn off the instrument and remove the power cord and any attached cables. When moving the instrument, hold the handles on each side as shown below.



When Cleaning the Instrument

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

3.2 Installing the Instrument

Installation Conditions

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

Flat, Even Surface

Install the instrument on a surface that is flat and even in all directions. If you install the instrument on an uneven or tilted surface, the accuracy of its measurements may be impeded.

Well-Ventilated

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

When connecting measurement wires and other various cables allow extra space for operation.

Appropriate Ambient Temperature and Humidity

Ambient temperature: 5 to 40°C

Ambient humidity: 20 to 80% RH

No matter what the circumstances, there must be no condensation.

Do not install the instrument in the following kinds of places.

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

Note

- For the most accurate measurements, use the instrument in the following kind of environment.
Ambient temperature: $23 \pm 5^\circ\text{C}$ Ambient humidity: 30 to 75%RH (no condensation)
When using the instrument in a place where the ambient temperature is 5 to 18°C or 28 to 40°C, add the temperature coefficient to the accuracy as specified in chapter 14.
- When installing the instrument in a place where the ambient humidity is 30% or below, take measures to prevent static electricity such as using an anti-static mat.
- Condensation may form when the instrument is moved from a low temperature/humidity environment to a high temperature/humidity environment, or when there is a sudden change in temperature. In these kinds of circumstances, wait for at least an hour before using the instrument, to acclimate it to the surrounding temperature.

Storing the Instrument

When storing the instrument, avoid the following kinds of places.

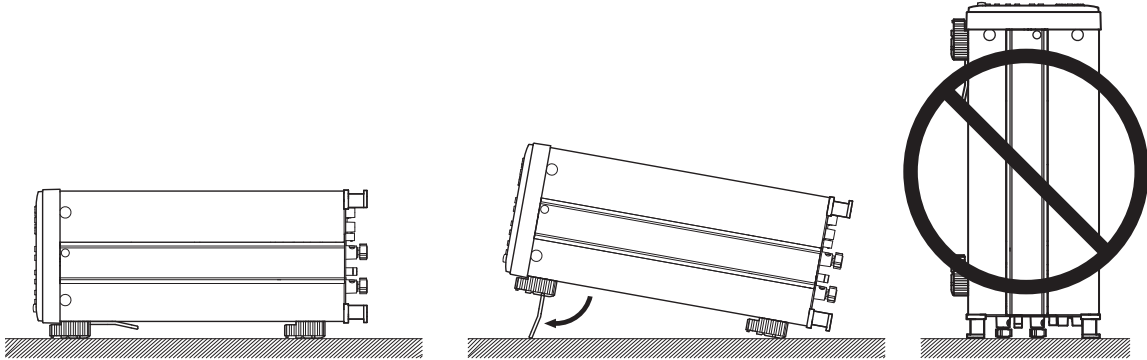
- Where the relative humidity is 80% or higher
- Where the level of mechanical vibration is high
- In direct sunlight
- Where there are corrosive or explosive gasses
- Where the temperature is 60°C or higher
- Where an excessive amount of soot, dust, salt, or iron is present
- Near a strong source of heat or moisture
- Where water, oil, or chemicals may splash

We recommend that the instrument be stored in an environment where the temperature is between 5 and 40°C and the relative humidity is between 20 and 80% RH.

Installation Position

Desktop

Place the instrument on a flat, even surface as shown in the figure below. If the instrument is installed in a horizontal position, rubber stoppers can be attached to the feet to prevent the instrument from sliding. One set of rubber feet (two feet) are included in the package. Do not install the instrument in positions other than the left two positions indicated below.



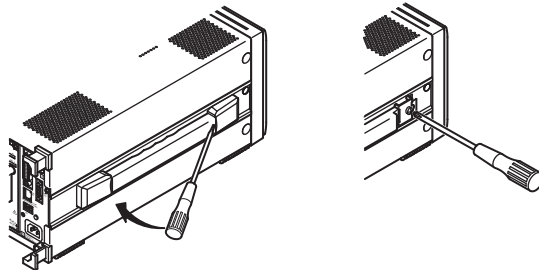
Mounting in a Rack

To mount the instrument in a rack, use the separately sold rack mount kit.

Part Name	Model	Note
Rack mount kit (for single mount)	751533-E4	for EIA
Rack mount kit (for multiple mount)	751534-E4	for EIA
Rack mount kit (for single mount)	751533-J4	For JIS
Rack mount kit (for multiple mount)	751534-J4	For JIS

An outline of the attachment procedures is given below. For detailed procedures, see the instructions that are included with the rack mount kit.

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



Note

- When mounting the instrument to a rack, allow at least 20 mm of space around the inlet and vent holes to prevent internal heating.
- Make sure to provide adequate support from the bottom of the instrument while avoiding blocking the inlet and vent holes.

3.3 Connecting the Power Supply

Before Connecting the Power Supply

To avoid electric shock and damage to the instrument, follow the precautions below.



WARNING

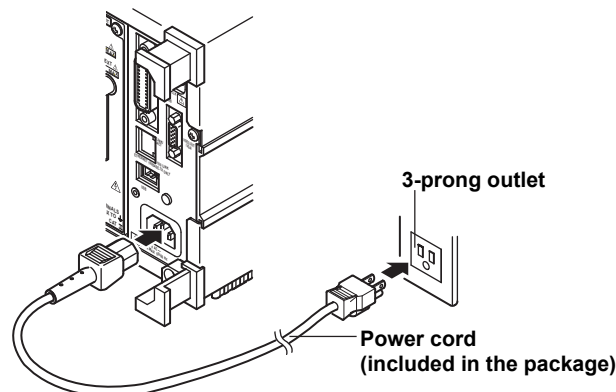
- Confirm that the power source voltage matches the instrument's rated power source voltage before connecting the power cord.
- Confirm that the power switch is off before connecting the power cord.
- To prevent fire and electric shock, use the power cord supplied by YOKOGAWA.
- To prevent electric shock, make sure to ground the instrument. Insert the instrument's power cord into a grounded three-prong outlet.
- Do not use an ungrounded extension cord. If you do, the device will not be grounded.
- Use an AC outlet that matches the power cord provided, and make sure that the instrument is properly grounded. If an appropriate AC outlet is unavailable and protective grounding cannot be furnished, do not use the instrument.

Connecting the Power Cord

1. Check that the power switch is off.
2. Connect the instrument's power cord to the power inlet on the rear panel.
3. Connect the plug on the other end of the power cord to an outlet that meets the conditions below. The AC outlet must be a three-prong outlet with a protective earth ground terminal.

Item	Specification
Rated supply voltage	100 to 240 VAC
Permitted supply voltage range	90 to 264 VAC
Rated supply frequency	50/60 Hz
Permitted supply voltage frequency range	48 to 63 Hz
Maximum power consumption	80 VA

* The instrument can use a 100-V or a 200-V power supply. Check that the voltage supplied to the instrument is less than or equal to the maximum rated voltage of the power cord provided with the instrument before using it (see page iii for the maximum rated voltage).



3.4 Turning the Power Switch On and Off

Before Turning On the Power, Check That:

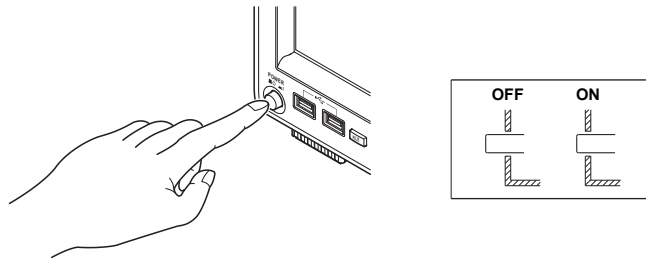
- The instrument is installed properly (see section 3.2, “Installing the Instrument”).
- The power cord is connected properly (see section 3.3, “Connecting the Power Supply”).

Power Switch Location

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

Turning the power switch on and off

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



Operations Performed When the Power Is Turned On

When the power switch is turned on, a self-test starts automatically. When the self-test completes successfully, the display shows the screen that was displayed immediately before the power switch was turned off.

Note

- If the instrument does not operate as described above when the power switch is turned on, turn the power switch off and check that:
 - The power cord is securely connected.
 - The power outlet is receiving the correct voltage (see section 3.3, “Connecting the Power Supply”).
 - After checking the above, try turning on the power switch while holding down ESC to reset the settings to their initial values (the factory default). For information about the initial settings, see section 3.13, “Initialization.”

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

- With certain types of USB memory, the instrument may not start if you turn ON the power while the memory is connected.
-

To Make Accurate Measurements

- Allow the instrument to warm up for at least 30 minutes after turning on the power switch.
- Perform zero-level compensation after you have allowed the instrument to warm up (see section 12.3, “Performing Zero- Level Compensation”).

Operations Performed When the Power Is Turned Off

After the power switch is turned off, the instrument stores the setup parameters in its memory before shutting down. The same operation is performed when the power cord is removed. The next time the power switch is turned on, the instrument powers up using the stored setup parameters.

Note

A lithium battery is used to retain the setup parameters. When the lithium battery voltage falls below a certain level and you turn the power switch on, the instrument displays a message on the screen (see section 13.2 for details). If this message appears frequently, the battery should be replaced quickly. Do not try to replace the battery yourself. Contact your nearest YOKOGAWA dealer to have the battery replaced. For information about the battery life, see section 13.5.

3.5 Precautions for Wiring the Circuit That You Will Measure

To avoid electric shock and damage to the instrument, follow the precautions below.



WARNING

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

- To make the protective measures effective, before applying the voltage or current from the circuit under measurement, check that:
 - The power cord provided with the instrument is being used to connect to the power supply and that the instrument is grounded.
 - The instrument's power switch is turned on.
 - The current input protective cover provided with the instrument is being used.
- When the instrument's power switch is turned on, do not apply a signal that exceeds the following values to the voltage or current input terminals. When the instrument is turned off, turn off the circuit under measurement. For information about other input terminals, see chapter 14.

Instantaneous Maximum Allowable Input (1 s or less)

Voltage Input

Peak value of 2000 V or rms value of 1500 V, whichever is less.

Current input

Direct input

Peak value of 150 A or rms value of 45 A, whichever is less.

External Sensor Input

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

Continuous Maximum Allowable Input

Voltage Input

Peak value of 1500 V or rms value of 1000 V, whichever is less.

Current input

Direct input

Peak value of 100 A or rms value of 45 A, whichever is less.

External Sensor Input

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



CAUTION

- Use measurement cables with dielectric strengths and current capacities that are appropriate for the voltage or current being measured.
Example: When making measurements on a current of 20 A, use copper wires that have a conductive cross-sectional area of 4 mm². or greater.
- Connecting cables may cause radio interference, in which case users will be required to correct the interference.

Note

- After you finish wiring, you must select the wiring system. For details, see section 4.2, "Selecting the Wiring System."
- If you are measuring large currents, voltages or currents that contain high frequency components, take special care in dealing with mutual interference and noise when wiring.
- Keep measurement cables as short as possible to minimize the loss between the circuit under measurement and the instrument.
- The thick lines on the wiring diagrams shown in sections 3.9 to 3.11 are the sections where the current flows. Use wires that are suitable for the current levels.
- To make accurate measurements of the voltage of the circuit under measurement, connect the cable to the circuit as closely as possible.
- To make correct measurements, separate the measurement cables as far away from the ground wires and the instrument's case as possible to minimize static capacitance to the ground.
- To measure the apparent power and power factor more accurately on an unbalanced three-phase circuit, we recommend that you use a three-voltage, three-current method with a three-phase, three-wire system (3P3W; 3V3A).

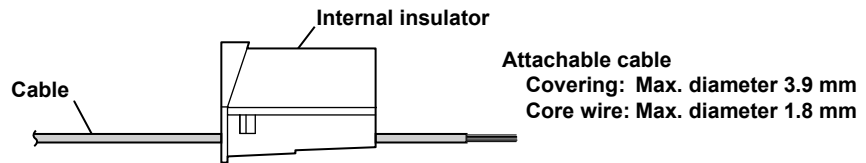
3.6 Assembling the Adapter for the Voltage Input Terminal

Assembling the 758931 Safety Terminal Adapter

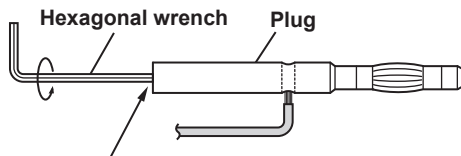
When connecting a measurement cable to a WT500 voltage input terminal, use the 758931 Safety Terminal Adapter that comes with the package or the 758923 Safety Terminal Adapter that is sold separately. When using the 758931 Safety Terminal Adapter, assemble it according to the following procedure.

Assembling the Safety Terminal Adapter

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

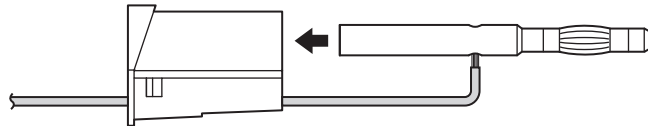


2. Insert the tip of the cable into the plug. Fasten the cable in place using the hexagonal wrench.

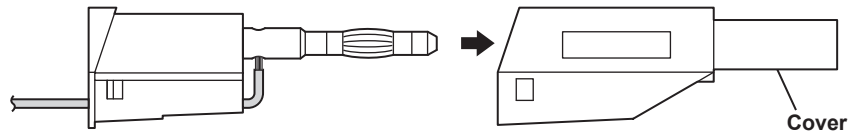


Insert the hexagonal wrench into the plug and tighten.

3. Insert the plug into the internal insulator.



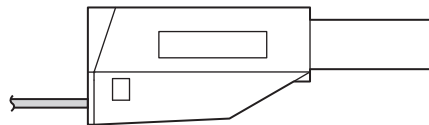
4. Attach the external cover. Make sure that the cover does not come off.



Note

Once the cover is attached, disassembly is difficult. Use care when attaching the cover.

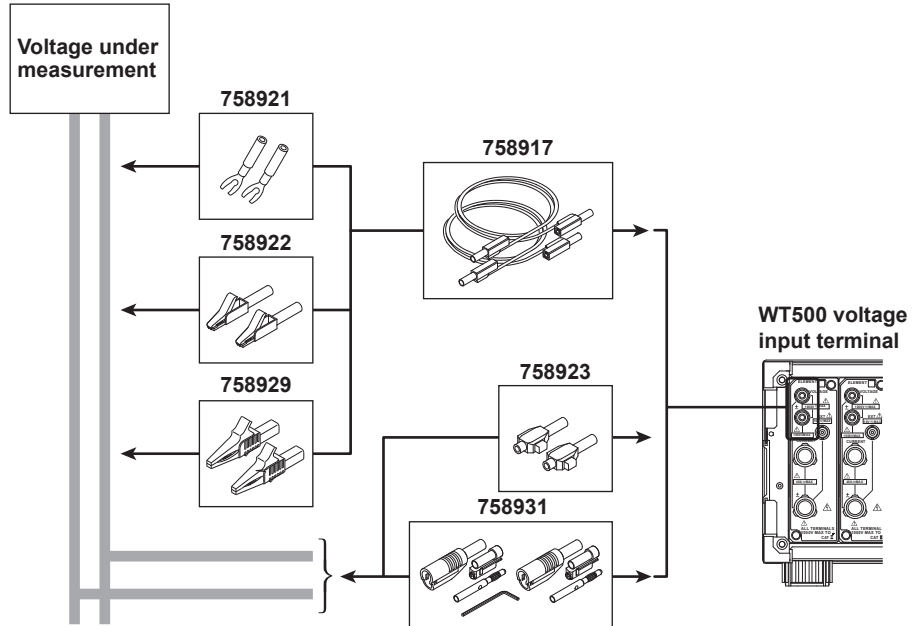
Below is an illustration of the adapter after it has been assembled.



Explanation

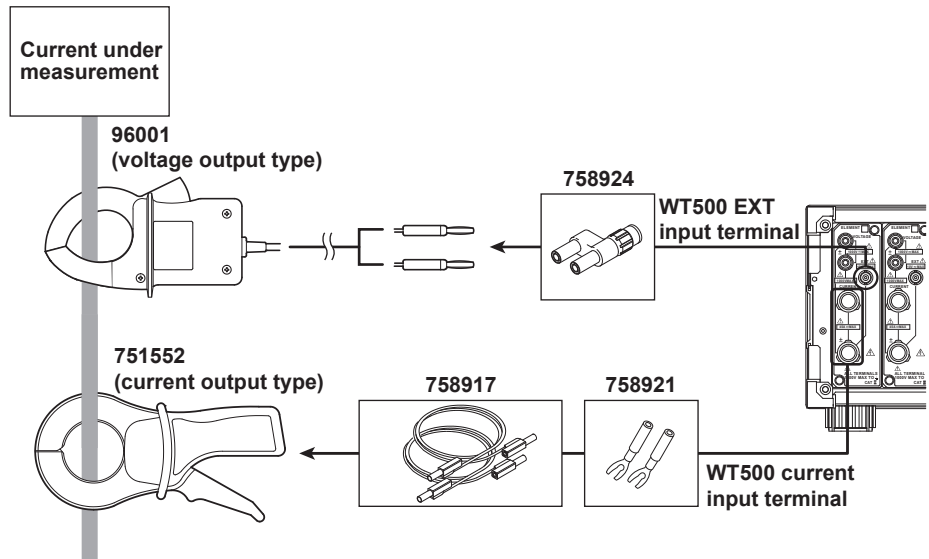
Wire the adapters that come with the WT500 or the adapters and various sensors that are sold separately as shown below:

Wiring to the Voltage Input Terminal



Use the separately sold clamp-on probes as follows:

Wiring to the Current Input Terminal



Connecting a clamp-on probe

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

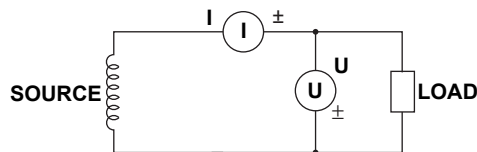
3.7 Wiring for Accurate Measurements

To make accurate measurements, refer to the items below when wiring the voltage input and current input terminals.

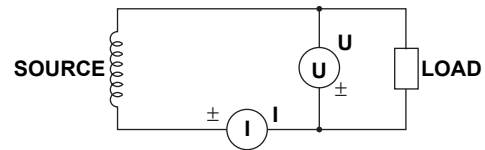
Effects of Stray Capacitance

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

- Easily affected

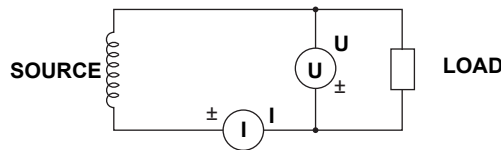


- Not easily affected

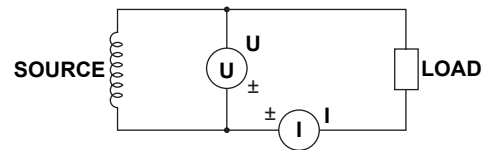


Effects of the Measured Voltage and Current Amplitudes

- When the measured current is relatively large
Connect the voltage input terminal to the load end.



- When the measured current is relatively small
Connect the current input terminal to the load end.



Explanation

For details on the effects of stray capacitance and the effects of the measured voltage and current amplitudes, see appendix 4, "How to Make Accurate Measurements."

3.8 Guide for Selecting the Method Used to Measure the Power

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

Voltage Measurement Methods

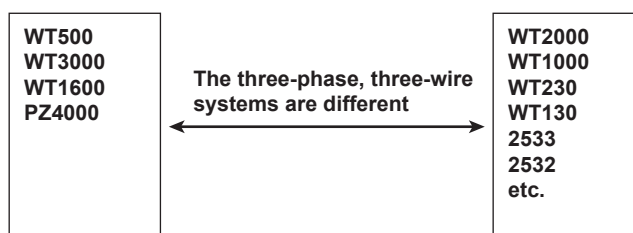
		When the voltage is less than or equal to 1000 V	When the voltage exceeds 1000 V
Voltage wiring	Direct input	See section 3.9	Direct input is not possible
	VT (voltage transformer)	See section 3.11	

Current Measurement Methods

		When the voltage is less than or equal to 1000 V		When the voltage exceeds 1000 V
		When the current is less than or equal to 40 A	When the current exceeds 40 A	
Current wiring	Direct input	See section 3.9	Direct input is not possible	
	Shunt resistor	See section 3.10		Shunt resistors cannot be used
	Clamp-type current sensor (voltage output type)	See section 3.10		
	Clamp-type current sensor (current output type)	See section 3.11		
	CT (current transformer)	See section 3.11		

Notes when Replacing Other Power Meters with the WT500

In three-phase, three-wire systems (3P3W) and three-phase, three-wire systems that use a three-voltage, three-current method (3P3W; 3V3A), the wiring system of the WT500 may be different from that of another product (another digital power meter) depending on whether the reference voltage used to measure the line voltage (see appendix 4 for details) is based on single-phase or three-phase power. To make correct measurements, see the referenced sections in the selection guide above and check the wiring method of the three-phase, three-wire system.



For example, if you replace the WT2000 (used in a three-phase, three-wire system) with the WT500 and leave the wiring unchanged, the measured power of each element will be different between the WT2000 and the WT500. Refer to this manual and re-wire the system correctly.

Note

In the wiring examples that follow, models are referred to by number. For information about the different WT500 models and their specifications, see page iii.

3.9 Wiring the Circuit That You Will Measure for Direct Input

This section explains how to wire the measurement cable directly from the circuit that you will measure to the voltage or current input terminal.

To avoid electric shock and damage to the instrument, follow the precautions given in section 3.5, "Precautions for Wiring the Circuit That You Will Measure."

Connecting to the Input Terminal

Voltage Input Terminal

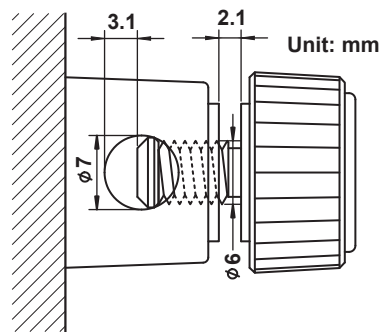
The terminal is a $\phi 4$ -mm safety banana jack (female).

Insert the safety terminal (whose conductive parts are not exposed) into the voltage input terminal.

If you are using the 758931 Safety Terminal Adapter that comes with the package, see section 3.6.

Current Input Terminal

- When the voltage of the circuit under measurement is being applied to the current input terminals, do not touch the current sensor input terminals. Doing so is dangerous because the terminals are electrically connected inside the instrument.
- When connecting measurement cables from external current sensors to current sensor input connectors, remove the cables connected to the current input terminals. In addition, when the voltage of the circuit under measurement is being applied to current sensor input terminals, do not touch the current input terminals. Doing so is dangerous because the terminals are electrically connected inside the instrument.
- The terminal is a binding post, and the screws are M6. Either wind the wire around the screw or pass the crimp-on lugs through the screw axis, then tighten firmly with the terminal knob.



Number of Installed Input Elements and Wiring Systems

The selectable wiring systems vary depending on the number of installed elements. For example, the three-phase, four-wire (3P4W) system cannot be selected on models with two input elements. For details, see "Number of Installed Input Elements and Wiring Systems" in section 2.3, "Measurement Conditions."

3.9 Wiring the Circuit That You Will Measure for Direct Input

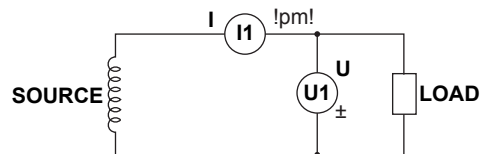
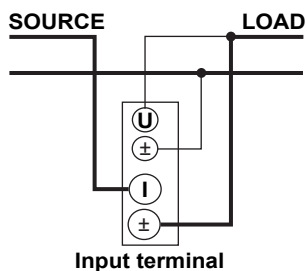
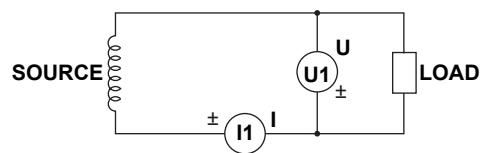
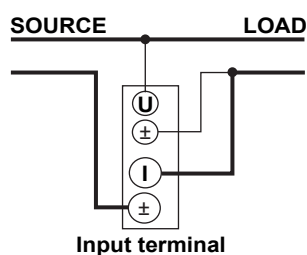
The assignment of elements to the input terminals in the wiring example figures below varies depending on the number of installed input elements. For details, see “Number of Installed Input Elements and Wiring Systems” in section 2.3, “Measurement Conditions.”

Note

- After you have finished wiring, you must select the wiring system. For details, see section 4.2, “Selecting the Wiring System.”
- The thick lines on the wiring diagrams are the sections where the current flows. Use wires that are suitable for the current levels.

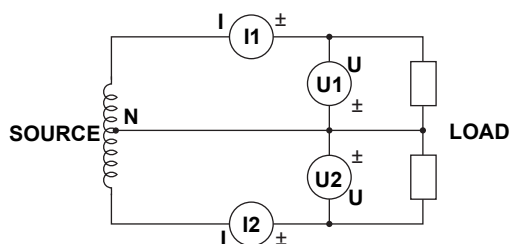
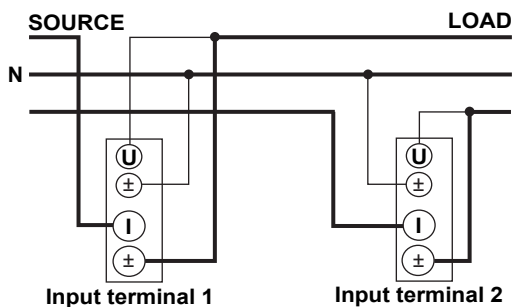
Single-Phase, Two-Wire System Wiring Example (Applicable for models 760201, 760202, and 760203)

If three input elements are available, three single-phase, two-wire systems can be set up. See section 3.7 for information about which of the wiring systems shown below should be selected.



Single-Phase, Three-Wire System Wiring Example (Applicable for models 760202 and 760203)

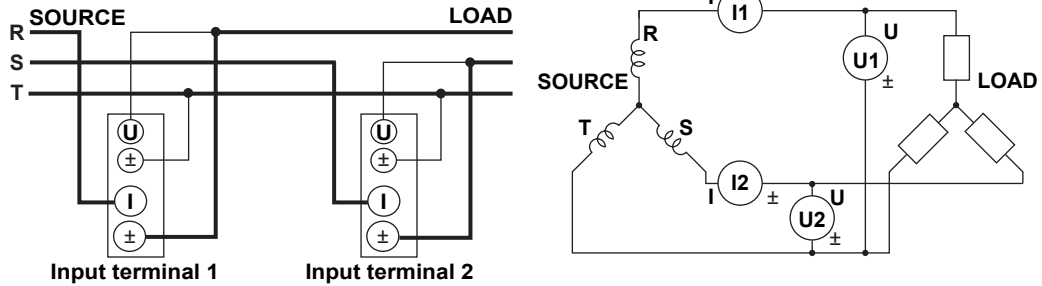
If three input elements are available, two single-phase, three-wire systems can be set up (elements 1 and 2, or elements 2 and 3).



3.9 Wiring the Circuit That You Will Measure for Direct Input

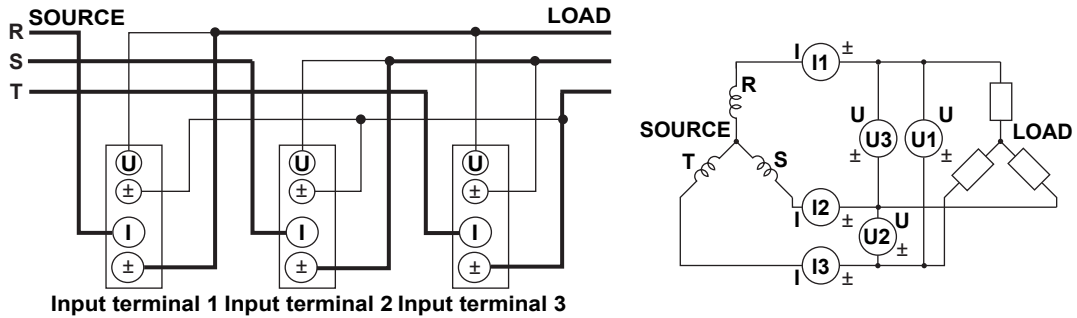
Three-Phase, Three-Wire System Wiring Example (Applicable for models 760202 and 760203)

If three input elements are available, two three-phase, three-wire systems can be set up (elements 1 and 2, or elements 2 and 3).



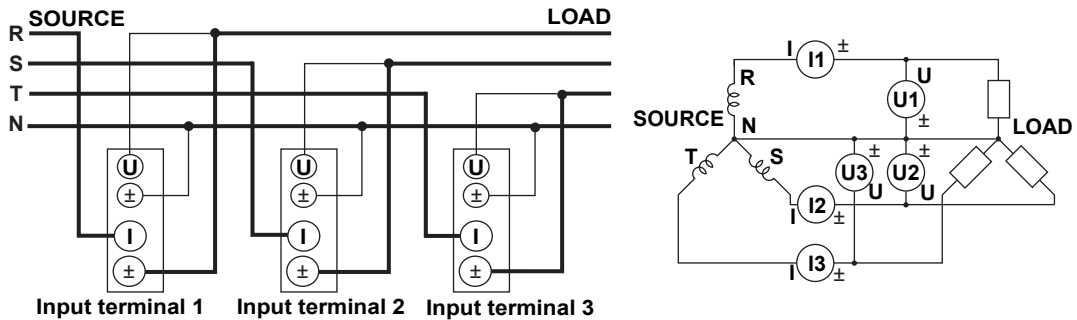
Wiring Example of a Three-Phase, Three-Wire System with a Three-Voltage, Three-Current Method (3P3W; 3V3A) (Applicable for model 760203)

If three input elements are available, one three-phase, three-wire system with a three-voltage, three-current method can be set up (elements 1, 2, and 3).



Three-Phase, Four-Wire System Wiring Example (Applicable for model 760203)

If three input elements are available, one three-phase, four-wire system can be set up (elements 1, 2, and 3).



Note

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

3.10 Wiring the Circuit That You Will Measure with a Current Sensor

To avoid electric shock and damage to the instrument, follow the precautions given in section 3.5, “Precautions for Wiring the Circuit That You Will Measure.”

If the maximum current value of the circuit under measurement exceeds the maximum range of the current input terminal, 40 Arms, you can measure the current by connecting an external sensor to the current sensor input connector.

Current sensor output type

- In the wiring example in this section, you can use a shunt resistor or a clamp-type current sensor as the external current sensor.
- When using a clamp-type current sensor that outputs current, see section 3.11.

Connecting to the Input Terminal

Voltage Input Terminal

The terminal is a ϕ 4-mm safety banana jack (female).

Insert the safety terminal (the conductive parts are not exposed) into the voltage input terminal.

If you are using the 758931 Safety Terminal Adapter that comes with the package, see section 3.6.

External Current Sensor Input Terminal

Connect an external sensor cable with a BNC connector (B9284LK, sold separately) to an external current sensor input connector.

Remove the measurement cable connected to the current input terminal. Because the current sensor input terminal and the current input terminal are connected internally, connecting both terminals simultaneously not only results in measurement errors but may also cause damage to the instrument.

In addition, when the voltage of the circuit under measurement is being applied to the current sensor input terminal, do not touch the current input terminals. Doing so is dangerous because the terminals are electrically connected inside the instrument.

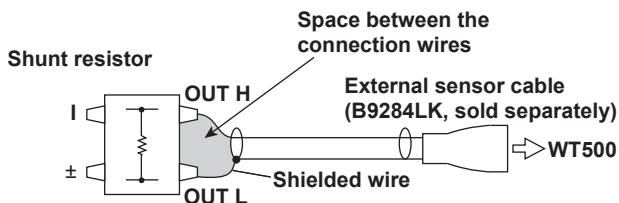
Number of Installed Input Elements and Wiring Systems

The selectable wiring systems vary depending on the number of input elements that are installed in the WT500. For details, see “Number of Installed Input Elements and Wiring Systems” in section 2.3, “Measurement Conditions.”

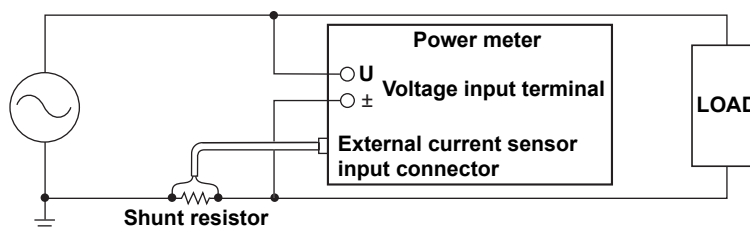
3.10 Wiring the Circuit That You Will Measure with a Current Sensor

Note

- After wiring has been completed, the wiring system must be selected. See section 4.2, “Selecting the Wiring System.”
- The thick lines on the wiring diagrams are the sections where the current flows. Use wires that are suitable for the current levels.
- To measure the apparent power and power factor more accurately on an unbalanced three-phase circuit, we recommend that you use a three-voltage, three-current method with a three-phase, three-wire system (3P3W; 3V3A).
- The current sensor input conversion feature can be used to convert the input signal data to the corresponding data that would be acquired from direct measurements. For information about how to set up this feature, see section 4.5, “Setting the Measurement Range for an External Current Sensor (Optional).”
- Note that the frequency and phase characteristics of the current sensor affect the measured data.
- Make sure that you have the polarities correct when you make connections. Otherwise, the polarity of the measurement current will be reversed, and you will not be able to make correct measurements. Be especially careful when connecting the clamp type current sensor, because it is easy to reverse the connection.
- To minimize error when using a shunt resistor, follow the guidelines below when connecting the external sensor cable.
 - Connect the shielded wire of the external sensor cable to the L side of the shunt output terminal (OUT).
 - Minimize the area of the space between the wires connecting the shunt resistor to the external sensor cable. This reduces the effects of the lines of magnetic force (which are caused by the measurement current) and the external noise that enter the space.

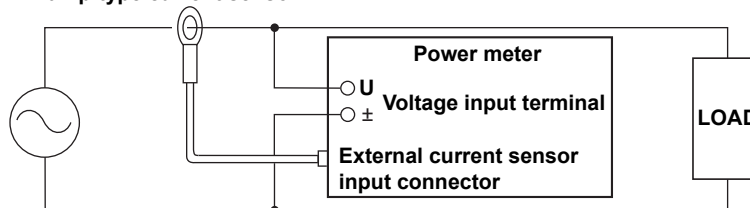


- Connect a shunt resistor to the power earth ground as shown in the figure below. If you have to connect the sensor to the non-earth side, use a wire that is thicker than AWG18 (conductive cross-sectional area of approx. 1 mm²) between the sensor and the instrument to reduce the effects of common mode voltage. Take safety and error reduction into consideration when constructing an external sensor cable.



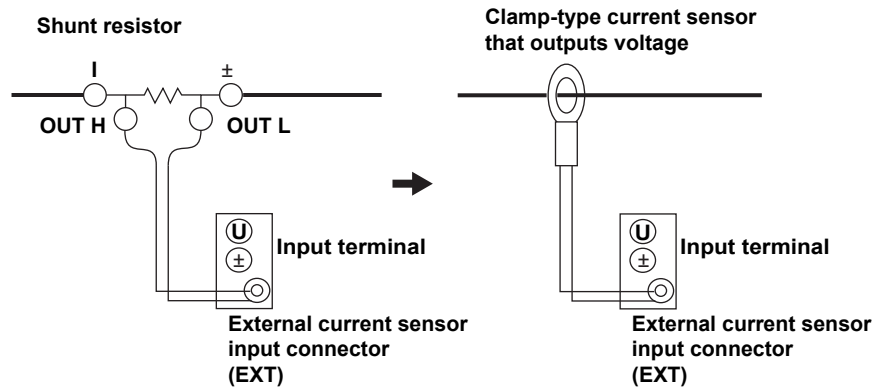
- When the circuit under measurement is not grounded and the signal is high in frequency or large in power, the effects of the inductance of the shunt resistor cable become large. In this case, use an isolation sensor (CT, DC-CT, or clamp).

Clamp-type current sensor



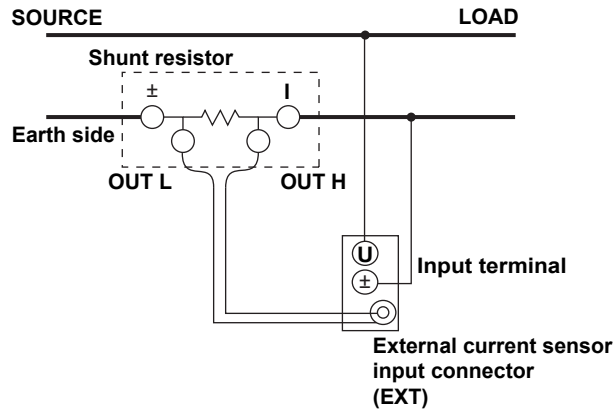
3.10 Wiring the Circuit That You Will Measure with a Current Sensor

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

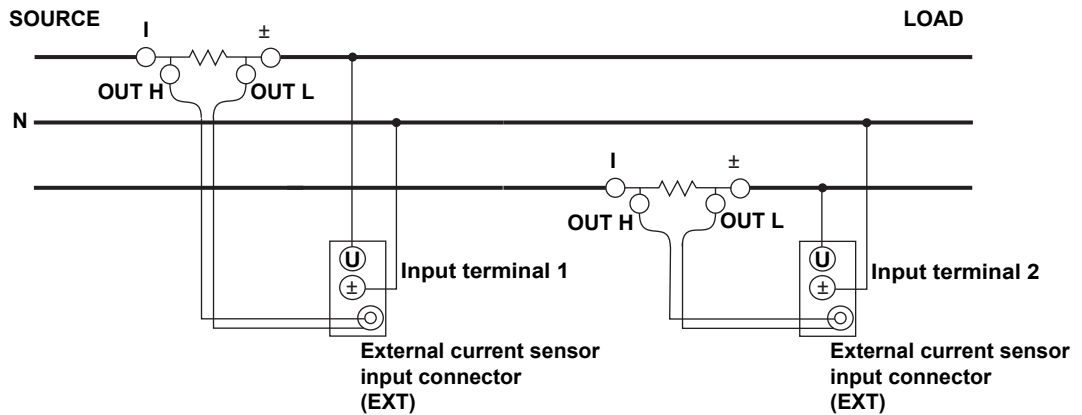


The assignment of elements to the input terminals in the figures below varies depending on the number of installed input elements. For details, see “Number of Installed Input Elements and Wiring Systems” in section 2.3, “Measurement Conditions.”

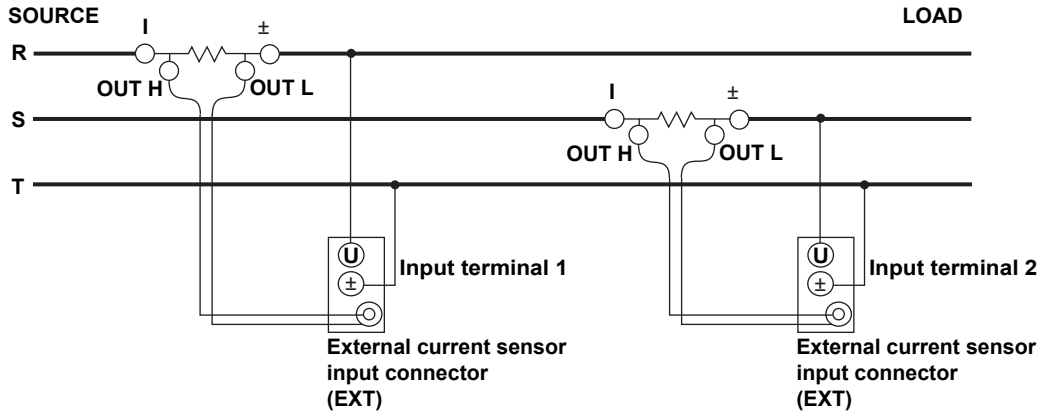
Wiring Example of a Single-Phase, Two-Wire System (1P2W) with a Shunt Resistor



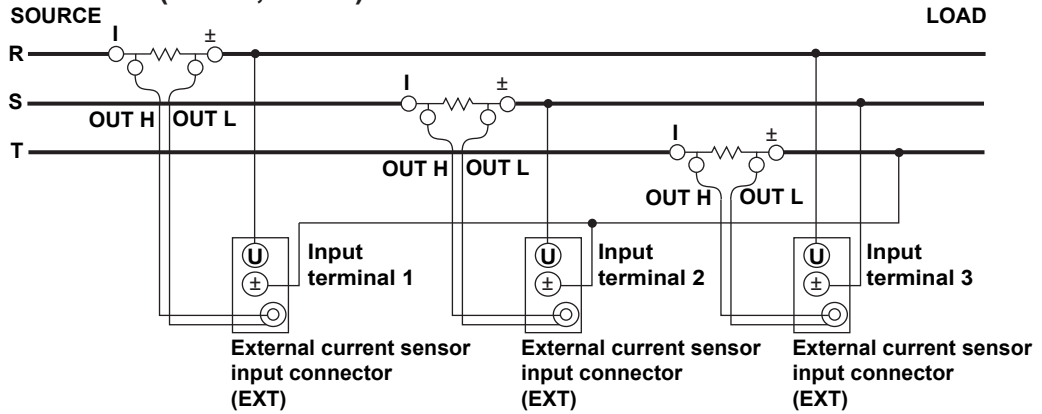
Wiring Example of a Single-Phase, Three-Wire System (1P3W) with a Shunt Resistor



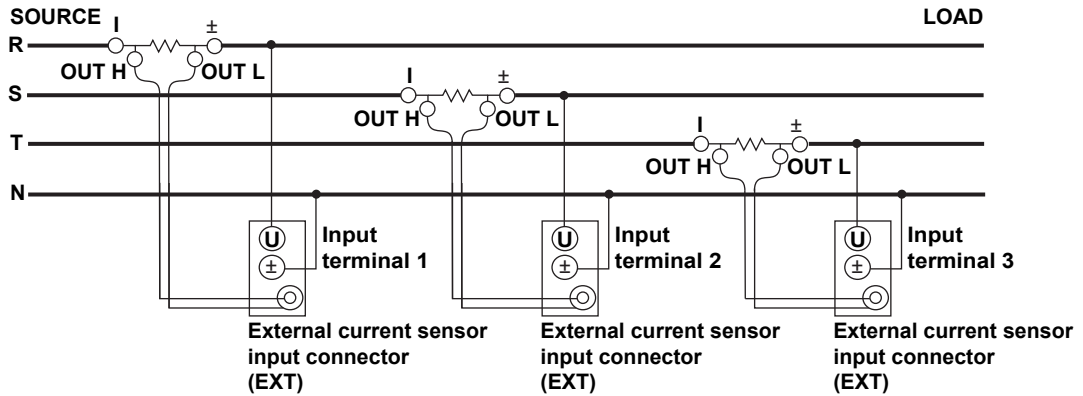
Wiring Example of a Three-Phase, Three-Wire System (3P3W) with a Shunt Resistor



Wiring Example of a Three-Phase, Three-Wire System with a Three-Voltage, Three-Current Method (3P3W; 3V3A) and a Shunt Resistor



Wiring Example of a Three-Phase, Four-Wire System (3P3W) with a Shunt Resistor



Note

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

3.11 Wiring the Circuit That You Will Measure with a VT or CT

This section explains how to wire a measurement cable from an external VT or CT to a voltage or current input terminal. Also refer to this section when wiring a clamp-type current sensor that outputs current.

To avoid electric shock and damage to the instrument, follow the precautions given in section 3.5, "Precautions for Wiring the Circuit That You Will Measure."

When the maximum voltage of the circuit under measurement exceeds 1000 Vrms, you can make measurements by connecting an external VT to the voltage input terminal.

If the maximum current value of the circuit under measurement exceeds the maximum range of the input elements, 40 Arms, you can measure the current by connecting an external CT, or a clamp-type sensor that outputs current, to a current input terminal.

Connecting to the Input Terminal

Voltage Input Terminal

The terminals are ϕ 4-mm safety banana jacks (female).

Only insert a safety terminal whose conductive parts are not exposed into a voltage input terminal.

If you are using the 758931 Safety Terminal Adapter that comes with the package, see section 3.6.

Current Input Terminal

- When the voltage of the circuit under measurement is being applied to the current input terminals, do not touch the current sensor input terminals. Doing so is dangerous because the terminals are electrically connected inside the instrument.
- When connecting a measurement cable from an external current sensor to a current sensor input connector, remove the cables connected to the current input terminals. In addition, when the voltage of the circuit under measurement is being applied to a current sensor input terminal, do not touch the current input terminal. Doing so is dangerous because the terminals are electrically connected inside the instrument.
- The screws used on the terminal (binding post) are M6 screws. Wind the wire around the screw, use the separately sold Fork Terminal Adapter (758921), or pass the crimp-on lugs through the screw axis, then tighten firmly with the terminal knob.
- For the dimensions of the terminal parts, see section 3.9.

Number of Installed Input Elements and Wiring Systems

The selectable wiring systems vary depending on the number of input elements that are installed in the WT500. For details, see "Number of Installed Input Elements and Wiring Systems" in section 2.3, "Measurement Conditions."

General VT and CT Handling Precautions

- Do not short the secondary side of a VT. Doing so may damage it.
 - Do not short the secondary side of a CT. Doing so may damage it.
- Also, follow the VT or CT handling precautions in the manual that comes with the VT or CT that you are using.

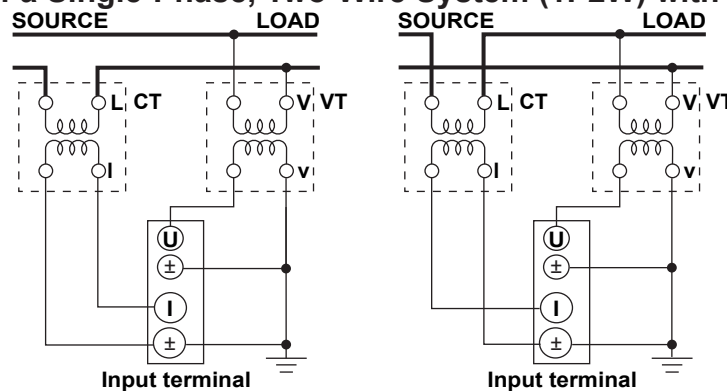
3.11 Wiring the Circuit That You Will Measure with a VT or CT

Note

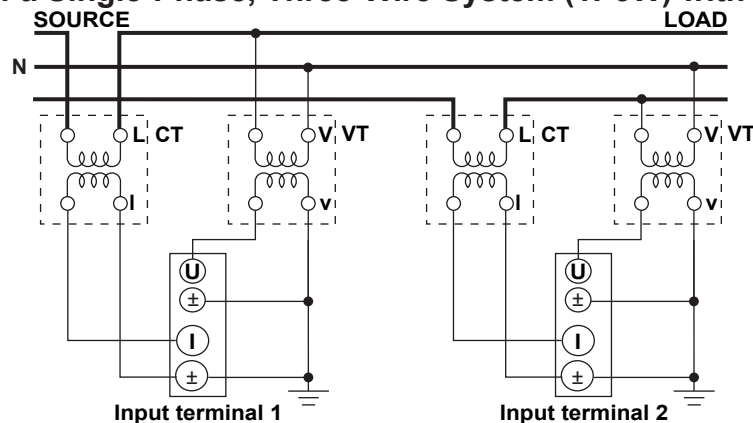
- After you have finished wiring, you must select the wiring system. For details, see section 4.2, “Selecting the Wiring System.”
- The thick lines on the wiring diagrams are the sections where the current flows. Use wires that are suitable for the current levels.
- Make sure that you have the polarities correct when you make connections. If the polarity is reversed, the polarity of the measurement current will be reversed, and you will not be able to make correct measurements. Be especially careful when connecting the clamp type current sensor, because it is easy to reverse the connection.
- The scaling feature can be used to transform the input signal to data that corresponds to direct measurements. For information about how to set up this feature, see section 4.6, “Setting the Scaling Feature When Using a VT or CT.”
- Note that the frequency and phase characteristics of the VT or CT affect the measured data.
- For safety reasons, the common terminals (+/-) of the secondary side of the VT and CT are grounded in the wiring diagrams in this section. However, the necessity of grounding and the grounding location (ground near the VT or CT or ground near the power meter) vary depending on the object being measured.
- To measure the apparent power and power factor more accurately on an unbalanced three-phase circuit, we recommend that you use a three-voltage, three-current method with a three-phase, three-wire system (3P3W; 3V3A).

The following wiring examples are for connecting a CT. When connecting a clamp-type current sensor that outputs current, substitute the CT with the clamp-type current sensor. The assignment of elements to the input terminals in the figures below varies depending on the number of installed input elements. For details, see “Number of Installed Input Elements and Wiring Systems” in section 2.3, “Measurement Conditions.”

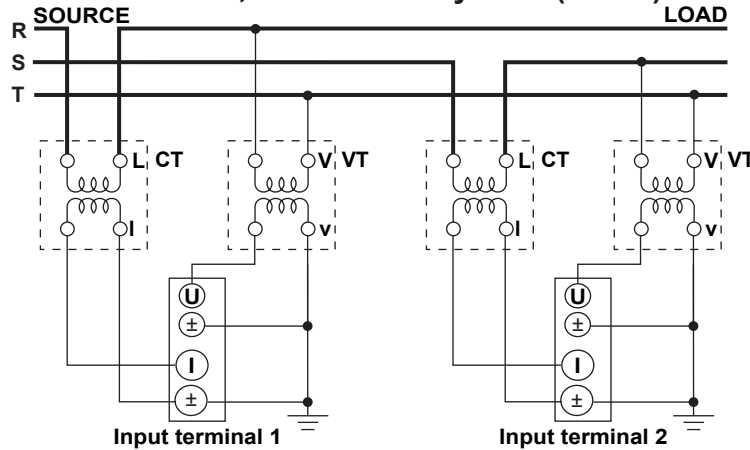
Wiring Example of a Single-Phase, Two-Wire System (1P2W) with a VT and CT



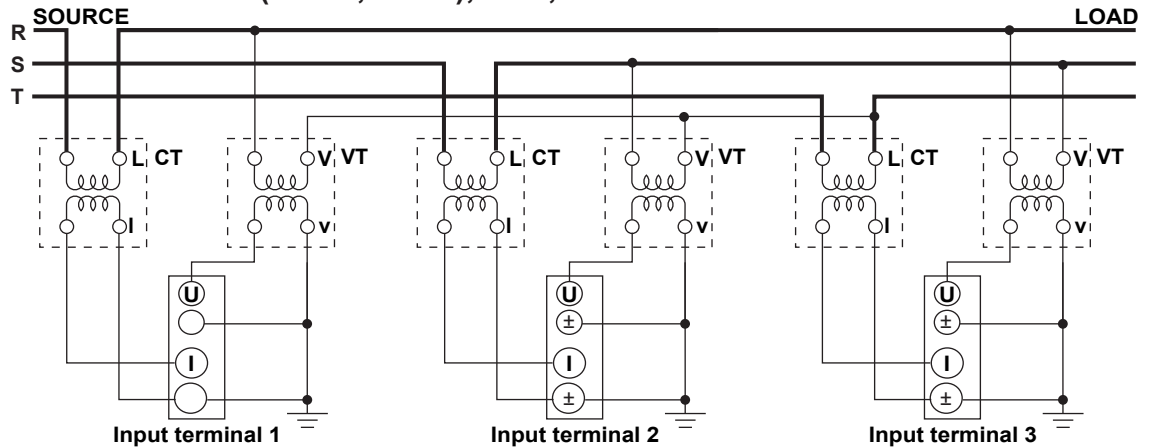
Wiring Example of a Single-Phase, Three-Wire System (1P3W) with a VT and CT



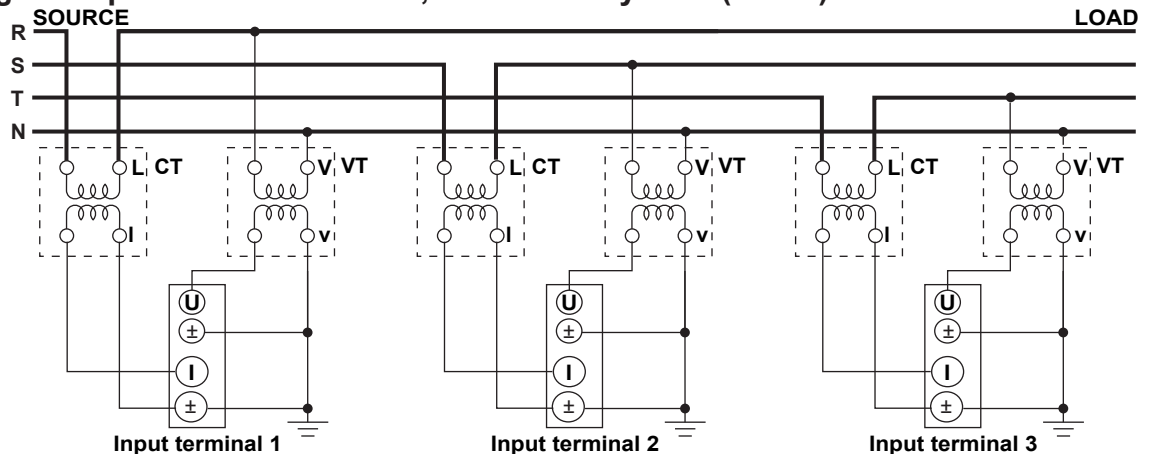
Wiring Example of a Three-Phase, Three-Wire System (3P3W) with a VT and CT



Wiring Example of a Three-Phase, Three-Wire System with a Three-Voltage, Three-Current Method (3P3W; 3V3A), a VT, and a CT



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



Note

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

3.12 Setting the Date and Time

Procedure

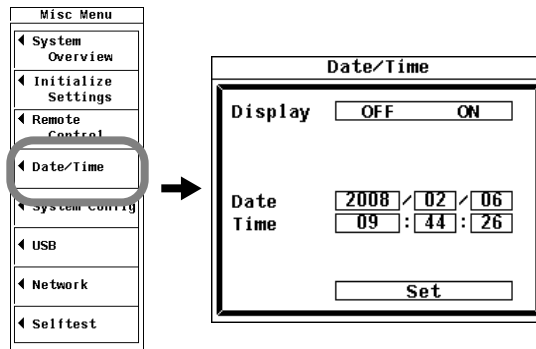
1. Press **MISC** to display the Misc Menu.

Turning the Date and Time Display On or Off

2. Use the **cursor keys** to select Date/Time.
3. Press **SET** to display the Date/Time dialog box.
4. Use the **cursor keys** to select Display.
5. Press **SET** to select ON or OFF.

Setting the Date or Time Manually

6. Use the **cursor keys** to select one of the Date (year, month, and day) or Time (hour, minute, and second) boxes.
7. Press **SET** to display an entry box.
8. Use the **cursor keys** to set the year, month, date, hour, minute, or second that you selected in step 6.
9. Press **SET** or **ESC** to close the entry box.
10. Repeat steps 6 to 8 to set the year, month, date, hour, minute, and second.
11. Use the **cursor keys** to select Set.
12. Press **SET**. If you selected ON in step 5, the new date and time are displayed in the lower right corner of the screen. If you cancel the procedure without pressing SET, the new settings are not reflected on the display.



Explanation**Turning the Date and Time Display On or Off**

You can select whether or not to display the date and time in the lower right of the screen.

- OFF: Do not display the date and time.
- ON: Display the date and time.

Setting the Date and Time**• Setting the Date**

The format for setting the date is YY/MM/DD (year/month/day).

• Setting the Date/Time

The format for setting the time is HH:MM:SS (hour:minute:second). The hour can be set to a value from 0 to 23.

Note

- The date and time information is backed up with an internal lithium battery when the power is turned off.
- The WT500 contains leap year information. The instrument determines the leap year calendar when new settings are confirmed. If you enter 2/29 for the date on a non-leap year, an error message will be displayed.

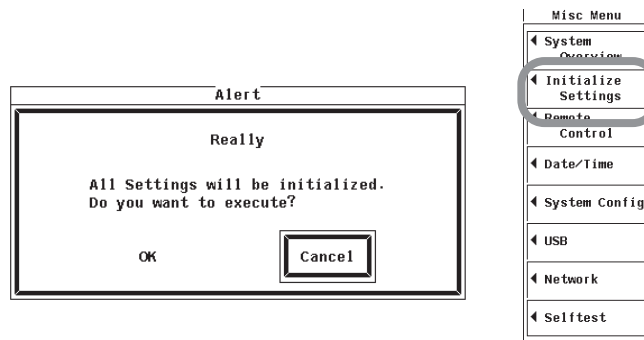
3.13 Initializing the Settings

Procedure

Note

Only initialize the WT500 if you are sure that it is okay for all of the settings to return to their initial values. You cannot undo an initialization. We recommend that you save the setup parameters before initializing the WT500 (see section 10.3 for details).

1. Press **MISC** to display the Misc Menu.
2. Use the **cursor keys** to select Initialize Settings.
3. Press **SET**. An alert message appears.
4. Use the **cursor keys** to select OK.
5. Press **SET** to execute initialization.
To cancel the initialization, select Cancel in step 3 and press SET.



Explanation

The values specified by using the panel keys can be reset to their factory default values. This is useful when you wish to clear previous settings or start the settings from scratch. For information about the initial settings, see appendix 2, "List of Initial Settings and Numeric Data Display Order."

Settings That Cannot Be Initialized

- Date and time settings
- Menu and message language settings
- The designation of the files display (Filter)
- File utility operation (Function)
- USB interface, GP-IB interface (optional), and Ethernet interface (optional) settings

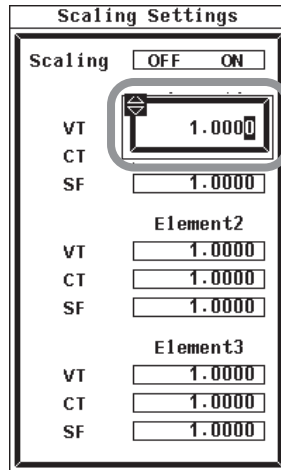
Initializing at Power Up

To make the WT500 start up with the initial settings, turn on the power. Then, when the message "Boot OK" appears, press and hold ESC until the NUMERIC key blinks. All of the settings listed under "Settings That Cannot be Initialized," except for the date and time, are initialized. A message indicating that the settings have been initialized appears on the screen.

3.14 Entering Values and Character Strings

Entering Values

When you select a setup parameter with SET, an entry box appears. Then, you can change the value by using the cursor keys. Use the left and right cursor keys to select digits, and use the up and down cursor keys to set the value of a digit.



The screenshot shows a menu titled "Scaling Settings". At the top, there is a "Scaling" option with "OFF" and "ON" radio buttons. Below this, there are three sections labeled "Element1", "Element2", and "Element3". Each section contains three parameters: VT, CT, and SF. The values for all parameters are currently set to "1.0000". A rectangular box with a cursor arrow is drawn around the first "1.0000" value in the VT row of the "Element1" section.

Element	VT	CT	SF
Element1	1.0000	1.0000	1.0000
Element2	1.0000	1.0000	1.0000
Element3	1.0000	1.0000	1.0000

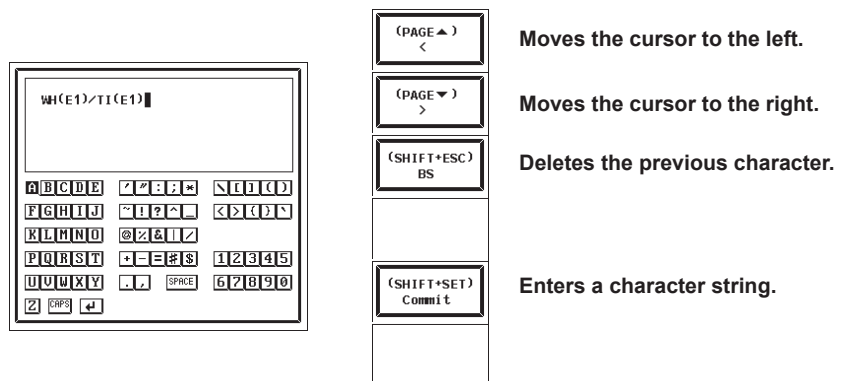
Note

Some of the parameters that can be changed using the cursor keys are reset to their initial values when SHIFT+ESC (RESET) is pressed.

Entering Character Strings

Units, file names, the equations for user-defined functions, and the user name and password for the Ethernet Interface (optional) can be entered using the keyboard that is displayed on the screen. Use the cursor keys and SET to navigate the keyboard and enter a character string.

1. Use the **cursor keys** to select a character.
2. Press **SET** to enter that character into the entry box.
If there are characters already in the entry box, use the Page ▲ and Page ▼ cursor keys to select the entry position.
3. Repeat steps 1 and 2 to enter all of the characters in the string.
4. After entering all of the characters, select ↵ on the keyboard, and press **SET**.
If you enter an incorrect user-defined function, an error message appears.



Keys Other Than the Character Keys

- CAPS: Switches between uppercase and lowercase.
- SPACE: Enters a space.
- ↵ : Enters the displayed characters.

Usable Characters and Maximum String Lengths

Setting	Max. Length	Usable Characters
Equation	1 to 50 characters	Spaces and all characters that are displayed on the keyboard
Unit	1 to 8 characters	Spaces and all characters that are displayed on the keyboard
File name	1 to 8 characters	0-9, A-Z, %, _, parentheses, and minus signs
Comment	0 to 25 characters	Spaces and all characters that are displayed on the keyboard
Server name	0 to 40 characters	Spaces and all characters that are displayed on the keyboard
User name	0 to 15 characters	Spaces and all characters that are displayed on the keyboard
Password	0 to 15 characters	Spaces and all characters that are displayed on the keyboard

Note

File names are not case-sensitive. Comments are case-sensitive. The following file names cannot be used due to MS-DOS limitations.

AUX, CON, PRN, NUL, CLOCK, COM1 to COM9, and LPT1 to LPT9

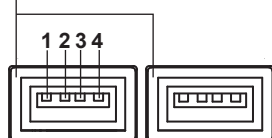
3.15 Entering Character Strings on a USB Keyboard

You can connect a USB keyboard to a USB port and enter file names, comments, and so on.

USB PERIPHERAL Connector

Use a USB cable to connect a USB keyboard to a USB PERIPHERAL connector on the left side of the front panel. There are two USB PERIPHERAL ports.

Ports



Pin No.	Signal Name
1	VBUS : +5 V
2	D- : -Data
3	D+ : +Data
4	GND : Ground

Usable Keyboards

The following keyboards conforming to USB Human Interface Devices (HID) Class Ver1.1 can be used.

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

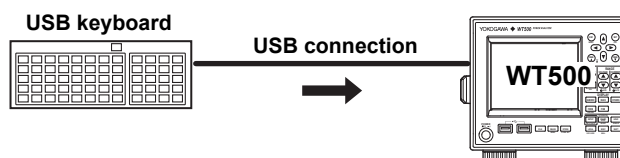
Section 3.19 explains how to select one of these two keyboards.

Note

- For USB keyboards that have been tested for compatibility, contact your nearest YOKOGAWA dealer.
- Do not connect USB devices other than USB keyboards or USB memory to the USB PERIPHERAL ports.
- The WT500 has two USB PERIPHERAL ports. However, USB devices whose maximum current consumption exceeds 100 mA cannot be connected simultaneously to the two ports.

Connection Procedure

Connect the USB keyboard to the WT500 directly using a USB cable as shown below. You can connect/disconnect a USB cable at any time regardless of whether the WT500 is on or off (supports hot-plugging). Connect the type A connector of the USB cable to the WT500, and connect the type B connector to the keyboard. When the power switch is on, the keyboard is detected and enabled approximately six seconds after it is connected.



3.15 Entering Character Strings on a USB Keyboard

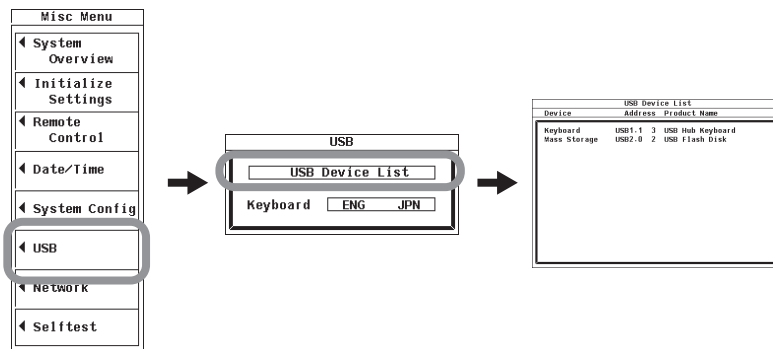
Note

- Connect the keyboard directly, not through a USB hub.
- Do not connect USB devices other than USB keyboards or USB memory to the USB PERIPHERAL ports.
- Do not connect multiple keyboards.
- Holding down a key on the keyboard does not enter the character or value repetitively.
- Do not connect and disconnect multiple USB devices repetitively. Leave a 10-second interval between removal and connection.
- Do not connect or disconnect the USB cable after the power is turned on until key operation is possible (approximately 20 to 30 s).

Confirming What Keyboard Is Connected

To confirm what keyboard is connected to the WT500, carry out the procedure below.

1. Press **MISC**.
2. Use the **cursor keys** to select USB.
3. Press **SET** to display the USB dialog box.
4. Use the **cursor keys** to select Device List.
5. Press **SET** to select USB Device List. Information about the connected USB keyboard appears.



Entering File Names, Comments, Etc.

When a keyboard is displayed on the screen, you can enter file names, comments, and other items using the USB keyboard. The characters that are entered by each key on the USB keyboard vary depending on the keyboard type.

Executing Functions Corresponding to the Keys on the Front Panel of the WT500

The keys on a USB keyboard can be used to perform the same operations that can be performed using the front panel keys. The assignment of front panel key functions to USB keyboard keys varies depending on the keyboard type. For details, see appendix 6.

3.16 Switching the Display

Procedure

Switching to the Numeric Display

1. Press **NUMERIC** to display numeric values.

Switching to the Waveform Display

1. Press **WAVE** to display waveforms.

Switching to the Trend, Bar Graph, or Vector Display

1. Press **OTHERS** to display the Others menu.

Using the Cursor Keys

2. Use the **cursor keys** to set the display to Trend, Bar, or Vector.
3. Press **SET**. The selected display appears.

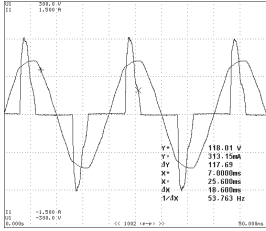
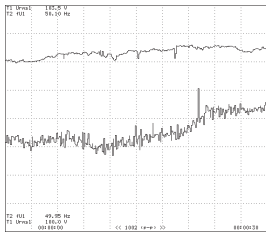
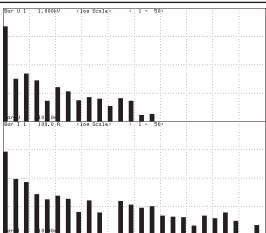
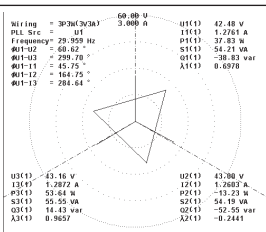
Using **OTHER**

2. Press **OTHER** to switch between display modes in this order: Trend > Bar > Vector > Trend > and so on.

3.16 Switching the Display

Explanation

On the WT500, you can choose from the following kinds of displays.

Display Mode	Without the harmonic measurement option	With the Harmonic Measurement Option
Power measurement (numeric display) (Numeric) U_{rms1} 102.64 V I_{rms1} 373.18 mA $P1$ 24.966 W $\lambda1$ 0.6518	For operating instructions, see chapter 5. For an explanation of the features, see section 2.4.	For operating instructions, see chapter 6. For an explanation of the features, see section 2.4.
Waveform display (Wave) 	For operating instructions, see chapter 7. For an explanation of the features, see section 2.7.	
Trend display (Trend) 	For operating instructions, see chapter 8. For an explanation of the features, see section 2.8.	
Bar graph display (Bar) 	Bar graph display is not possible.	For operating instructions, see chapter 6. For an explanation of the features, see section 2.8.
Vector display (Vector) 	Vector display is not possible.	For operating instructions, see chapter 6. For an explanation of the features, see section 2.8.

Note

When waveforms are displayed, the measurement mode indicated on the screen is Normal Mode (Trg). For details, see section 7.1.

3.17 Displaying a List of Setup Parameters

Procedure

Displaying the Setup Parameter List

1. Press **SHIFT+SETUP (INPUT INFO)**. A list of input conditions (such as the wiring units for each element, the measurement range, the scaling coefficient, the synchronization source, and the input filter) appears.

Closing the Setup Parameter List

2. Press **SHIFT+SETUP (INPUT INFO)** or **ESC** (when no menus are displayed). The list of setup parameters closes.

Explanation

Setup Parameter List

The figure below is an example of a setup parameter list when the crest factor is set to 3.

Power Element Settings

	Element 1	Element 2	Element 3
Wiring	1P2W	1P2W	1P2W
Voltage Range	100V	100V	100V
Current Range	10V Ext	1A	1A
Sensor Ratio (mV/A)	10.0000	10.0000	10.0000
Scaling	Off	Off	Off
VT Ratio	1.0000	1.0000	1.0000
CT Ratio	1.0000	1.0000	1.0000
Scaling Factor	1.0000	1.0000	1.0000
Sync Source	I1	I2	I3
Line Filter	Off	Off	Off
Freq Filter	Off	Off	Off

Note

The list of input conditions shows the settings when measurement took place. If the measurement range or some other setting is changed while the hold feature is on, the changes will not be reflected in the list.

3.18 Selecting the Message Language

Procedure

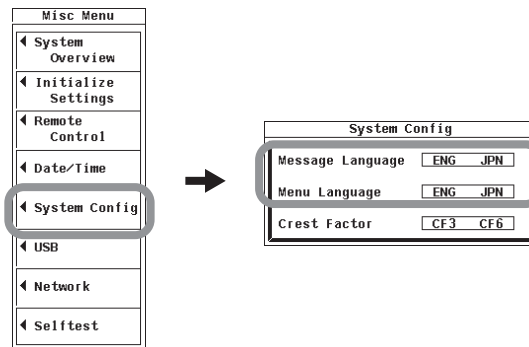
1. Press **MISC** to display the Misc Menu.
2. Use the **cursor keys** to select System Config.
3. Press **SET** to display the System Config menu.

Selecting the Message Language

4. Use the **cursor keys** to select Message Language.
5. Press **SET** to select JPN or ENG.

Selecting the Menu Language

4. Use the **cursor keys** to select Menu Language.
5. Press **SET** to select JPN or ENG.



Explanation

Selecting the Message Language

Error messages appear when errors occur. You can choose to display these messages using one of the following languages. The error codes that accompany error messages are the same for both English and Japanese messages. For more information about error messages, see section 13.2.

- JPN: Japanese
- ENG: English

Selecting the Menu Language

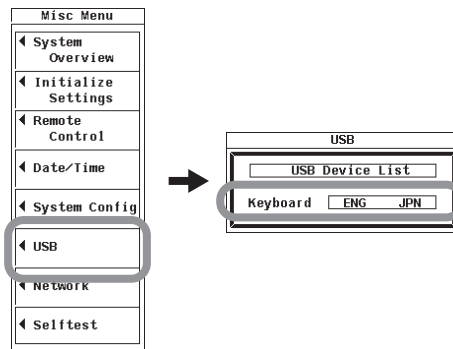
You can choose to display menus using one of the following languages.

- JPN: Japanese
- ENG: English

3.19 Setting the USB Keyboard Language

Procedure

1. Press **MISC** to display the Misc Menu.
2. Use the **cursor keys** to select USB.
3. Press **SET** to display the USB menu.
4. Use the **cursor keys** to select Keyboard.
5. Press **SET** to select JPN or ENG.



Explanation

Set the language to use when entering file names, comments, and other items (see section 3.15 for details) from the USB keyboard. The following keyboards conforming to USB Human Interface Devices (HID) Class Ver1.1 can be used.

- ENG: 104 keyboard
- JPN: 109 keyboard

The characters that are entered by each key on the USB keyboard vary depending on the keyboard type. For details, see appendix 6.

Note

For USB keyboards that have been tested for compatibility, contact your nearest YOKOGAWA dealer.

3.20 Selecting the Font Size

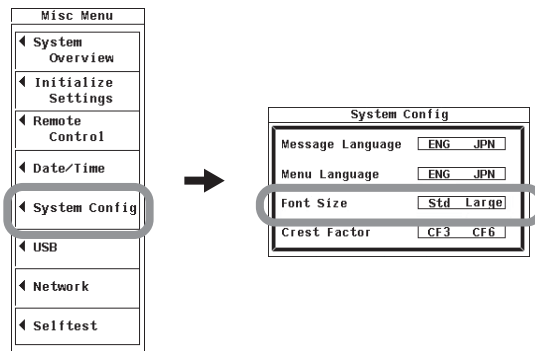
This feature is corresponding to the firmware version 1.02 or later.

Procedure

1. Press **MISC** to display the Misc Menu.
2. Use the **cursor keys** to select System Config.
3. Press **SET** to display the System Config menu.

Selecting the Message Language

4. Use the **cursor keys** to select Font Size.
5. Press **SET** to select Std or Large.



Explanation

Selecting the Font Size

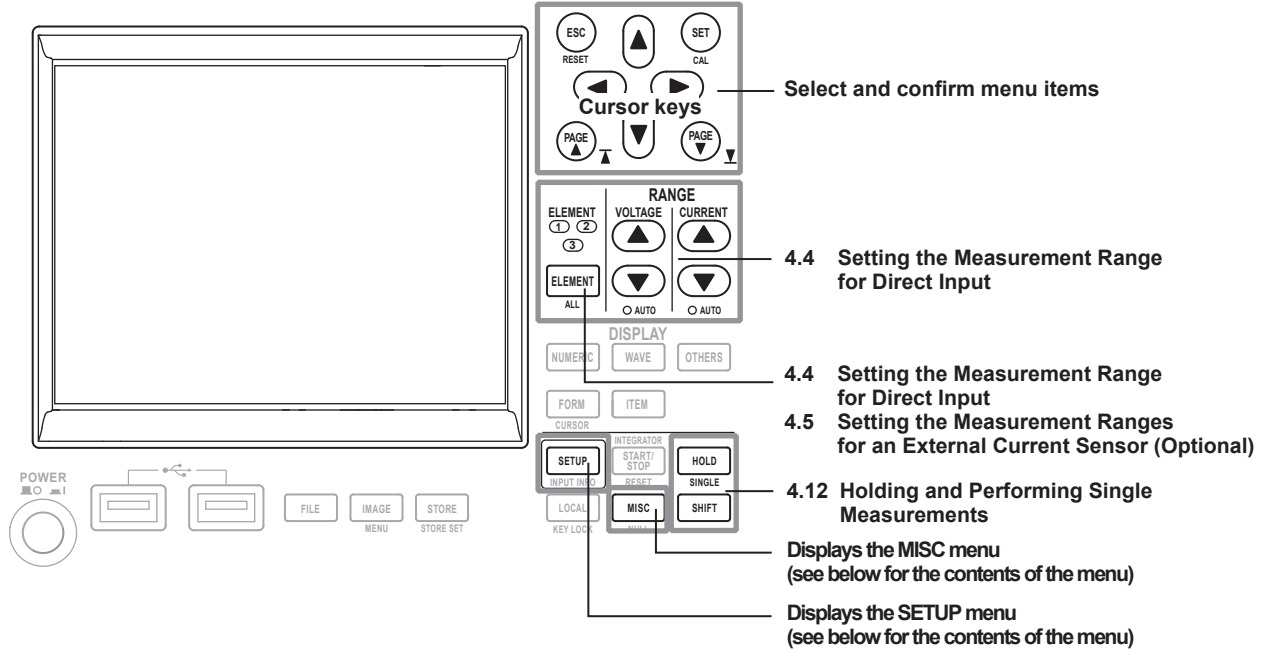
You can choose the following size of the font which is indicated in the display.

Std: Standard size indication

Large: Indicates at bigger size than standard

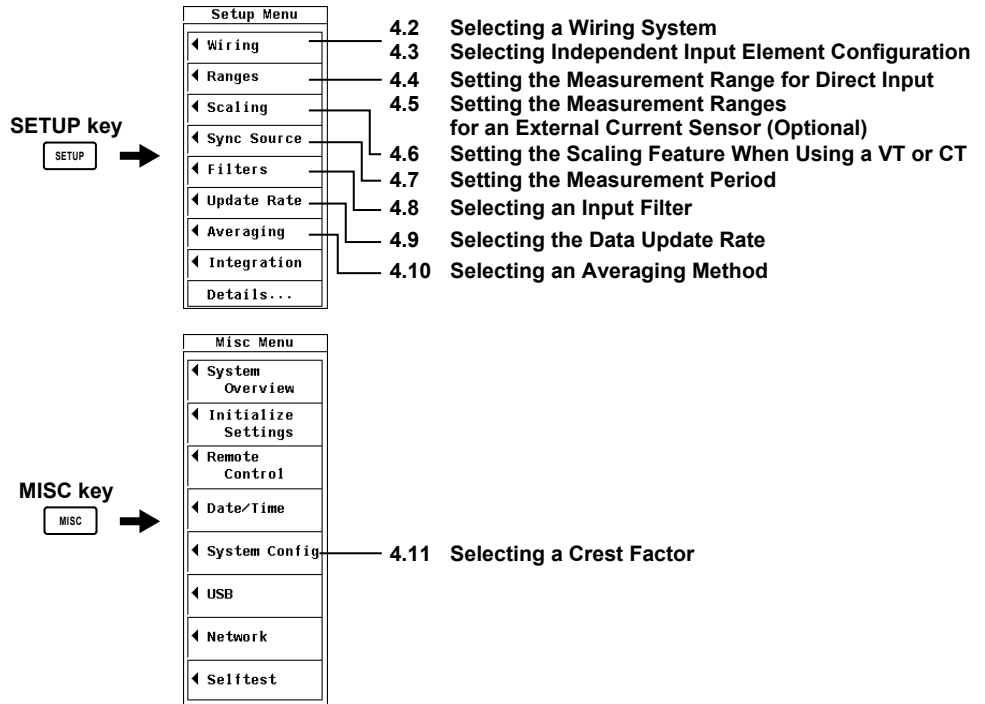
4.1 Panel Keys and Setup Menus Used in This Chapter

Panel Keys Used in This Chapter



Setup Menus Used in This Chapter

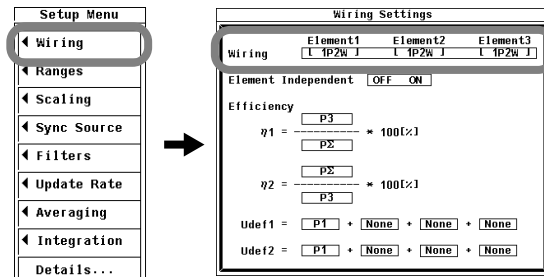
To set a parameter, access its menu by pressing the appropriate panel key. The setup menus and menu items used in this chapter are shown below, along with the sections that correspond to their operating instructions.



4.2 Selecting a Wiring System

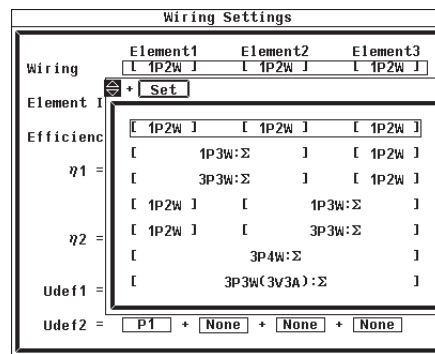
Procedure

1. Press **SETUP** to display the Setup menu.
2. Use the **cursor keys** to select Wiring.
3. Press **SET** to display the Wiring Settings dialog box.



Selecting a Wiring System

4. Use the **cursor keys** to select Wiring.
5. Press **SET**. The pattern selection dialog box appears.



6. Use the **cursor keys** to select a pattern.
7. Press **SET** to confirm the pattern.

Explanation

Wiring System

- There are five wiring systems available on the WT500. The selectable wiring systems vary depending on the number of elements installed in the WT500.
(1) 1P2W, single-phase, two-wire; (2) 1P3W, single-phase, three-wire; (3) 3P3W, three-phase, three-wire; (4) 3P4W, three-phase, four-wire; and (5) 3V3A, three-voltage, three-current.
- The wiring system determines how input elements are assignment to wiring unit Σ and how Σ functions (such as voltage, current, active power, apparent power, reactive power, power factor, and phase difference) are determined. For details about the relationship between the wiring system and how Σ functions are determined, see Appendix 1.
- The following table shows the relationship between the number of installed input elements, the selectable wiring systems, and the assignment of input elements to wiring unit Σ .

Number of installed input elements	1		
Wiring system	Pattern 1	1P2W	
Number of installed input elements	1	2	
Wiring system	Pattern 1	1P2W	1P2W
Wiring system	Pattern 2	1P3W: Σ or 3P3W: Σ	
Number of installed input elements	1	2	3
Wiring system	Pattern 1	1P2W	1P2W
Wiring system	Pattern 2	1P3W: Σ or 3P3W: Σ	
Wiring system	Pattern 3	1P2W	1P3W: Σ or 3P3W: Σ
Wiring system	Pattern 4	3P4W: Σ or 3P3W (3V3A): Σ	

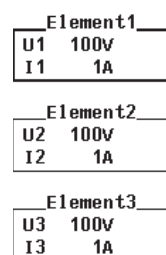
Note

- Select the wiring system to match the actual wiring of the circuit under measurement. The method in which the Σ functions are determined varies depending on the wiring system. If the selected wiring system does not match the wiring of the actual circuit, measurements and computation will not be correct.
- For details about the relationship between the wiring system and how Σ functions are determined, see Appendix 1.

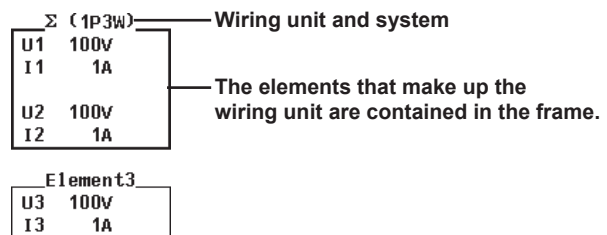
Wiring System Display

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 figure below shows wiring system display examples for a model with three input elements installed.

When elements 1 to 3 are set to single-phase, two-wire system



When element 1 and 2 are set to single-phase, three-wire system, and element 3 is set to single-phase, two-wire system



Settings of Elements Grouped in a Wiring Unit

If the independent configuration of input elements (described in section 4.3) is off and a wiring system other than 1P2W is selected when the measurement range or synchronization source settings of each input element are different, the following settings are changed in the manner described below:

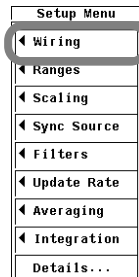
- The measurement range of all input elements included in the wiring unit is set to the highest range among all input elements. The external current sensor input range has precedence over the direct input current range.
- The auto range settings are changed to match the setting of the input element whose measurement range is highest. If multiple input elements are set to a common highest measurement range, the settings of the input element with the smallest input element number take precedence.
- The synchronization source setting is changed to match the setting of the input element with the smallest input element number among the input elements included in the wiring unit.

When you press ELEMENT to select the element to be configured, the LEDs of input elements in the wiring unit light simultaneously.

4.3 Selecting Independent Input Element Configuration

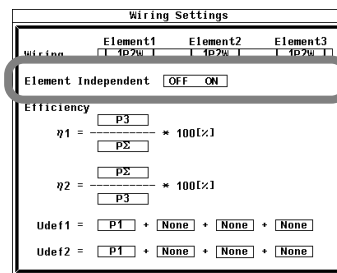
Procedure

1. Press **SETUP** to display the Setup menu.
2. Use the **cursor keys** to select Wiring.
3. Press **SET** to display the Wiring Settings dialog box.



Selecting Whether or Not to Configure Input Elements Independently

4. Use the **cursor keys** to select Element Independent.
5. Press **SET** to select ON or OFF.



4.3 Selecting Independent Input Element Configuration

Explanation

In the wiring system settings, you can select whether to set the measurement range or synchronization source of input elements in the same wiring unit collectively or independently.

Turning Independent Input Element Configuration On or 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 Σ .

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

Settings That Are Shared between Input Elements When Independent Input Element Configuration Is Turned Off

- Measurement range (including auto range on or off)
- Synchronization source setting

Settings That Can Be Configured Independently Even When Independent Input Element Configuration Is Turned Off

- Scaling values (VT ratio, CT ratio, and power factor)
- 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.

When independent input element configuration is switched from on to off, the measurement range and synchronization source settings of each input element in wiring unit Σ are changed as follows:

- The measurement range of all input elements included in the wiring unit is set to the highest range among all input elements. The external current sensor input range has precedence over the direct input current range.
- The auto range 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 settings of the input element with the smallest input element number take precedence.
- The synchronization source setting is changed to match the setting of the input element with the smallest input element number among the input elements included in the wiring unit.

4.4 Setting the Measurement Ranges for Direct Input

Procedure

Selecting Which Element to Set

1. Press **ELEMENT** to select the element that you want to set. The indicator for the selected element (located above the ELEMENT key) lights. To select all elements, press **SHIFT+ELEMENT (ALL)**.

Setting the Voltage Range

2. Press the **VOLTAGE keys (▲ and ▼)** to set the voltage range. The range specified for each element is displayed at the upper right of the screen.
 - Press the voltage range up key to increase the voltage range.
 - Press the voltage range down key to decrease the voltage range.
 - Press **SHIFT+▼ (AUTO)** to set the range automatically. The AUTO LED lights.

Setting the Current Range

3. Press the **CURRENT keys (▲ and ▼)** to set the current range. The range specified for each element is displayed at the upper right of the screen.
 - Press the current range up key to increase the current range.
 - Press the current range down key to decrease the current range.
 - Press **SHIFT+▼ (AUTO)** to set the range automatically. The AUTO LED lights.
4. Repeat steps 1 to 3 to enter the measurement ranges for all of the elements.

Note

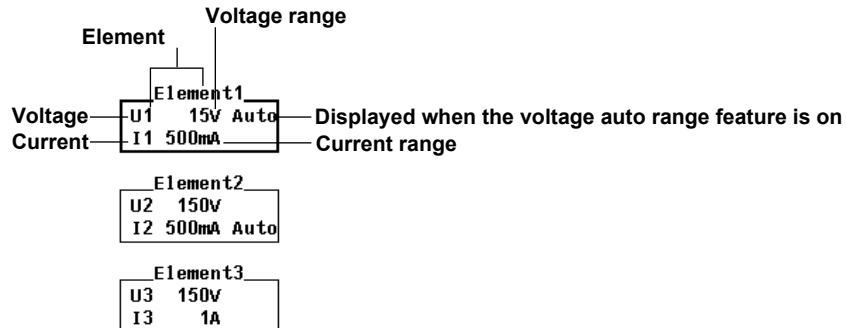
When the current range is set for an external current sensor (optional), before you set the input range, refer to section 4.5, "Setting the Measurement Ranges for an External Current Sensor (Optional)," to switch to direct input.

4.4 Setting the Measurement Range for Direct Input

Explanation

Display Positions of the Element Being Set and the Specified Range

When a voltage or current range selection key (VOLTAGE or CURRENT ▲ or ▼) is pressed, the following appears at the right of the screen.



Selecting Which Element to Set

Only the indicators of elements that are installed will light. When independent element configuration is off, the selected elements will switch by wiring unit, according to the wiring system.

Setting the Voltage and Current Ranges

There are two types of ranges, fixed and auto.

- **Fixed Range**

The range is set in reference to the rms value of the input signal.

- Voltage range
 - When the crest factor is set to 3
You can select 15 V, 30 V, 60 V, 100 V, 150 V, 300 V, 600 V, or 1000 V.
 - When the crest factor is set to 6
You can select 7.5 V, 15 V, 30 V, 50 V, 75 V, 150 V, 300 V, or 500 V.
- Current range
 - When the crest factor is set to 3
You can select 500 mA, 1 A, 2 A, 5 A, 10 A, 20 A, or 40 A.
 - When the crest factor is set to 6
You can select 250 mA, 500 mA, 1 A, 2.5 A, 5 A, 10 A, or 20 A.

Note

- The range is set in reference to 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), accurate measurements can be obtained by selecting the smallest measurement range that does not produce any of the conditions below.
 - The input peak over-range indicator at the top center of the screen lights or blinks in red.
 - The measured values of the voltage and current are indicated as over range ("-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 the WT500 (approximately 100 ks/S).
 - If the high frequency components of the pulse waveform attenuate due to the bandwidth limitations of the WT500 measurement circuit, causing the waveform peak value to be less than the peak over-range detection level.

- **Auto Range**
- Press SHIFT+▼ (AUTO) to set the range automatically. The AUTO LED lights. The measurement range is switched automatically depending on the amplitude of the input signal as described below. The different ranges used in the auto range are the same as those available for the fixed range.
 - **Range Increase**
 - The measurement range is increased when the data of measurement function U_{rms} or I_{rms} exceeds 110% of the currently set measurement range.
 - The measurement range is increased when the crest factor is set to 3 and the peak value of the input signal exceeds 330% of the currently set measurement range, or when the crest factor is set to 6 and the peak value of the input signal exceeds 660% of the currently set measurement range.
 - If all of the installed input elements are selected (all the element indicators are lighted), 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 the data of the measurement function U_{rms} or I_{rms} is less than or equal to 30% of the measurement range and Upk^* and Ipk^* are less than or equal to 300% of the next lower range when the crest factor is set to 3, or 600% of the next lower range when the crest factor is set to 6.

 - If all of the installed input elements are selected (all the element indicators are lighted), the measurement range is decreased on all input elements when all of the elements meets 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 of the elements in the unit meet the range-decrease conditions described above.
- * Even if the NULL feature is on, the values are determined as if though it were off.

Note

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

4.4 Setting the Measurement Range for Direct Input

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 system)	Voltage range × current range
1P3W (single-phase, three-wire system)	Voltage range × current range × 2
3P3W (three-phase, three-wire system)	(when the voltage and current ranges on the elements in the wiring unit are set to the same range)
3P3W (3V3A; three-voltage, three-current method)	
3P4W (three-phase, four-wire system)	Voltage range × current range × 3 (when the voltage and current ranges on the elements in the wiring unit are set to the same range)

- When the result of the equation voltage range × current range exceeds 1000 W (VA or var), the displayed unit changes to kW (kVA or kvar).
- The display resolution is 60000.

Note

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.

4.4 Setting the Measurement Range for Direct Input

The table below shows actual voltage and current range combinations and the power ranges that result from them. The values are based on the table on the previous page (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 replace the unit with VA or var.

- When the crest factor is set to 3 (see section 4.11 for details)

Active Power Range of Each Element

Current Range (A)	Voltage Range (V)							
	15.000	30.000	60.000	100.00	150.00	300.00	600.00	1000.0
500.00m	7.500 W	15.000 W	30.000 W	50.000 W	75.00 W	150.00 W	300.00 W	500.00 W
1.0000	15.000 W	30.000 W	60.000 W	100.00 W	150.00 W	300.00 W	600.00 W	1.0000 kW
2.0000	30.000 W	60.000 W	120.00 W	200.00 W	300.00 W	600.00 W	1.2000 kW	2.0000 kW
5.0000	75.00 W	150.00 W	300.00 W	500.00 W	0.7500 kW	1.5000 kW	3.0000 kW	5.0000 kW
10.000	150.00 W	300.00 W	600.00 W	1.0000 kW	1.5000 kW	3.0000 kW	6.0000 kW	10.000 kW
20.000	300.00 W	600.00 W	1.2000 kW	2.0000 kW	3.0000 kW	6.0000 kW	12.000 kW	20.000 kW
40.000	600.00 W	1.2000 kW	2.4000 kW	4.0000 kW	6.0000 kW	12.000 kW	24.000 kW	40.000 kW

Active Power Range of a Wiring Unit with a 1P3W or 3P3W system, or a 3P3W system with a 3P3W (3V3A) Method

Current Range (A)	Voltage Range (V)							
	15.000	30.000	60.000	100.00	150.00	300.00	600.00	1000.0
500.00m	15.000 W	30.000 W	60.000 W	100.000 W	150.00 W	300.00 W	600.00 W	1000.00 W
1.0000	30.000 W	60.000 W	120.000 W	200.00 W	300.00 W	600.00 W	1200.00 W	2.0000 kW
2.0000	60.000 W	120.000 W	240.00 W	400.00 W	600.00 W	1200.00 W	2.4000 kW	4.0000 kW
5.0000	150.00 W	300.00 W	600.00 W	1000.00 W	1.5000 kW	3.0000 kW	6.0000 kW	10.0000 kW
10.000	300.00 W	600.00 W	1200.00 W	2.0000 kW	3.0000 kW	6.0000 kW	12.0000 kW	20.000 kW
20.000	600.00 W	1200.00 W	2.4000 kW	4.0000 kW	6.0000 kW	12.0000 kW	24.000 kW	40.000 kW
40.000	1200.00 W	2.4000 kW	4.8000 kW	8.0000 kW	12.0000 kW	24.000 kW	48.000 kW	80.000 kW

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

Current Range (A)	Voltage Range (V)							
	15.000	30.000	60.000	100.00	150.00	300.00	600.00	1000.0
500.00m	22.500 W	45.000 W	90.000 W	150.000 W	225.00 W	450.00 W	900.00 W	1500.00 W
1.0000	45.000 W	90.000 W	180.000 W	300.00 W	450.00 W	900.00 W	1800.00 W	3.0000 kW
2.0000	90.000 W	180.000 W	360.00 W	600.00 W	900.00 W	1800.00 W	3.6000 kW	6.0000 kW
5.0000	225.00 W	450.00 W	900.00 W	1500.00 W	2.2500 kW	4.5000 kW	9.0000 kW	15.0000 kW
10.000	450.00 W	900.00 W	1800.00 W	3.0000 kW	4.5000 kW	9.0000 kW	18.0000 kW	30.000 kW
20.000	900.00 W	1800.00 W	3.6000 kW	6.0000 kW	9.0000 kW	18.0000 kW	36.000 kW	60.000 kW
40.000	1800.00 W	3.6000 kW	7.2000 kW	12.0000 kW	18.0000 kW	36.000 kW	72.000 kW	120.000 kW

4.4 Setting the Measurement Range for Direct Input

- When the crest factor is set to 6

Active Power Range of Each Element

Current Range (A)	Voltage Range (V)							
	7.5000	15.000	30.000	50.000	75.00	150.00	300.00	500.00
250.00m	1.8750 W	3.7500 W	7.500 W	12.500 W	18.7500 W	37.5000 W	75.000 W	125.000 W
500.00m	3.7500 W	7.500 W	15.000 W	25.000 W	37.5000 W	75.000 W	150.000 W	250.000 W
1.0000	7.500 W	15.000 W	30.000 W	50.000 W	75.000 W	150.000 W	300.000 W	500.000 W
2.5000	18.750 W	37.500 W	75.000 W	125.00 W	187.500 W	375.000 W	0.75000 kW	1.25000 kW
5.0000	37.500 W	75.000 W	150.00 W	250.00 W	375.000 W	0.75000 kW	1.50000 kW	2.50000 kW
10.000	75.000 W	150.00 W	300.00 W	500.00 W	0.75000 kW	1.50000 kW	3.00000 kW	5.00000 kW
20.000	150.00 W	300.00 W	600.00 W	1.0000 kW	1.5000 kW	3.0000 kW	6.0000 kW	10.000 kW

Active Power Range of a Wiring Unit with a 1P3W or 3P3W system, or a 3P3W system with a 3V3A Method

Current Range (A)	Voltage Range (V)							
	7.500	15.000	30.000	50.000	75.00	150.00	300.00	500.00
250.00m	3.7500 W	7.5000 W	15.000 W	25.000 W	37.500 W	75.000 W	150.00 W	250.00 W
500.00m	7.5000 W	15.000 W	30.000 W	50.000 W	75.000 W	150.00 W	300.00 W	500.00 W
1.0000	15.000 W	30.000 W	60.000 W	100.000 W	150.00 W	300.00 W	600.00 W	1000.00 W
2.5000	37.500 W	75.000 W	150.00 W	250.00 W	375.00 W	750.00 W	1.5000 kW	2.5000 kW
5.0000	75.000 W	150.00 W	300.00 W	500.00 W	750.00 W	1.5000 kW	3.0000 kW	5.0000 kW
10.000	150.00 W	300.00 W	600.00 W	1000.00 W	1.5000 kW	3.0000 kW	6.0000 kW	10.0000 kW
20.000	300.00 W	600.00 W	1200.00 W	2.0000 kW	3.0000 kW	6.0000 kW	12.0000 kW	20.000 kW

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

Current Range (A)	Voltage Range (V)							
	7.500	15.000	30.000	50.000	75.00	150.00	300.00	500.00
250.00m	5.6250 W	11.2500 W	22.500 W	37.500 W	56.250 W	112.500 W	225.00 W	375.00 W
500.00m	11.2500 W	22.500 W	45.000 W	75.000 W	112.500 W	225.00 W	450.00 W	750.00 W
1.0000	22.500 W	45.000 W	90.000 W	150.000 W	225.00 W	450.00 W	900.00 W	1500.00 W
2.5000	56.250 W	112.500 W	225.00 W	375.00 W	562.50 W	1125.00 W	2.2500 kW	3.7500 kW
5.0000	112.500 W	225.00 W	450.00 W	750.00 W	1125.00 W	2.2500 kW	4.5000 kW	7.5000 kW
10.000	225.00 W	450.00 W	900.00 W	1500.00 W	2.2500 kW	4.5000 kW	9.0000 kW	15.0000 kW
20.000	450.00 W	900.00 W	1800.00 W	3.0000 kW	4.5000 kW	9.0000 kW	18.0000 kW	30.000 kW

4.5 Setting the Measurement Ranges for an External Current Sensor (Optional)

Procedure

Selecting the External Current Sensor Input Connector

1. Press **SETUP** to display the Setup menu.
2. Use the **cursor keys** to select Ranges.
3. Press **SET** to display the Range Settings dialog box.
4. Use the **cursor keys** to select the Ext Sensor boxes of the elements that will use external current sensor connectors.
5. Press **SET**. The Ext Sensor box lights.
If the Ext Sensor box is already lit, proceed to step 7.

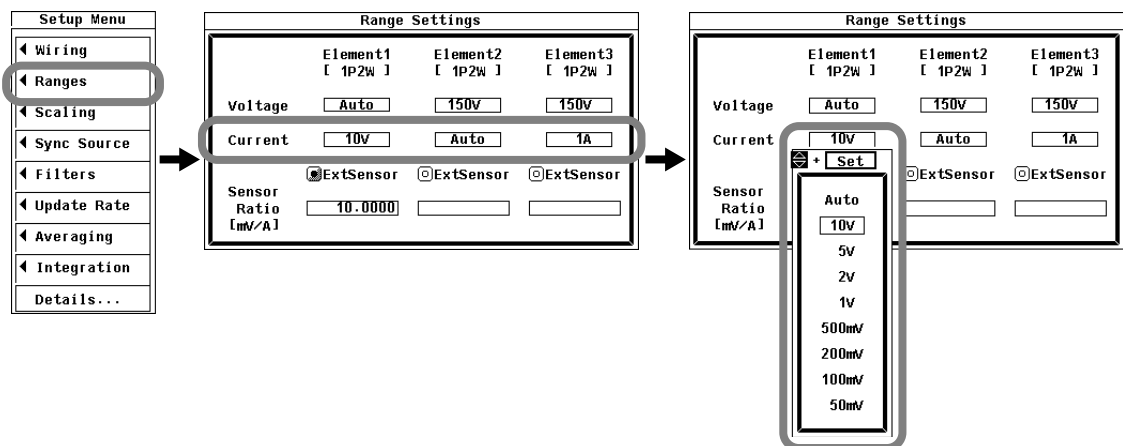
Setting the External Current Sensor Range

6. Use the **cursor keys** to select Current.
7. Press **SET**. The external current sensor range entry box appears.
8. Use the **cursor keys** to select the external current sensor range.
9. Press **SET** to confirm the external current sensor range.

Note

The external current sensor range can also be set using the CURRENT (**▲** and **▼**) keys. For information about how to use the CURRENT (**▲** and **▼**) keys, see section 4.4.

10. Repeat steps 1 to 10 to enter the external current sensor ranges for all of the elements.



4.5 Setting the Measurement Ranges for an External Current Sensor (Optional)

Setting the External Current Sensor Conversion Ratio

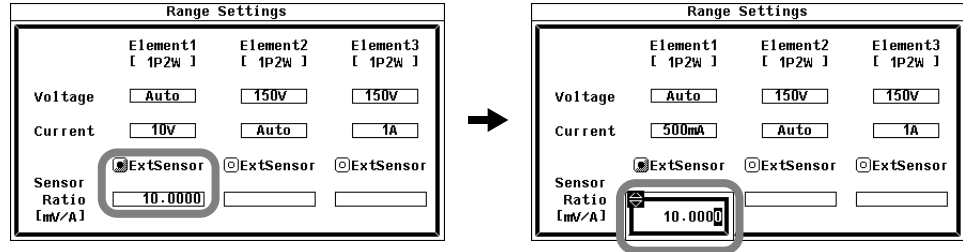
11. Use the **cursor keys** to select Sensor Ratio[mV/A].

You can only set the conversion ratio for elements whose Ext Sensor boxes are lighted.

- **Setting the External Current Sensor Conversion Ratio**

12. Press **SET** to display the external current sensor conversion ratio entry box.

13. Use the **cursor keys** to set the conversion ratio.



Explanation

The output of current sensors that produce voltage, such as shunts and clamps, can be applied to an element's current sensor input connector and measured. When using a current sensor that produces current, set the conversion ratio as the CT ratio (see section 4.6 for instructions).

Display Positions of the Element Being Set and the Specified Range

The display positions are the same as those described in section 4.4, "Setting the Measurement Range during Direct Input."

Selecting the External Current Sensor Input Connector

To measure the current of an element using the input signal from the external current sensor input connector, you must select the Ext Sensor box of that element and then specify the external current sensor range.

Selecting the External Current Sensor Range

There are two types of ranges, fixed and auto.

- **Fixed Range**

- When the crest factor is set to 3
You can select 50 mV, 100 mV, 200 mV, 500 mV, 1 V, 2 V, 5 V, or 10 V.
- When the crest factor is set to 6
You can select 25 mV, 50 mV, 100 mV, 250 mV, 500 mV, 1 V, 2.5 V, or 5 V.

- **Auto Range**

When you press SHIFT+▼ (AUTO) or select Auto in the external current sensor range entry box, the AUTO indicator lights and the auto range feature is enabled. The range is switched automatically depending on the amplitude of the input signal. For auto range switching conditions and precautions, see section 4.4, "Setting the Measurement Range during Direct Input." The different ranges used in the auto range are the same as those listed above for the fixed range.

Setting the External Current Sensor Conversion Ratio

The conversion ratio can be set to a value from 0.0001 to 99999.9999.

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 produces 10 mV when 1 A of current is flowing, the maximum voltage that the current sensor produces is $10 \text{ mV/A} \times 100 \text{ A} = 1 \text{ V}$. Therefore, set the external current sensor range to 1 V and the external current sensor conversion ratio to 10 mV/A.

Note

- When attempting to directly read the current of the circuit under measurement by multiplying the output of the external current sensor by the conversion ratio, turn off the external VT/CT scaling feature (see section 4.6 for instructions). If it 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), accurate measurements can be obtained by selecting the smallest measurement range that does not produce any of the conditions below.
 - The input peak over-range indicator at the top center of the screen lights or blinks in red.
 - The measured values of the voltage and current are indicated as over range ("OL").

4.6 Setting the Scaling Feature When Using a VT or CT

Procedure

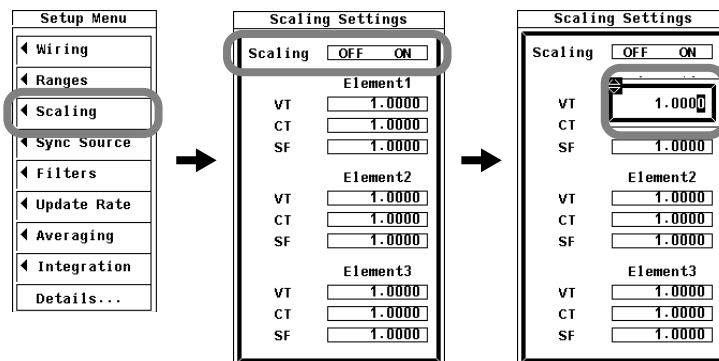
1. Press **SETUP** to display the Setup menu.
2. Use the **cursor keys** to select Scaling.
3. Press **SET** to display the Scaling Settings menu.

Turning the Scaling Feature On or Off

4. Use the **cursor keys** to select Scaling.
5. Press **SET** to select ON or OFF. If you select ON, the Scaling indicator lights at the top of the screen (see section 1.3 for details).

Setting the VT Ratio

6. Use the **cursor keys** to select the VT of the element that you want to set the VT ratio of.
7. Press **SET** to display the VT ratio entry box.
8. Use the **cursor keys** to set the VT ratio.
9. Press **SET** or **ESC** to close the VT ratio entry box.
10. Repeat steps 6 to 10 to enter the VT ratios for all of the elements.



Setting the CT Ratio

6. Use the **cursor keys** to select the CT of the element that you want to set the CT ratio of.
7. Press **SET** to display the CT ratio entry box.
8. Use the **cursor keys** to set the CT ratio.
9. Press **SET** or **ESC** to close the CT ratio entry box.
10. Repeat steps 6 to 9 to enter the CT ratios for all of the elements.

The screenshot shows the 'Scaling Settings' menu. At the top, 'Scaling' is set to 'OFF' and 'ON'. Below this, there are three sections for 'Element1', 'Element2', and 'Element3'. Each section has three rows: 'VT', 'CT', and 'SF'. In the 'Element1' section, the 'CT' row is highlighted with a cursor, and a small entry box is open over it, displaying the value '1.0000'. The other rows in all sections show '1.0000' in their respective boxes.

Setting the Power Factor (SF)

6. Use the **cursor keys** to select the power factor of the element that you want to set the SF (Scaling Factor) of.
7. Press **SET** to display the power factor entry box.
8. Use the **cursor keys** to set the power factor.
9. Press **SET** or **ESC** to close the power factor entry box.
10. Repeat steps 6 to 9 to enter the power factors for all of the elements.

The screenshot shows the 'Scaling Settings' menu. At the top, 'Scaling' is set to 'OFF' and 'ON'. Below this, there are three sections for 'Element1', 'Element2', and 'Element3'. Each section has three rows: 'VT', 'CT', and 'SF'. In the 'Element1' section, the 'SF' row is highlighted with a cursor, and a small entry box is open over it, displaying the value '1.0000'. The other rows in all sections show '1.0000' in their respective boxes.

4.6 Setting the Scaling Feature When Using a VT or CT

Explanation

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 (see section 4.4 for instructions). In addition, set the CT ratio (or the conversion ratio of the current sensor that produces current) when applying the secondary output of a CT or clamp-type current sensor that produces current to the current input terminal. Then, set the current range according to the maximum current sensor output. For details, see section 2.3.

Turning the Scaling Feature On or Off

You can select whether to multiply the applicable measurement functions by the VT ratio, CT ratio, or power factor. When reading measured values directly by using a VT or CT (or current sensor), select ON. The Scaling indicator lights when ON is selected.

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

Setting the VT Ratio

The ratio can be set to a value from 0.0001 to 99999.9999.

Setting the CT Ratio

The ratio can be set to a value from 0.0001 to 99999.9999.

Setting the Power Factor (SF, Scaling Factor)

The factor can be set to a value from 0.0001 to 99999.9999.

Note

- If the value of the result of multiplying the measured value by the VT ratio, CT ratio, or power factor (scaling factor) exceeds 9999.9M, "-OF-" will appear in the numeric data display frame.
 - For information about how to display a list of the VT and CT ratios and power factors of all input elements, see section 3.17, "Displaying a List of Setup Parameters." When the scaling feature is off, the list displays 1.0000 for all VT and CT ratios and power factors.
 - To correctly compute the power and efficiency of Σ functions, set the power factors of all elements so that all power units used in the computation are the same. For example, the efficiency cannot be computed correctly if elements or wiring units used in the computation have different power units, such as W (watt) and J (joule). To compute the efficiency correctly, make all of the power units the same (either all W or all J).
-

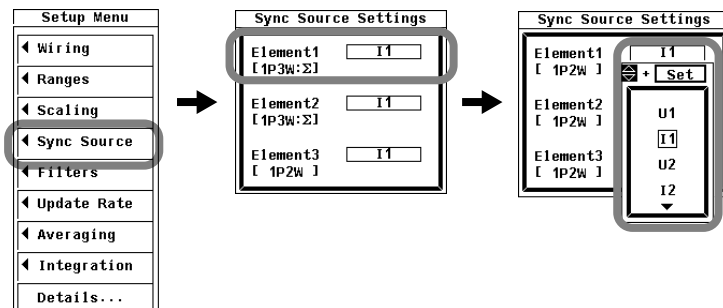
4.7 Setting the Measurement Period

Procedure

1. Press **SETUP** to display the Setup menu.
2. Use the **cursor keys** to select Sync Source.
3. Press **SET** to display the Sync Source Settings menu.

Setting the Synchronization Source

4. Use the **cursor keys** to select the sync source of the element that you want to set.
5. Press **SET** to display the sync source entry box.
6. Use the **cursor keys** to select a sync source.
7. Press **SET** to confirm the sync source.



4.7 Setting the Measurement Period

Explanation

The measurement period is determined by the data update rate (see section 4.9 for details) and by the synchronization source, which is specified by following the procedure described in this section. For details, see appendix 6.

During normal measurement, numeric data is measured or computed from the data sampled within the measurement period.

Setting the Synchronization Source

Only installed elements appear. For each element, you can select which input signal will be the synchronization source (the measurement period will be synchronized to the zero-crossing point of the input signal). You can select the synchronization source signal from the choices listed below. The selectable items vary depending on the installed elements. When independent element configuration is off, the synchronization source for all elements in a wiring unit is determined by the synchronization source of the first element in the wiring unit.

U1, I1, U2, I2, U3, I3, Ext Clk (external clock), and None

Note

If you specify no synchronization source by selecting "None," all of the sampled data within the data update interval is used to determine the numeric data. When measuring DC signals, this method can be used to prevent errors in the detection of the measurement period caused by noise.

When Setting the Synchronization Source to Ext Clk

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



• Ext Clk Specifications

Item	Specification
Connector type	BNC connector
Input level	TTL
Input waveform	50% duty ratio rectangular wave



CAUTION

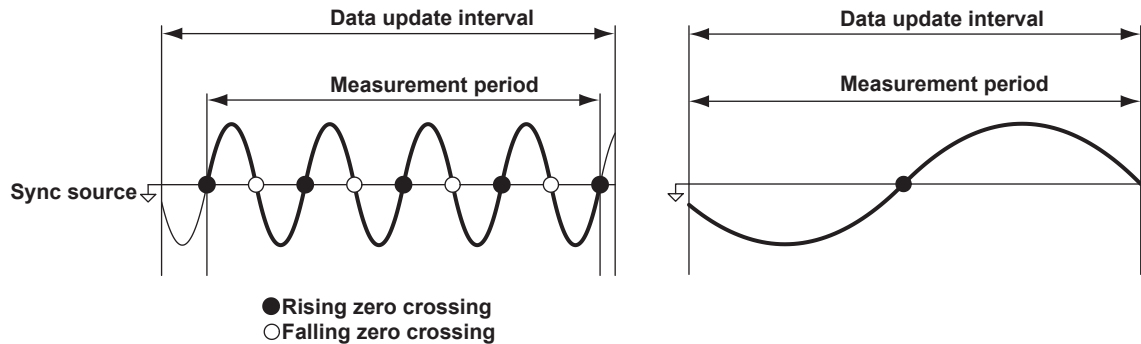
Applying a voltage outside of the range of 0 to 5 V to the external clock input connector (EXT CLK) can damage the WT500.

Note

- The synchronized measurement slave setting and the synchronization source Ext Clk setting cannot be made at the same time because they both use the same connector (see section 12.6 for information about synchronized measurement).
- To connect a BNC cable to the external clock input/external start signal output connector (EXT CLK) when a GP-IB cable is connected to the GP-IB connector, first remove the GP-IB cable. Then connect the BNC cable. Finally, reconnect the GP-IB cable.

Measurement Period

The measurement period is set within the data update interval between the first point where the synchronization source crosses the level-zero point (center of the amplitude) on a rising slope (or falling slope) and the last point where the synchronization source crosses the level-zero point (center of the amplitude) on a rising slope (or falling slope). If there is not more than one rising or falling slope within the data update interval, the entire data update interval is set as the measurement period. For details, see appendix 5.



Note

- The measurement period for determining the numeric data of the peak voltage or peak current is the entire span of the data update interval, regardless of the above settings. 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, Cfl, FfU, and Ffl) is also the entire span of the data update interval.
- If the synchronization source is not set correctly, the measured value may fluctuate or be incorrect. Refer to appendix 5 when setting the synchronization source.

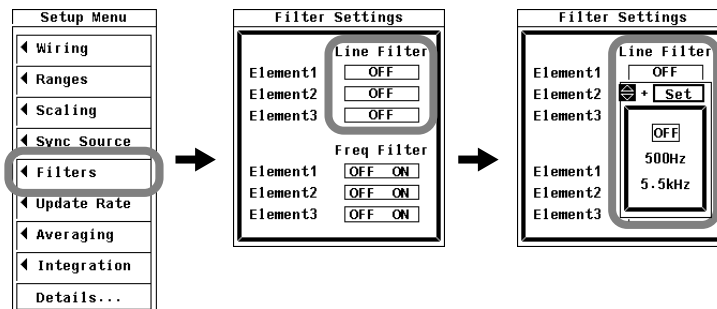
4.8 Selecting an Input Filter

Procedure

1. Press **SETUP** to display the Setup menu.
2. Use the **cursor keys** to select Filters.
3. Press **SET** to display the Filter Settings menu.
Only installed elements appear.

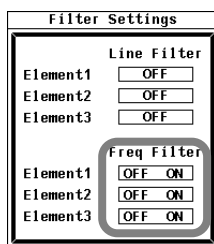
Selecting a Line Filter

4. In the Line Filter menu, use the **cursor keys** to select the line filter of the element that you want to set.
5. Press **SET** to display the line filter entry box.
6. Use the **cursor keys** to select a line filter.
7. Press **SET** to confirm the line filter. If any of the measured elements are set to a setting other than OFF, the LineFilt indicator lights (see section 1.3 for details).



Selecting a Frequency Filter

4. In the Freq Filter menu, use the **cursor keys** to select the frequency filter of the element that you want to set.
Only installed elements appear.
5. Press **SET** to select ON or OFF. If any of the measured elements are set to a setting other than OFF, the FreqFilt indicator lights (see section 1.3 for details).



Explanation

There are two types of input filters, line filters and frequency filters.

Selecting a Line Filter

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 section 2.1). When the line filter is turned on, measured values do not contain high frequency components. Thus, the voltage, current, and power of inverter waveforms, strain waveforms, etc., can be measured with their high frequency components eliminated.

- You can select from one of the following cutoff frequencies.
OFF, 500 Hz, and 5.5 kHz
- If any of the measured elements is set to a setting other than OFF, the LineFilt indicator lights.
- Selecting OFF disables the line filter.
- If you select 500 Hz as the cutoff frequency, the line filter is turned on automatically.

Selecting the Frequency Filter

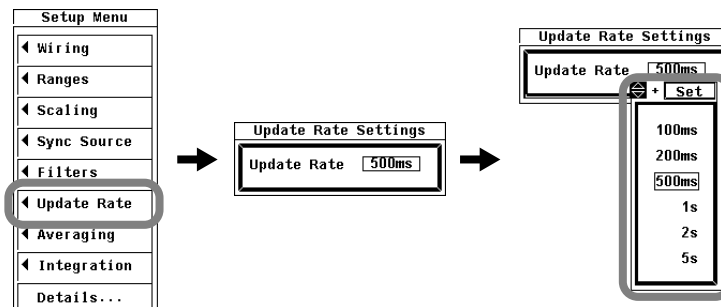
Because the frequency filter is inserted into the frequency measurement input circuit, it affects frequency measurements. It also affects the detection of the measurement period for voltage, current, and power measurements (see appendix 5 for details). In this case, the filter also acts as a filter for detecting the zero-crossing of the synchronization source signal (see section 2.2 for details) 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.

- The WT500 detects the zero-crossing point with a hysteresis of approximately 5% of the measurement range.
- If the line filter described above is on, it affects the frequency measurement even when the frequency filter is off.
- We recommend that you turn the frequency filter on when the input signal frequency is less than or equal to 440 Hz.
- If the frequency filters of any of the measured elements are set to ON, the FreqFilt indicator lights.

4.9 Selecting the Data Update Rate

Procedure

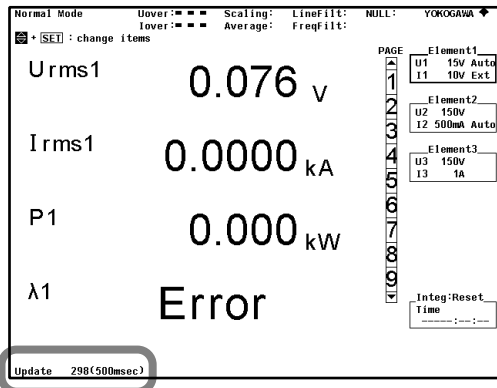
1. Press **SETUP** to display the Setup menu.
2. Use the **cursor keys** to select Update Rate.
3. Press **SET** to display the Update Rate Settings menu.
4. Press **SET** to display the data update rate entry box.
5. Use the **cursor keys** to select a data update rate.
6. Press **SET** to confirm the data update rate. The set data update rate appears at the lower left of the screen.



Explanation

When the screen is not displaying waveforms, numeric data is transmitted and stored at the selected interval.

Display Position of the Data Update Rate



Data Update Rate Limits

You can select the rate from one of the choices below. The numeric data is updated at the selected interval. To capture relatively fast load fluctuations in the power system, select a fast data update rate. To capture relatively low frequency signals, select a low data update rate.

- 100 ms, 200 ms, 500 ms, 1 s, 2 s, 5 s

Note

- The display update rates of numeric data and waveform data may be lower than the data update rate.
- The low frequency limit of the AC signal that can be measured varies depending on the data update rate. The measured value may not be stable if an AC signal of a frequency lower than the low frequency measurement limit (see section 14.5 for details) is measured.

4.10 Selecting an Averaging Method

Procedure

1. Press **SETUP** to display the Setup menu.
2. Use the **cursor keys** to select Averaging.
3. Press **SET** to display the Averaging Settings menu.

Selecting Whether or Not to Average Values

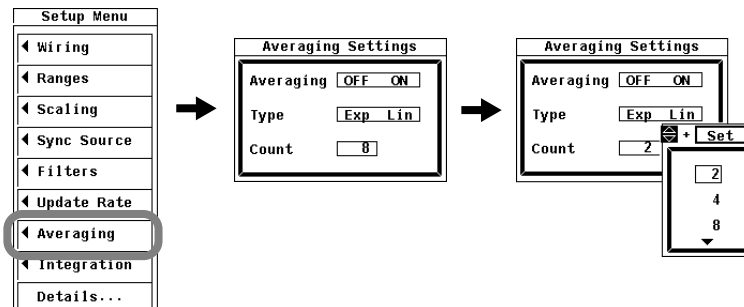
4. Use the **cursor keys** to select Averaging.
5. Press **SET** to select ON or OFF.

Selecting an Averaging Method

6. Use the **cursor keys** to select Type.
7. Press **SET** to select Exp or Lin.

Setting the Attenuation Constant or the Average Count

8. Use the **cursor keys** to select Count.
9. Press **SET** to display the attenuation constant or average count entry box.
If the averaging type is Exp (exponential averaging), set the attenuation constant. If the averaging type is Lin (moving averaging), set the average count.
10. Press **SET** to confirm the attenuation constant or average count.



Explanation

For an explanation of the averaging feature, see section 2.3.

The averaging function is effective when reading of the numeric display is difficult 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.

Measurement Functions Used in Normal Measurement**Turning Averaging On or Off**

You can choose whether or not to perform the selected averaging operation.

- ON: The selected averaging operation is performed.
- OFF: The selected averaging operation is not performed.

Selecting the Averaging Type

You can select one of the choices below. For details about the equations used for each choice, see section 2.3.

- Exp: Exponential averaging is performed.
- Lin: Linear averaging is performed.

Setting the Attenuation Constant or Average Count

If the averaging type is Exp (exponential averaging), set the attenuation constant. If the averaging type is Lin (moving averaging), set the average count.

- Exp: The attenuation constant can be selected from 2, 4, 8, 16, 32, and 64.
- Lin: The average count can be selected from 8, 16, 32, and 64.

Measurement Functions That Are Averaged

The measurement functions that are directly averaged are indicated below. Other functions that use these functions in their computation are also affected by averaging. For details about how each measurement function is determined, see appendix 1.

- Urms, Umn, Udc, Urmn, Uac, Irms, Imn, Idc, Irmn, Iac, P, S, and Q
- $\Delta F1$ to $\Delta F4$ (on models with the delta computation option)
- CfU, Cfl, WS, WQ, $\eta 1$, and $\eta 2$ are computed using Urms, Irms, P, S, and Q, which are all averaged.

Measurement Functions Used in Harmonic Measurement (Optional)

Turning Averaging On or Off

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

Setting the Attenuation Constant

If averaging is turned on, and the averaging type is Exp (exponential averaging), exponential averaging is performed using the selected attenuation constant (2, 4, 8, 16, 32, or 64).

Measurement Functions That Are Averaged

The measurement functions that are directly averaged are indicated below. Other functions that use these functions in their computation are also affected by averaging. For details about how each measurement function is determined, see appendix 1.

- $U(k)$, $I(k)$, $P(k)$, $S(k)$, and $Q(k)$
- $\lambda(k)$, and $\phi(k)$ are computed using $P(k)$ and $Q(k)$, which are both averaged.
- $Uhdf$, $Ihdf$, $Phdf$, $Uthd$, $Ithd$, and $Pthd$ are computed using $U(k)$, $I(k)$, and $P(k)$, which are all averaged.
* k : The harmonic order

Note

- 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 averaging) or average count (for moving averages) will result in more stable (and less responsive) measured values.
 - The following measurement functions are not affected by averaging.
 - Measurement Functions Used in Normal Measurement
 fU , fI , $U+pk$, $U-pk$, $I+pk$, $I-pk$, Time, WP, WP+, WP-, WP Σ , WP+ Σ , WP- Σ , q, q+, q-, q Σ , q+ Σ , q- Σ
 - Measurement Functions Used in Harmonic Measurement (Optional)
 $\phi U(k)$, $\phi I(k)$, ϕU_i-U_j , ϕU_i-U_k , ϕU_i-I_i , ϕU_i-I_j , ϕU_i-I_k
* k : The harmonic order
-

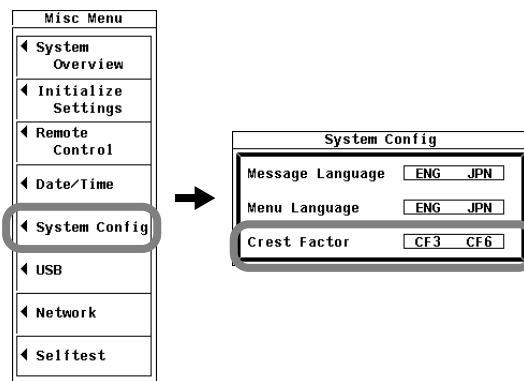
4.11 Selecting a Crest Factor

Procedure

1. Press **MISC** to display the Misc Menu.
2. Use the **cursor keys** to select System Config.
3. Press **SET** to display the System Config menu.

Selecting a Crest Factor

4. Use the **cursor keys** to select Crest Factor.
5. Press **SET** to select CF3 or CF6.



Explanation

For details, see section 2.3.

Selecting a Crest Factor

The crest factor is the ratio of the amplitude to the rms value. You can set the crest factor to CF3 or CF6.

Note

- When you select a crest factor, the voltage range and current range are set to the maximum range on all elements.
- If the crest factor is set to 6, the measurement conditions of crest factor 5 and higher required by IEC62018 are met.
- When measuring waveforms whose crest factor is less than or equal to 3, you can achieve more accurate measurements by setting the crest factor to 3.

4.12 Holding the Display and Performing Single Measurements

Procedure

Holding the Numeric Data Display

1. Press **HOLD**. The HOLD key lights, and the numeric data display is held.

Performing a Single Measurement

2. Press **SHIFT+HOLD (SINGLE)**. Measurement is performed once, and then the display is re-held.

Un-Holding the Display

3. Press **HOLD** when the display is held. The HOLD key stops lighting, and the numeric data display is updated.

Explanation

Hold

The hold operation stops data measurement and display operations and holds the display of all measurement function data. Communication output data is the same as the held numeric data.

Single Measurement

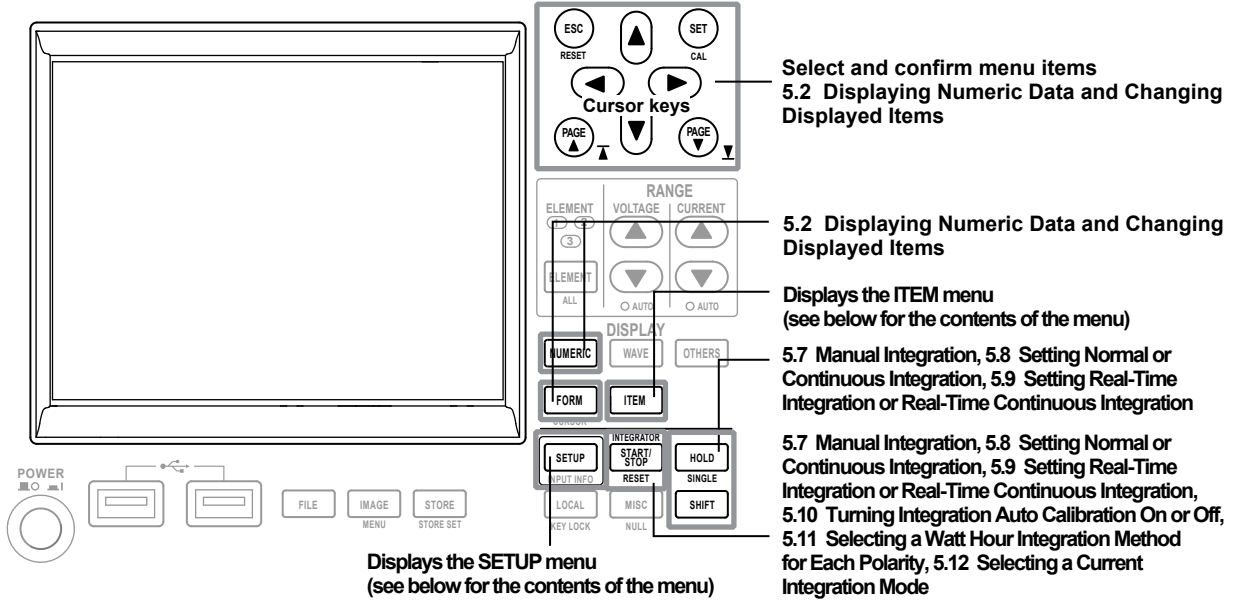
While the display is held, this operation measures the signal once at the set data update rate, and then re-holds the display. If you press SHIFT+HOLD (SINGLE) when the display is not held, measurement restarts from that point.

Note

For information about how the hold feature works during integration, see section 5.9.

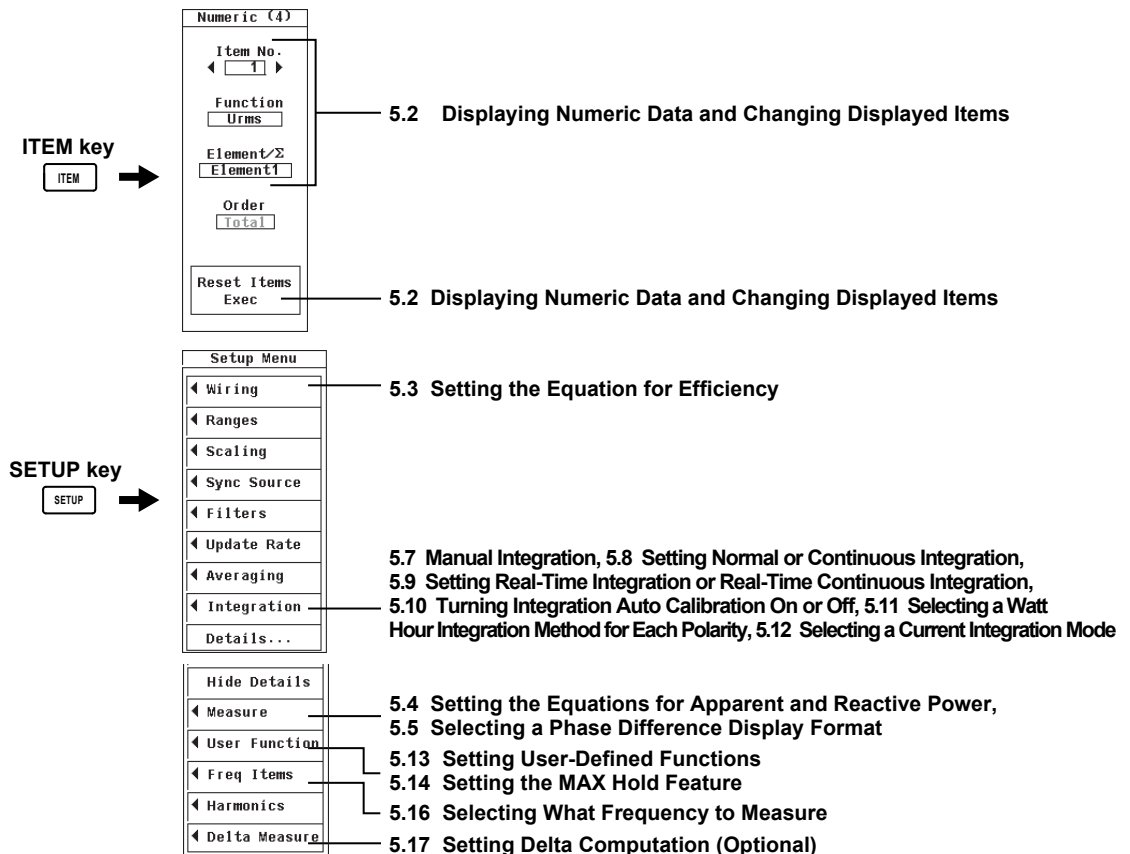
5.1 Panel Keys and Setup Menus Used in This Chapter

Panel Keys Used in This Chapter



Setup Menu Used in This Chapter

To set a parameter, access its menu by pressing the appropriate panel key. The setup menu and menu items used in this chapter are shown below, along with the sections that correspond to their operating instructions.

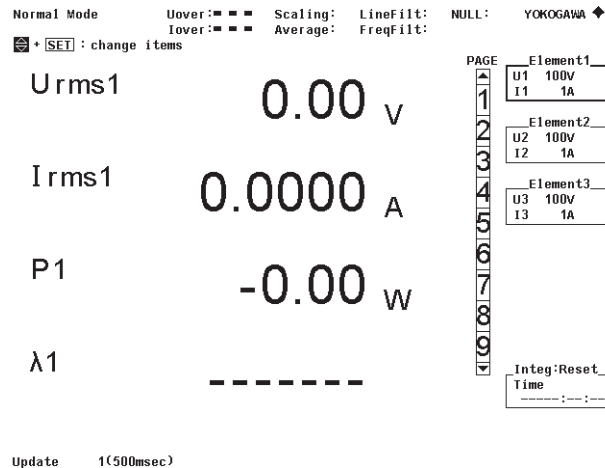


5.2 Displaying Numeric Data and Changing Displayed Items

Procedure

Displaying Numeric Data

1. Press **NUMERIC** to display numeric values.

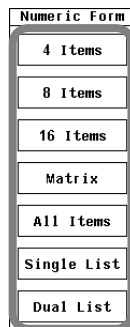


Selecting the Number of Displayed Items

2. Press **FORM** to display the Numeric Form menu.
3. Use the **cursor keys** to select one of the following options: 4 Items, 8 Items, 16 Items, Matrix, All Items, Single List, or Dual List.*
 - * Only appears on models with the harmonic measurement option.
4. Press **SET** to confirm the selected option.

You can also change the number of displayed items by pressing **NUMERIC**. Each time you press **NUMERIC**, the number of displayed items switches in this order: 4 Items > 8 Items > 16 Items > Matrix > All Items > Single List* > Dual List* > 4 Items > and so on.

* Only appears on models with the harmonic measurement option.



There are two ways to change the displayed measurement functions, elements, and wiring units.

- Using the function select menu
- Using **ITEM**.

Changing Displayed Items Using the Function Select Menu

You can change the display of elements; wiring units; functions U, I, P, S, Q, λ , ϕ , WP, q, TIME, FU, FI, and η ; and voltage and current modes using the function select menu.

- **Selecting the Item to Change**
 5. Clear any menus that are displayed (so that **SET** : change items appears in the upper left of the screen). For details, see section 1.3.
 6. Use the **cursor keys** to select the item that you want to change. The selected item is highlighted.
- **Changing a Measurement Function**
 7. Press **SET** to display the Change Item menu.
 8. Use the **cursor keys** to select a group of measurement functions you want to display from U/I/P, S/Q/ λ / ϕ , WP/q/Time, and FU/FI/ η .
 9. Each time you press **SET**, the display switches between the measurement functions in the selected group. For example, if U/I/P is selected, the measurement function that is displayed switches in this order each time you press SET: U > I > P.
- **Changing an Element or Wiring Unit**
 10. Use the **cursor keys** to select Element.
 11. The element or wiring unit will change each time you press **SET**.
- **Changing a Voltage or Current Mode**
 12. Use the **cursor keys** to select rms, mean, dc, rmean, or ac.
 13. The voltage or current mode will change each time you press **SET**.
This ends the description of how to change displayed items using the function select menu.



5.2 Displaying Numeric Data and Changing Displayed Items

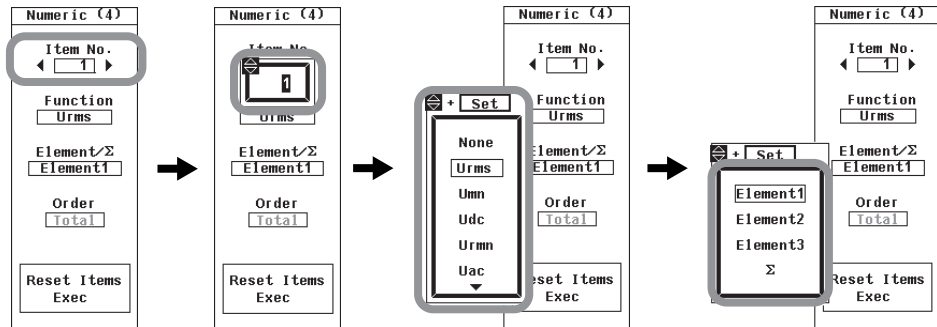
Changing Displayed Items Using the ITEM Key

5. Press **ITEM** to display the Numeric menu.
- **Selecting the Item to Change**
 6. Use the **cursor keys** to select Item No.
 7. Press **SET** to display the item selection box.
 8. Use the **cursor keys** to select the desired item. The selected item is highlighted.
 9. Press **SET** or **ESC** to close the item selection box.

Note

In steps 6 through 9, you can use the ◀ or ▶ key instead of SET.

- **Changing a Measurement Function**
 10. Use the **cursor keys** to select Function.
 11. Press **SET** to display the measurement function selection box.
 12. Use the **cursor keys** to select a measurement function.
 13. Press **SET**. The symbol for the selected measurement function appears in the highlighted area.
- **Changing an Element or Wiring Unit**
 14. Use the **cursor keys** to select Element/Σ.
 15. Press **SET** to display the element or wiring unit selection box.
 16. Use the **cursor keys** to select an element or wiring unit.
 17. Press **SET**. The element number or wiring unit symbol for the selected element or wiring unit appears in the highlighted area. This ends the description of how to change displayed items using menus.
 - * For instructions on how to change the harmonic orders of harmonic measurement functions, see section 6.2, “Changing Numeric Data Display Items.”



Scrolling through Displayed Pages

18. Use **PAGE▼** and **PAGE▲** to scroll through pages.
 - Press **PAGE▼** to display the next page.
 - Press **PAGE▲** to display the previous page.

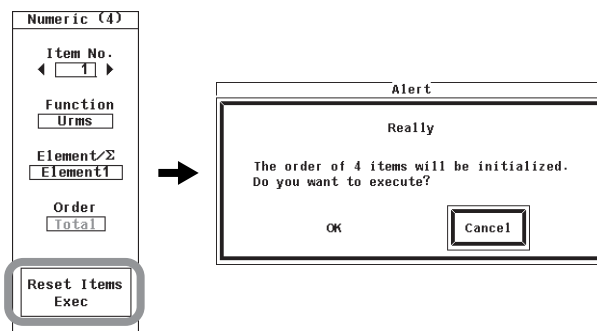
Jumping to the Last or First Page

19. Press **SHIFT+PAGE▼** or **SHIFT+PAGE▲** to jump to the first or last page.
 - Press **SHIFT+PAGE▼** to display the last page.
 - Press **SHIFT+PAGE▲** to display the first page.

Resetting the Displayed Item Order

1. Press **ITEM** to display the Numeric menu.
2. Use the **cursor keys** to select Reset Items Exec.
3. Press **SET**. An Alert dialog box appears.
4. Use the **cursor keys** to select OK or Cancel.
5. If you select OK and press **SET**, the orders of the displayed items on all pages will be reset.

If select Cancel and press **SET**, the order of the displayed items will not be reset.



Explanation

The following is an example of the numeric value display:

Displayed when the displayed item can be changed using the function select key. The item that can be changed is also highlighted.

The color changes from green to red if the input signal level exceeds approximately three or six times the specified measurement range when the crest factor is set to 3 or 6, respectively. The first and second lines correspond to voltage and current, respectively. The conditions of the input signals of elements 1 to 3 are displayed in numeric order from the left.

Page bar
The current page is highlighted. If page scrolling is possible using **PAGE▲** or **PAGE▼**, the top and bottom sections of the page bar show ▲/▼. If page scrolling is not possible, △/▽ is shown.

Data update count

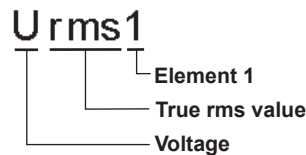
- The data update count is displayed under Update in the lower left corner of the screen.
- Press **HOLD** to hold the data update count. Press **HOLD** again to un-hold it.
- When the value exceeds 65535, it returns to zero.
- The data update count is reset to zero if the power is turned off or if a setting such as the measurement range or filter is changed.

Measurement Functions Used in Normal Measurement

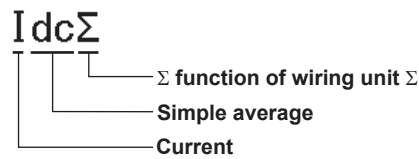
Displayed Measurement Function Symbols and Their Meanings

U (voltage Urms, Umn, Udc, Urmn, Uac)	I (Current Irms, Imn, Idc, Irmn, Iac)
P (active power)	S (apparent power)
Q (reactive power)	λ (power factor)
ϕ (phase difference)	fU/fl (or freqU/freqI; voltage/current frequency)
U+pk/U-pk (maximum/minimum voltage)	I+pk/I-pk (maximum/minimum current)
CfU/CfI (voltage/current crest factor)	WP (watt hour; sum of positive and negative watt hours)
WP+ (positive watt hours consumed)	WP- (negative watt hours returned to the power supply)
q (ampere hours; sum of positive and negative ampere hours)	q+ (positive ampere hours consumed)
q- (negative ampere hours returned to the power supply)	WS (volt-ampere hours)
WQ (var hours)	Time (integration time)
η 1 to η 2 (efficiency)	F1 to F8 (user-defined functions)
Δ F1 to Δ F4 (delta computation option)	

Example The True Rms Voltage of Element 1



Simple Average of the Currents of the Elements in Wiring Unit Σ



Note

“-----” or space is displayed if a measurement function is not selected or if there is no numeric data.

Displaying Numeric Data

Press NUMERIC to display numeric data.

Selecting the Number of Displayed Items

You can select the number of numeric data items that are displayed simultaneously from the choices below.

- 4 Items
Four numeric data values are displayed in one column.
- 8 Items
Eight numeric data values are displayed in one column.
- 16 Items
Sixteen numeric data values are displayed in two columns.
- Matrix/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 the WT500. In the Matrix display, the displayed items (measurement functions) can be changed. In the All Items display, the displayed items cannot be changed, so scroll through the pages to change the displayed items.
- Single List*
The numeric values of a single measurement function are displayed in two columns, with a total of 42 items listed on a page.
- Dual List*
The numeric values of two measurement functions are displayed in two separate columns, with a total of 22 items in each column.

* This item only appears on models with the harmonic measurement option. For instructions on how to change the displayed items in the Single List and Dual List displays, see chapter 6.

Note

- "-----" 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, "-OL-" (for over range) is displayed.
- If the voltage or current exceeds 140% of the measurement range, "-OL-" (for over range) is displayed for P.
- If the measured or computed result cannot be displayed using the specified decimal place or unit, "-OF-" (for overflow) is displayed.
- If Urms, Uac, Irms, or Iac is less than or equal to 0.5% (when the crest factor is set to 3, less than or equal to 1.0% if the crest factor is set to 6) or Umn, Urmn, Imn, or Irmn is less than or equal to 2% of the measurement range (when the crest factor is set to 3, less than or equal to 4% if the crest factor is set to 6), the values of Urms, Umn, Urmn, Irms, Imn, Irmn, and the measurement functions that are determined using these measurement functions are zero. The λ and ϕ functions will return errors ("Error" is displayed).
- 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, harmonic data is not measured, and "-----" (no data) is displayed. If this happens, decrease the data update rate. For example, if the fundamental frequency is 10 Hz (100-ms cycle), the analysis window width is 1 wave (see section 14.6 for details), and the data measurement interval is 100 ms. In this case, the time required for harmonic measurement is approximately 150 ms or greater (data measurement interval + data processing time). To measure and display harmonic data, set the data update rate to a value greater than or equal to 200 ms.
- If the measured frequency is outside the measurement range, the fU or fI function returns an error ("Error" is displayed).
- If the power factor λ is greater than 1 and less than or equal to 2, λ returns 1. ϕ returns zero.
- If λ is greater than 2, λ and ϕ return errors ("Error" is displayed).
- In the Matrix display, if you select a measurement function ($\eta 1$, $\eta 2$, or F1 to F8) that does not require an element or wiring unit, the data for that function appears in the Element 1 column.

5.2 Displaying Numeric Data and Changing Displayed Items

Changing a Measurement Function

- The types of measurement functions that can be selected are the functions described in “Types of Measurement Functions Used in Normal Measurement” and “Measurement Functions Used in Harmonic Measurement (Optional)” in section 2.2, in “User-Defined Functions” in section 2.5, in “Integration Functions” in section 2.6, and in “Delta Computation (Optional)” in section 5.17.
- You can also choose not to display a measurement function (None).
- The numbers (1, 2, 3, and 4) that are attached to delta computation measurement function symbols are a part of the symbols and have no relation to the element numbers.
- The numbers attached to user-defined functions F1 to F8 are a part of the measurement function symbols and are not related to the element numbers.

Changing the Element or Wiring Unit

- You can select the element/wiring unit from the choices below. The selectable items vary depending on the number of elements installed in the WT500. Element1, Element2, Element3, and Σ
- If there are no elements that are assigned to the selected wiring unit, because there is no numeric data, Σ measurement functions will display “-----” (no data).

U rms1	102.70	v		U rms1	102.49	v
I rms1	373.44	mA		I rms1	371.50	mA
P 1	24.73	w	Changing the measurement function of the third item	λ 1	0.6447	
S 1	38.35	VA		S 1	38.21	VA
			Changing the element of the third item	U rms1	102.86	v
				I rms1	379.32	mA
				P 2	20.02	w
				S 1	39.85	VA

Resetting the Displayed Item Order

You can reset the displayed item order to a preset order. For details about resetting, see appendix 2, “List of Initial Settings and Numeric Data Display Order.”

Note

- For the meanings of the displayed measurement function symbols, see section 2.2, “Measurement Functions and Measurement Periods”; section 2.5, “Computation”; section 2.6, “Integration”; and appendix 1, “Symbols and Determination of Measurement Functions.”
 - For instructions on how to change the displayed harmonic measurement function items, see chapter 6.
 - For information about wiring unit Σ , see section 4.2, “Selecting a Wiring System.”
-

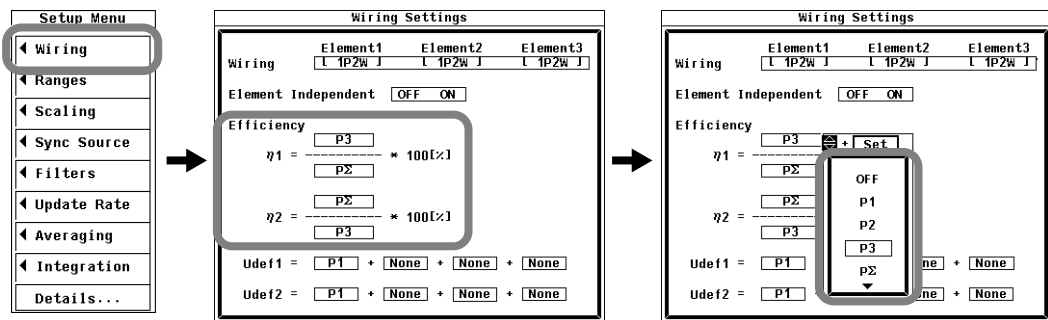
5.3 Setting the Equation for Efficiency

Procedure

1. Press **SETUP** to display the Setup menu.
2. Use the **cursor keys** to select Wiring.
3. Press **SET** to display the Wiring Settings menu.

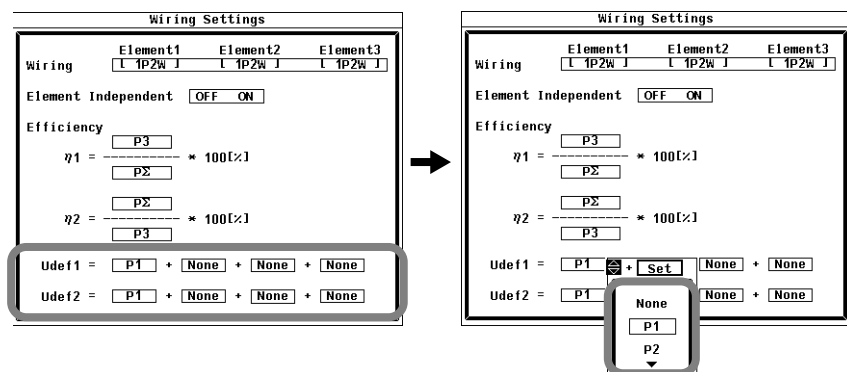
Setting the Equation for Efficiency

4. Use the **cursor keys** to set the numerator or denominator of the efficiency equation η_1 or η_2 .
5. Press **SET** to display the efficiency equation computation parameter selection box.
6. Use the **cursor keys** to select an efficiency computation parameter. To assign the sum of multiple parameters to the numerator or denominator of an equation, select Udef1 or Udef2.
7. Press **SET** to confirm.



Setting the Efficiency Computation Parameters

4. Press the **cursor keys** to set the operand of the equation to Udef1 or Udef2.
5. Press **SET** to display the computation parameter selection box.
6. Use the **cursor keys** to select a computation parameter.
7. Press **SET** to confirm the parameter.



5.3 Setting the Equation for Efficiency

Explanation

You can create an efficiency equation by combining measurement function symbols. The WT500 can determine the energy conversion efficiency of the device using the numeric values of the measurement functions.

Setting the Equation

Two efficiency equations (η_1 and η_2) can be defined by assigning the power of an element or the power of an Σ function as an operand. You can combine up to 4 terms in Udef1 and Udef2 to set the sum of multiple measurement function symbols as an operand of an equation.

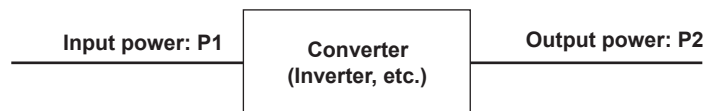
Equation Examples

- **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 equation: P_2/P_1



- **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 (P_Σ)

Efficiency equation: P_Σ/P_1

- **Efficiency of a Three-Phase, Three-Wire Input/Single-Phase, Two-Wire Output Device**

Input: Σ power of elements 1 and 2 (P_Σ)

Output: Power of element 3 (P3)

Efficiency equation: P_3/P_Σ

Note

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

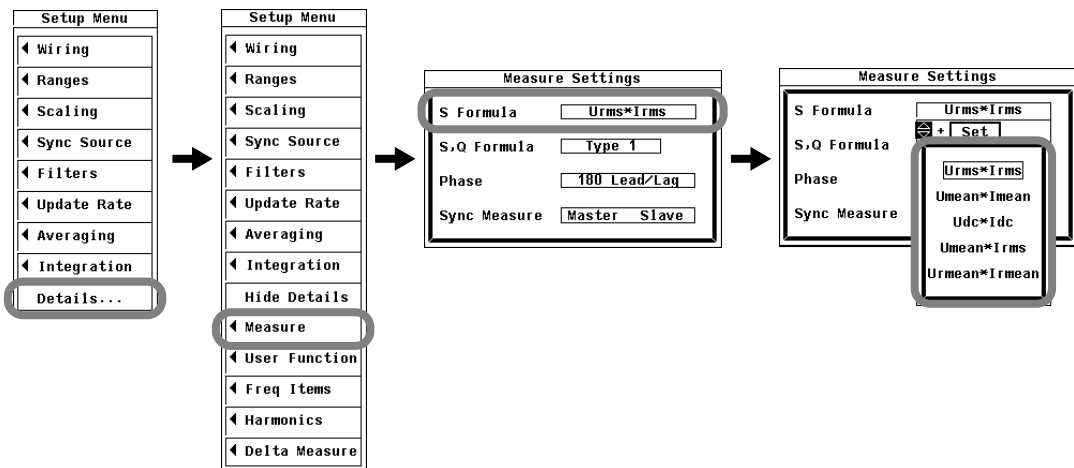
5.4 Setting the Equations for Apparent and Reactive Power

Procedure

1. Press **SETUP** to display the Setup menu.
If the full Setup menu does not appear, proceed to step 2. If the full Setup menu appears, proceed to step 4.
2. Use the **cursor keys** to select Details.
3. Press **SET** to display the full Setup menu.
4. Use the **cursor keys** to select Measure.
5. Press **SET** to display the Measure Settings dialog box.

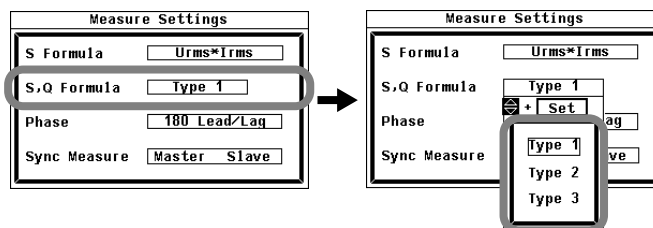
Selecting an Apparent Power Equation

6. Use the **cursor keys** to select S Formula.
7. Press **SET** to display the apparent power equation selection dialog box.
8. Use the **cursor keys** to select an apparent power equation.
9. Press **SET** to confirm the equation.



Selecting an Apparent Power and Reactive Power Equation

6. Use the **cursor keys** to select S,Q Formula.
7. Press **SET** to display the apparent power equation selection dialog box.
8. Use the **cursor keys** to select an apparent power equation.
* Type 3 only appears on models with the harmonic measurement option.
9. Press **SET** to confirm the equation.



Explanation

Selecting an Apparent Power Equation

In normal measurement, apparent power is the product of voltage times current. You can choose which normal measurement voltage function (Urms, Umean, Udc, Urmean) and current function (Irms, Imean, Idc, Irmean) the WT500 will multiply to determine the apparent power from one of the combinations below.

- **Urms*Irms**
The apparent power is determined from the product of the voltage and current true rms values.
- **Umean*Imean**
The apparent power is determined from the product of the voltage and current rectified mean values calibrated to the rms values.
- **Udc*Idc**
The apparent power is determined from the product of the voltage and current linear averages.
- **Umean*Irms**
The apparent power is determined from the product of the voltage's rectified mean value calibrated to the rms value and the current's true rms value.
- **Urmean*Irmean**
The apparent power is determined from the product of the voltage and current rectified mean values.

Selecting an Apparent Power and Reactive Power Equation

You can choose the equation for apparent and reactive power from one of the following three types. For details, see section 2.5.

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

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 three-phase, four-wire system	$Q_{\Sigma} = Q1 + Q2 + Q3$
- **Type 2**

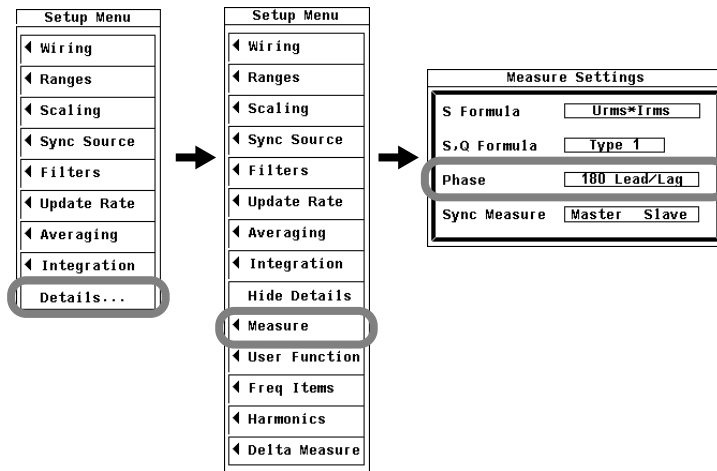
Active power for a three-phase, four-wire system	$P_{\Sigma} = P1 + P2 + P3$
Apparent power for a three-phase, four-wire system	$S_{\Sigma} = S1 + S2 + S3$ (= $U1 \times I1 + U2 \times I2 + U3 \times I3$)
Reactive power for a three-phase, four-wire system	$Q_{\Sigma} = \sqrt{S_{\Sigma}^2 - P_{\Sigma}^2}$
- **Type 3 (The method used in the harmonic measurement modes of the WT1600, the PZ4000, and the WT3000)**
This equation can be selected on models with the harmonic measurement option if harmonic measurement is proceeding properly. For an explanation of harmonic measurement, see chapter 6.

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	$Q_{\Sigma} = Q1 + Q2 + Q3$

5.5 Selecting a Phase Difference Display Format

Procedure

1. Press **SETUP** to display the Setup menu.
If the full Setup menu does not appear, proceed to step 2. If the full Setup menu appears, proceed to step 4.
2. Use the **cursor keys** to select Details.
3. Press **SET** to display the full Setup menu.
4. Use the **cursor keys** to select Measure.
5. Press **SET** to display the Measure Settings dialog box.
6. Use the **cursor keys** to select Phase.
7. Press **SET** to display the phase difference display format selection box.
8. Use the **cursor keys** to set the phase difference display format to 180 Lead/Lag or to 360 degrees.
9. Press **SET** to confirm the format selection.



5.5 Selecting a Phase Difference Display Format

Explanation

The phase difference ϕ between the voltage and current indicates the position of the current phase relative to the voltage of each element. You can select the phase display format from one of the choices below.

- 180 Lead/Lag
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 to 180° (see appendix 3 for details).
- 360 degrees
The phase difference is expressed as an angle between 0 and 360° in the clockwise direction.

Note

- If the measured voltage or current value is zero, "Error" is displayed.
 - When both the voltage and current signals are sinusoidal waves and the ratios of the voltage and current inputs with respect to the measurement range do not differ greatly, the phase difference ϕ lead and lag are still detected and displayed correctly.
 - If the computation result of power factor λ exceeds "1," ϕ is displayed as follows:
 - If the power factor 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).
 - The phase differences, ϕ_U and ϕ_I , of harmonic orders 1 to 50 of the voltage and current are always displayed using an angle between 0 and 180° (no sign for lead and negative sign for lag).
-

5.6 Integration

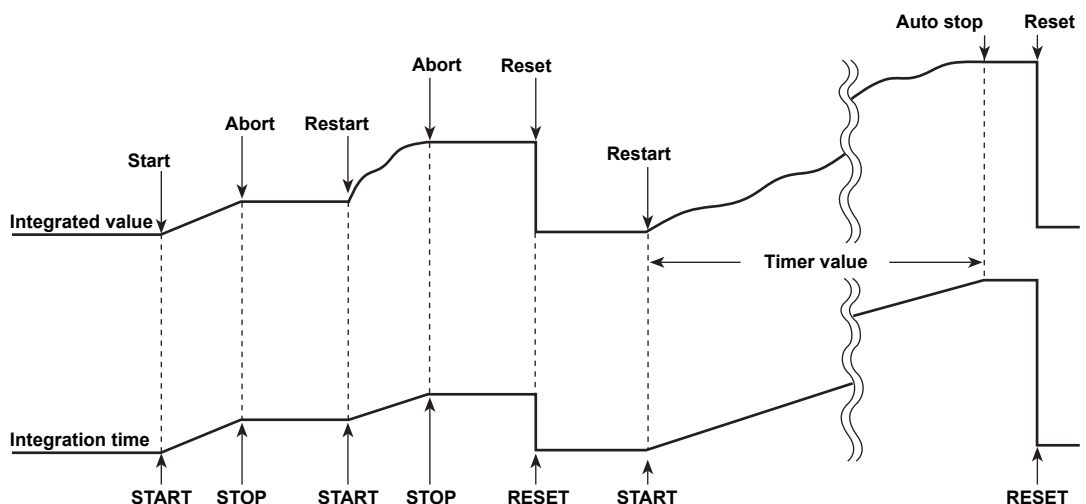
The integration feature has the following five modes.

Integration Mode	Start	Stop	Repetition	Reference
Manual integration mode A WT500 key is used to start/stop integration.	Key operation	Key operation	---	Section 5.7
Normal integration mode A WT500 key is used to start integration. Integration ends when a specified amount of time elapses.	Key operation	Stopped by the timer	---	Section 5.8
Continuous integration mode A WT500 key is used to start integration. Integration resets when a specified amount of time elapses. Integration repeats until you press STOP.	Key operation	Key operation	Repeats when the timer expires	Section 5.8
Real-time normal integration mode The integration start and end times are specified.	Date and time	Date and time	---	Section 5.9
Real-time continuous integration mode The integration start and end times are specified. Integration resets when a specified amount of time elapses.	Date and time	Date and time	Repeats when the timer expires	Section 5.9

For details on each integration mode, see section 2.6.

Starting, Stopping, and Resetting Integration

- You can start, stop, or reset integration by using the front panel keys or communication commands.
- The following figure shows the relationship between the integration operation and the actions of starting, stopping, and resetting. Pressing RESET after integration has stopped resets the integrated value and the integration time.



5.6 Integration

Integration-Related Display Indications

Normal Mode Uover: ■ ■ ■ Scaling: ■ LineFilt: ■ NULL: ■ YOKOGAWA ◆
 Iover: ■ ■ ■ Average: ■ FreqFilt: ■

☒ + [SET] : change items

U _{rms1}	102.70	v
I _{rms1}	373.44	mA
P ₁	24.73	W
S ₁	38.35	VA
Q ₁	29.32	var
λ ₁	0.6447	
φ ₁	G49.86	°
f _{U1}	50.021	Hz

Update 1371(500msec)

PAGE

Element1
 U1 300V Auto
 I1 500mA

Element2
 U2 1000V
 I2 40A

Element3
 U3 1000V
 I3 40A

Integ:Reset
 Time
 -----:--:--

Integ:Reset
 Displayed when the integrated value is reset and integration can be started.

Integ:Start
 Displayed, along with the elapsed integration time, when integration is in progress.

Integ:Stop
 Displayed, along with the elapsed integration time, when integration is aborted, canceled, or finished.

Integ:Ready
 Displayed when a ready state is entered in real-time integration mode.

Note

In addition to Reset, Start, Stop, and Ready, the following integration status indicators may also appear.

- TimeUp: When integration continues up to the time specified by the integration timer, it automatically stops. This integration status is referred to as the TimeUp status.
- Error: The WT500 stores and holds the integration result even when a power failure occurs while integration is in progress. When the power returns, integration is stopped, and the integration result calculated up to the point when the power failure occurred is displayed. This integration status is referred to as the Error status.

Displayed when the integration time is set to a non-zero value

☒ + [SET] : change items

U _{rms1}	102.64	v
I _{rms1}	373.18	mA
P ₁	24.966	W
λ ₁	0.6518	

PAGE

Element1
 U1 100V
 I1 500mA

Element2
 U2 100V
 I2 1A

Element3
 U3 100V
 I3 1A

Integ:Stop
 Time 0:00:13
 Timer 0:10:00

Elapsed integration time

Integration timer

Displayed during a ready state

Element1
 U1 100V
 I1 1A

Element2
 U2 100V
 I2 1A

Element3
 U3 100V
 I3 1A

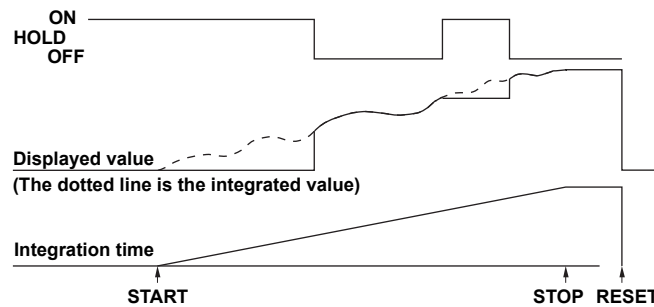
Integ:Ready
 Start Time
 2008/04/01
 00:00:00

Scheduled integration start time

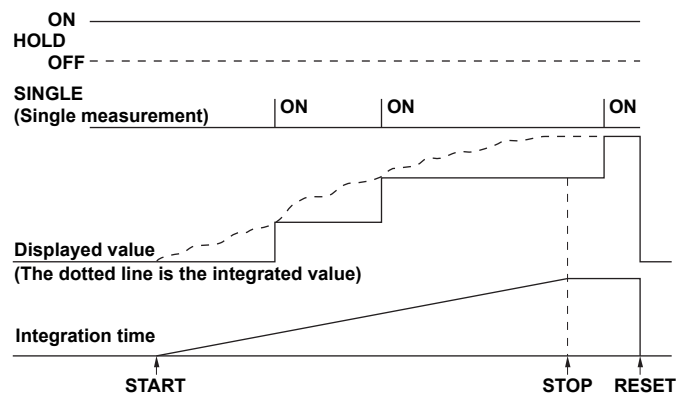
Holding, Starting, and Stopping Integration

When the display is held, the integration operation continues, but the display and transmission of the integration result are held. The relationship between the hold function and the start and end operations is as follows:

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



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



Sample Rate, and Valid Frequency Ranges for Integration

The sample rate is approximately 100 kHz. 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 50 kHz
Current	When integrating I_{rms}	DC or the lower frequency limit determined by the data update rate to approximately 50 kHz
	When integrating I_{mn}	DC or the lower frequency limit determined by the data update rate to approximately 50 kHz
	When integrating I_{dc}	DC to approximately 50 kHz
	When integrating I_{rmn}	DC or the lower frequency limit determined by the data update rate to approximately 50 kHz
	When integrating I_{ac}	The lower frequency limit determined by the data update rate to approximately 50 kHz

Display Resolution

The maximum display resolution for an integrated 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.

Display When Integration Overflow Occurs

If either of the conditions below is met, integration is stopped, 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 below.

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

Integration When the MAX Hold Feature Is Enabled

The integrated value is determined and displayed by summing the value that is measured at every display update rate, irrespective of the MAX hold feature (section 5.12 for details).

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

Integration is performed assuming a current of zero when the current input relative to the measurement range is as indicated below.

- **When the crest factor is set to 3**
When I_{rms} or I_{ac} is less than or equal to 0.5% or I_{mn} or I_{mnn} is less than or equal to 2%
- **When the crest factor is set to 6**
When I_{rms} or I_{ac} is less than or equal to 1.0% or I_{mn} or I_{mnn} is less than or equal to 4%

Backup When a Power Failure Occurs

- If a power failure occurs when integration is in progress, the integration result is held. When the power returns, integration stops, and the integration result calculated up to the point when the power failure occurred is displayed.
- After the power returns, you must reset integration to start it again.

Limitations on Modifying the Settings during Integration

When integration is in progress, the settings shown below cannot be changed.

Feature	Integration Operation Condition		
	Integration Reset	Integrating	Integration Suspended
Wiring system	Yes	No	No
Measurement range	Yes	No	No
Scaling	Yes	No	No
Filter	Yes	No	No
Averaging	Yes	No	No
Sync source	Yes	No	No
Hold	Yes	Yes	Yes
Single measurement	Yes	Yes	Yes
Data update rate	Yes	No	No
Display mode	Yes	Yes	Yes
Integration mode	Yes	No	No
Integration timer	Yes	No	No
Integration start	Yes	No	Yes
Integration stop	No	Yes	No
Integration reset	Yes	No	Yes
Storage (excluding integration synchronization mode)	Yes	Yes	Yes
Zero-level compensation	Yes	No	No
Null	Yes	No	No

- Yes: Settings can be changed.
- No: Settings cannot be changed.
- Starting integration in auto range mode switches the measurement range to fixed range mode.

Note

In addition to the settings and operations listed above, other settings and operations that affect integration (such as the self-test operation and date and time settings) cannot be performed. (Doing so will result in an error.)

Limitations on Waveform Display during Integration

- The trigger feature for waveform display does not work while integration is in progress or is suspended (see section 7.5 for details). Therefore, the signal level of the waveform display at the left end 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.

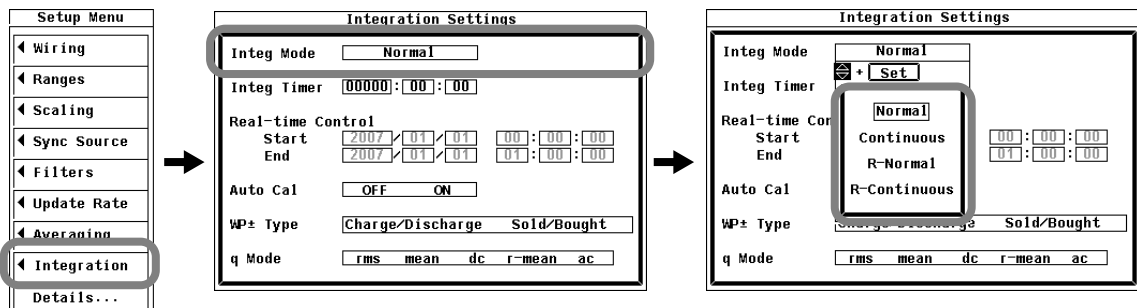
5.7 Setting Manual Integration

Procedure

1. Press **SETUP** to display the Setup menu.
2. Use the **cursor keys** to select Integration.
3. Press **SET** to display the Integration Settings menu.

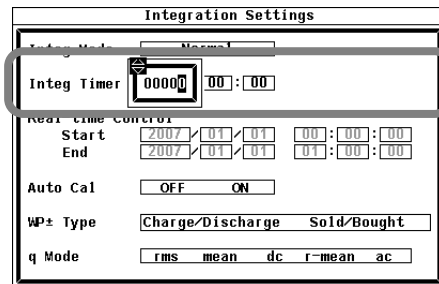
Selecting Normal Integration Mode

4. Use the **cursor keys** to select Integ Mode.
5. Press **SET** to display the integration mode selection box.
6. Use the **cursor keys** to select Normal.
7. Press **SET** to confirm the selection.



Setting the Integration Timer

8. Use the **cursor keys** to select one of the Integ Timer boxes (hour, minute, or second).
9. Press **SET** to display an entry box.
10. Use the **cursor keys** to set the hour, minute, or second that you selected in step 8 to zero.
11. Press **SET** or **ESC** to close the entry box.
12. Repeat steps 8 to 11 to set the hour, minute, and second to 00000:00:00.
13. Press **ESC** twice to close the entry box and the setup menu.



Integrating in Manual Integration Mode

- **Starting Integration**

14. Press **START/STOP**. The integration indicator changes to Start (displayed in green), and integration starts.

- **Holding Integration**

15. Press **HOLD**. The HOLD key lights, and the numeric data display is held. The WT500 continues the integration operation internally.

- **Un-Holding**

16. Press **HOLD** when the display is held. The HOLD key is no longer lighted, and the numeric data display is updated. While the display is held, you can execute a single measurement by pressing **SHIFT+HOLD (SINGLE)** to update the display.

- **Stopping Integration**

17. Press **START/STOP**. The integration indicator changes to Stop (displayed in red). The integration time and integrated value are held. You can press **START/STOP** again to resume integration.

- **Resetting Integration**

18. Press **SHIFT+START/STOP (RESET)**. The integration indicator changes to Reset, the integration time and integrated value are reset, and the displays for integration-related functions such as WP change to "-----" (no data).

Explanation

For an explanation of the integration feature, see section 2.6.

To perform manual integration, you must select the integration mode, set the integration timer to 00000:00:00, and then start integration.

Setting the Integration Mode/Integration Timer

In normal integration mode, when the integration timer is set to 00000:00:00, integration is performed in manual integration mode.

For information about integration, such as how to start, stop, and reset it, see the explanations in section 5.6.

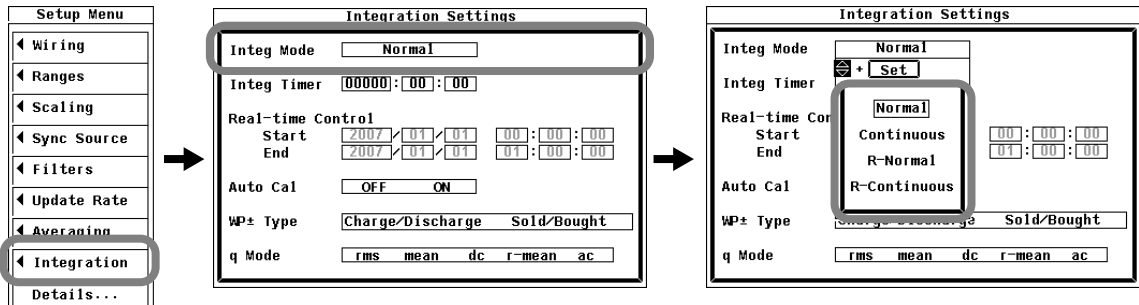
5.8 Setting Normal or Continuous Integration

Procedure

1. Press **SETUP** to display the Setup menu.
2. Use the **cursor keys** to select Integration.
3. Press **SET** to display the Integration Settings menu.

Selecting Normal or Continuous Mode

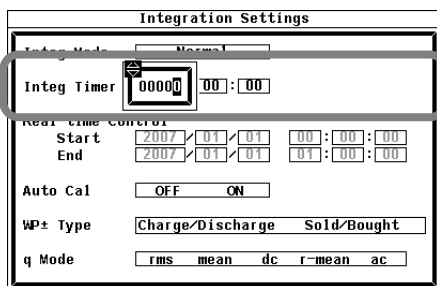
4. Use the **cursor keys** to select Integ Mode.
5. Press **SET** to display the integration mode selection box.
6. Use the **cursor keys** to select Normal or Continuous.
7. Press **SET** to confirm the selection.



5.8 Setting Normal or Continuous Integration

Setting the Integration Timer

8. Use the **cursor keys** to select one of the Integ Timer boxes (hour, minute, or second).
9. Press **SET** to display an entry box.
10. Use the **cursor keys** to set the hour, minute, or second that you selected in step 8.
11. Press **SET** or **ESC** to close the entry box.
12. Repeat steps 8 to 11 to set the hour, minute, and second.
13. Press **ESC** twice to close the entry box and the setup menu.



Integrating in Normal or Continuous Integration Mode

• Starting Integration

14. Press **START/STOP**. The integration indicator changes to Start (displayed in green), and integration starts.

• Holding Integration

15. Press **HOLD**. The HOLD key lights, and the numeric data display is held. Integration continues.

• Un-Holding

16. Press **HOLD** when the display is held. The HOLD key is no longer lighted, and the numeric data display is updated. While the display is held, you can execute a single measurement by pressing SHIFT+HOLD (SINGLE) to update the display.

• Stopping Integration

17. Press **START/STOP**. The integration indicator changes to Stop (displayed in red). The integration time and integrated value are held. If you press **START/STOP** before the integration timer expires and then press **START/STOP** again, integration will restart and continue until the timer expires.

In normal integration mode, once the integration timer expires, the integration indicator switches from Start, displayed in green, to TimeUp, displayed in red. The integration time and integrated value are held.

In continuous integration mode, once the integration timer expires, the integration time and integrated value are automatically reset, and integration continues until you press START/STOP.

• Resetting Integration

18. Press **SHIFT+START/STOP (RESET)**. The integration indicator changes to Reset, the integration time and integrated value are reset, and their displays change to "-----" (no data).

Explanation

For an explanation of the integration feature, see section 2.6.

For the WT500 to perform integration, you must set the parameters such as the integration mode and the integration timer, and then start integration.

Selecting Normal or Continuous Mode

There are two integration modes that allow you to set a length of time (using the timer) for which integration will take place. They are listed below.

- **Normal Integration Mode**

Integration continues until (1) the specified amount of time (which is determined by the timer setting) elapses, (2) you press START/STOP, or (3) the maximum or minimum displayable integrated value (see section 5.6 for details) is reached. When integration stops, the integration time and integrated value are held.

- **Continuous Integration Mode**

Integration continues for a specified amount of time, and then resets and starts again. Integration repeats until you press START/STOP. If the integrated value reaches its maximum or minimum displayable value before the specified amount of time has elapsed, integration is stopped, and the integration time and integrated value at that point are held.

Setting the Integration Timer

- You can set the timer hour, minute, and second within the following range.
00000 : 00 : 00 to 10000 : 00 : 00

Note

If you set the integration timer to 00000 : 00 : 00 in normal mode, the WT500 will integrate in manual mode (see sections 2.6 and 5.7 for details).

For information about integration, such as how to start, stop, and reset it, see the explanations in section 5.6.

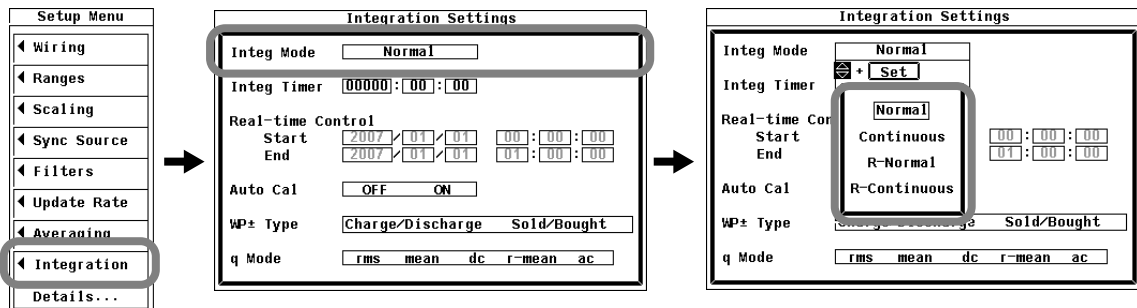
5.9 Setting Real-Time Integration or Real-Time Continuous Integration

Procedure

1. Press **SETUP** to display the Setup menu.
2. Use the **cursor keys** to select Integration.
3. Press **SET** to display the Integration Settings menu.

Selecting Real-Time Integration Mode (R-Normal) or Real-Time Continuous Integration Mode (R-Continuous)

4. Use the **cursor keys** to select Integ Mode.
5. Press **SET** to display the integration mode selection box.
6. Use the **cursor keys** to select R-Normal or R-Continuous.
7. Press **SET** to confirm the selection.



Setting the Integration Timer

8. Use the **cursor keys** to select one of the Integ Timer boxes (hour, minute, or second).
9. Press **SET** to display an entry box.
10. Use the **cursor keys** to set the hour, minute, or second that you selected in step 8.
11. Press **SET** or **ESC** to close the entry box.
12. Repeat steps 8 to 11 to set the hour, minute, and second.

The screenshot shows the 'Integration Settings' menu. The 'Integ Mode' is set to 'Normal'. The 'Integ Timer' field is highlighted with a cursor, showing '00000' and ':00:00'. Below it, the 'Real-time Control' section shows 'Start' and 'End' times set to '2007/01/01 00:00:00' and '2007/01/01 01:00:00' respectively. The 'Auto Cal' is set to 'OFF', 'WP± Type' is 'Charge/Discharge', and 'q Mode' is 'rms mean dc r-mean ac'.

Setting the Scheduled Start and End Times

13. Use the **cursor keys** to select one of the Real-time Control integration start time boxes (year, month, day, hour, minute, or second).
14. Press **SET** to display an entry box.
15. Use the **cursor keys** to set the year, month, date, hour, minute, or second that you selected in step 13.
16. Press **SET** or **ESC** to close the entry box.
17. Repeat steps 13 to 16 to set the year, month, date, hour, minute, and second.
18. Use the **cursor keys** to select one of the Real-time Control integration end time boxes (year, month, day, hour, minute, or second).
19. Repeat steps 14 to 17 to set the year, month, date, hour, minute, and second.
20. Press **ESC** twice to close the entry box and the setup menu.

The screenshot shows the 'Integration Settings' menu. The 'Integ Mode' is set to 'R-Normal'. The 'Integ Timer' field shows '00000:00:00'. The 'Real-time Control' section is highlighted with a cursor, showing 'Start' and 'End' times set to '2007/01/01 00:00:00' and '2007/01/01 01:00:00' respectively. The 'Auto Cal' is set to 'OFF', 'WP± Type' is 'Charge/Discharge', and 'q Mode' is 'rms mean dc r-mean ac'.

Integrating in Real-Time Integration Mode or Real-Time Continuous Integration Mode

- **Starting Integration**

21. Press **START/STOP**. The integration indicator changes to Ready (displayed in yellow), and the WT500 is ready to integrate. When the scheduled integration start time is reached, the integration indicator changes to Start (displayed in green), and integration starts.

- **Holding Integration**

22. Press **HOLD**. The HOLD key lights, and the numeric data display is held. Integration continues.

- **Un-Holding**

23. Press **HOLD** when the display is held. The HOLD key is no longer lighted, and the numeric data display is updated. While the display is held, you can execute a single measurement by pressing **SHIFT+HOLD (SINGLE)** to update the display.

- **Stopping Integration**

24. Press **START/STOP**. The integration indicator changes to Stop (displayed in red). The integration time and integrated value are held. If you press **START/STOP** before the scheduled integration end time is reached and then press **START/STOP** again, integration will restart and continue until the scheduled integration end time is reached.

In real-time integration mode, once the scheduled integration end time is reached, the integration indicator switches from Start, displayed in green, to Stop, displayed in red. The integration time and integrated value are held.

In real-time continuous integration mode, once the integration timer expires, the integration time and integrated value are automatically reset, and integration continues until you press **START/STOP** or until the scheduled integration end time is reached.

- **Resetting Integration**

25. Press **SHIFT+START/STOP (RESET)**. The integration indicator changes to Reset, the integration time and integrated value are reset, and their displays change to "-----" (no data).

Explanation

For an explanation of the integration feature, see section 2.6.

To perform integration, you must set the integration mode, the integration timer, and the integration start and stop times, and then start integration.

Selecting Real-Time Integration Mode or Real-Time Continuous Integration Mode

There are two integration modes that allow you to set integration start and end times between which integration takes place. They are listed below:

- **Real-Time Integration Mode**
You specify the dates and times when integration will start and end. Integration stops when (1) the specified stop time is reached, (2) the timer expires before the specified stop time is reached, (3) the maximum integration time of 10000 hours is exceeded, or (4) the maximum or minimum displayable integrated value (see section 5.6 for details) is reached. The integration time and integrated value at that point are held.
- **Real-Time Continuous Integration Mode**
You specify the dates and times when integration will start and end and the duration of the integration timer. Integration repeats within the start and end times at the interval specified by the timer. When the amount of time specified by the timer elapses, integration resets and starts again. When the specified stop time is reached, or when the integrated value reaches its maximum or minimum displayable value, integration is stopped, and the integration time and integrated value at that point are held.

Setting the Integration Timer

- You can set the timer hour, minute, and second within the following range.
00000 : 00 : 00 to 10000 : 00 : 00

Note

If you set the integration timer to 00000 : 00 : 00 in real-time integration mode, the WT500 starts integration at the specified start time, and integration stops when (1) the specified stop time is reached, (2) the maximum integration time of 10000 hours is exceeded, or (3) the maximum or minimum displayable integrated value is reached. The integration time and integrated value at that point are held.

Setting the Scheduled Start and End Times

You can set the year, month, day, hour, minute, and second of the integration start and end times. Be sure to set the integration end time to a time after the integration start time. The start and end times can be set within the following ranges:

Year: Any four-digit Gregorian calendar value
Hour:Minute:Second 00:00:00 to 23:59:59

Note

- You can set the day for the scheduled start or end time in February to a value as high as the 31st day. If you do so, an error message appears when integration is executed (see section 5.8 for details). Reset the scheduled start or end time.
- The WT500 recognizes leap years when it executes the integration operation.

For information about integration, such as how to start, stop, and reset it, see the explanations in section 5.6.

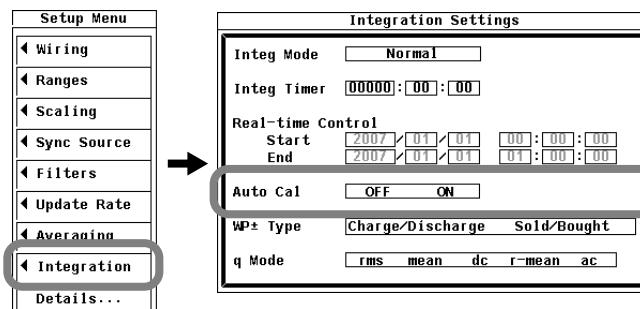
5.10 Turning Integration Auto Calibration On or Off

Procedure

1. Press **SETUP** to display the Setup menu.
2. Use the **cursor keys** to select Integration.
3. Press **SET** to display the Integration Settings menu.

Selecting Whether or Not to Use Integration Auto Calibration

4. Use the **cursor keys** to select Auto Cal.
5. Press **SET** to select ON or OFF.



Explanation

Turning Integration Auto Calibration On or Off

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

Note

When integration auto calibration is on and zero-level compensation is in progress, the power or current value measured immediately before is integrated.

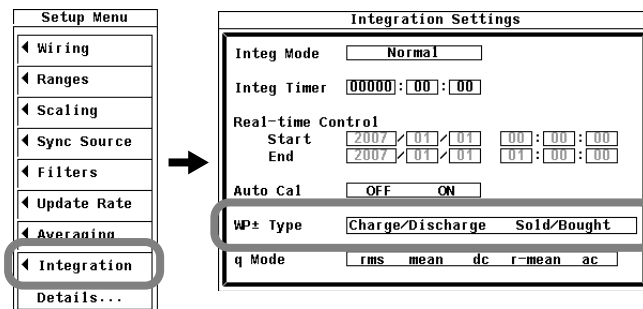
5.11 Selecting a Watt Hour Integration Method for Each Polarity

Procedure

1. Press **SETUP** to display the Setup menu.
2. Use the **cursor keys** to select Integration.
3. Press **SET** to display the Integration Settings menu.

Selecting a Watt Hour Integration Method for Each Polarity

4. Use the **cursor keys** to select WP±Type.
5. Press **SET** to select either Charge/Discharge or Sold/Bought.



Explanation

Selecting a Watt Hour Integration Method for Each Polarity

You can set the integration method for WP+ and WP- to one of the choices listed below.

- Charge/Discharge: Measure DC watt hours by polarity (integrate sampled values).
- Sold/Bought: Measure AC watt hours by polarity (integrate the values at each data update interval).

For the equations that correspond to these integration methods, see section 2.6.

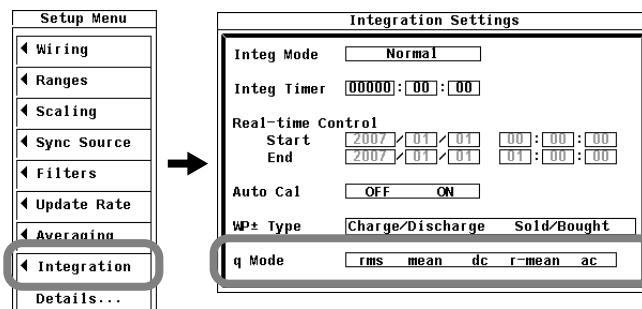
5.12 Selecting a Current Integration Mode

Procedure

1. Press **SETUP** to display the Setup menu.
2. Use the **cursor keys** to select Integration.
3. Press **SET** to display the Integration Settings menu.

Selecting a Current Integration Mode

4. Use the **cursor keys** to select q Mode.
5. Press **SET** to select rms, mean, dc, r-mean, or ac.



Explanation

Selecting a Current Integration Mode

You can select the type of current whose values will be integrated from one of the choices listed below. For the integration methods that correspond to these different current types, see section 2.6.

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

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

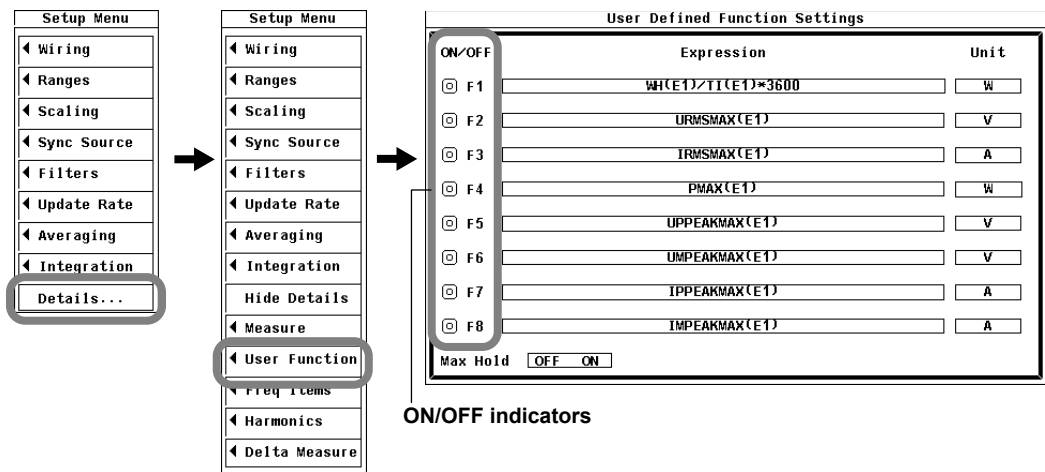
5.13 Setting User-Defined Functions

Procedure

1. Press **SETUP** to display the Setup menu.
If the full Setup menu does not appear, proceed to step 2. If the full Setup menu appears, proceed to step 4.
2. Use the **cursor keys** to select Details.
3. Press **SET** to display the full Setup menu.
4. Use the **cursor keys** to select User Function.
5. Press **SET** to display the User-Defined Function Settings dialog box.

Selecting Whether or Not to Compute a User-Defined Function

6. Use the **cursor keys** to select the user-defined function that you want to set.
7. Press **SET** to select ON or OFF. If you select ON, the ON/OFF indicator lights.



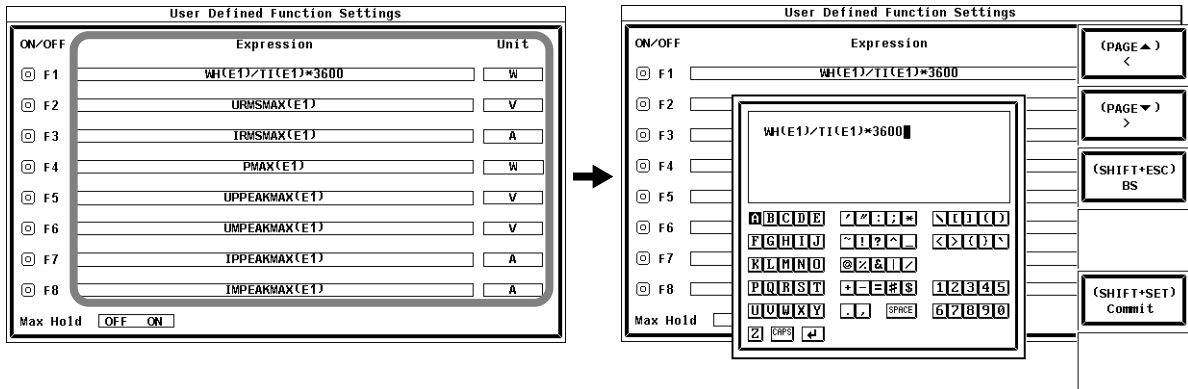
5.13 Setting User-Defined Functions

Setting the Equation

8. Use the **cursor keys** to select the Expression of the user-defined function that you want to compute.
9. Press **SET**. A keyboard appears on the screen.
10. Use the **keyboard** to set the equation.
For instructions on how to use the keyboard, see section 3.14, "Entering Values and Character Strings."

Setting the Unit

11. Use the **cursor keys** to select the Unit of the user-defined function that you want to compute.
12. Press **SET**. A keyboard appears on the screen.
13. Use the keyboard to set the unit.
For instructions on how to use the keyboard, see section 3.14, "Entering Values and Character Strings."



Explanation

You can combine function symbols to create equations and use the numeric data of the combined functions to determine the value of the equation. It is convenient to use a USB keyboard when entering multiple equations or particularly long equations.

Turning the Computation of a User-Defined Function On or Off

You can choose to turn the computation of the selected user-defined function on or off.

- ON (The ON/OFF indicator lights)
The function is computed.
- OFF (The ON/OFF indicator does not light)
The function is not computed.

Setting the Unit

- String Length
Up to eight characters. Not all eight characters can be displayed in the numeric display. The number of characters that can be displayed in the numeric display varies depending on the number of displayed items (see section 5.1 for details).
- Usable Characters
Spaces and all characters that are displayed on the keyboard

Equation Types

Combinations of measurement functions and element numbers (e.g., Urms1) can be used as operands to create up to eight equations (F1 to F8). There can be up to 16 operands in one equation. Some operands cannot be computed in measurement modes other than normal measurement mode. For details, see appendix 12.

- **Measurement Functions That Can Be Computed**

The operators for the measurement functions are shown below in this format:

measurement function: operand.

Urms:URMS()	Umn: UMN()	Udc: UDC()
Urmn: URMN()	Uac: UAC()	
Irms: IRMS()	Imn: IMN()	Idc: IDC()
Irmn: IRMN()	Iac: IAC()	
P: P()	S: S()	Q: Q()
λ : LAMBDA()	ϕ : PHI()	fU: FU()
fI: FI()	U+pk: UPPK()	U-pk: UMPK()
I+pk: IPPK()	I-pk: IMPK()	CfU: CFU()
CfI: CFI()	η 1: ETA1()	η 2: ETA2()
Wp: WH()	Wp+: WHP()	Wp-: WHM()
q: AH()	q+: AHP()	q-: AHM()
WS: SH()	WQ: QH()	Time: TI()
F1: F1()	F2: F2()	F3: F3()
F4: F4()	F5: F5()	F6: F6()
F7: F7()	F8: F8()	

- **The following measurement functions can be computed on models with the delta computation option.**

Δ F1rms(): DELTAF1RMS()	Δ F1mn(): DELTAF1MN()	Δ F1dc(): DELTAF1DC()
Δ F2rms(): DELTAF2RMS()	Δ F2mn(): DELTAF2MN()	Δ F2dc(): DELTAF2DC()
Δ F3rms(): DELTAF3RMS()	Δ F3mn(): DELTAF3MN()	Δ F3dc(): DELTAF3DC()
Δ F4rms(): DELTAF4RMS()	Δ F4mn(): DELTAF4MN()	Δ F4dc(): DELTAF4DC()
Δ F1rmn(): DELTAF1RMN()	Δ F1ac(): DELTAF1AC()	
Δ F2rmn(): DELTAF2RMN()	Δ F2ac(): DELTAF2AC()	
Δ F3rmn(): DELTAF3RMN()	Δ F3ac(): DELTAF3AC()	
Δ F4rmn(): DELTAF4RMN()	Δ F4ac(): DELTAF4AC()	

- **The following measurement functions can be computed on models with the harmonic measurement option.**

ϕ U: UPHI(,)	ϕ I: IPHI(,)	Uhdf: UHDF(,)
Ihdf: IHDF(,)	Phdf: PHDF(,)	U_k: UK(,)
I_k: IK(,)	P_k: PK(,)	S_k: SK(,)
Q_k: QK(,)	λ _k: LAMBDK(,)	ϕ _k: PHIK(,)
Uthd: UTHD()	Ithd: ITHD()	Pthd: PTHD()
ϕ U1-U2: PHIU1U2()	ϕ U1-U3: PHIU1U3()	ϕ U1-I1: PHIU1I1()
ϕ U1-I2: PHIU1I2()	ϕ U1-I3: PHIU1I3()	

Setting Operand Parameters

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

- Setting parameters for functions followed by “(,)”
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 used to represent elements
E1 to E3: Element 1 to element 3
E4: Σ
 - Symbols used to represent harmonic orders*
ORT: Total
OR0: DC
OR1: Fundamental signal
OR2 to OR50: Harmonics
- * The harmonic measurement feature (optional) is required.
- Setting parameters for functions followed by “()”
Specify the element. You do not need to specify a harmonic order. For example: (E1).

For information about the symbols that can be used in the parameters of each operand, see appendix 7.

Values Substituted in Operands

- The substituted value of Tl() is the same regardless of which element symbol (E1 to E3) is used in Tl(). The unit of Tl values is seconds.
- The U1 in PHIU1U2 represents the voltage signal of the element whose element number is the smallest in the wiring unit (Σ). For example, if input elements 2 and 3 are assigned to wiring unit Σ , PHIU1U2 is the phase difference between the voltage signals of input elements 2 and 3.

- User-defined functions allow you to determine physical values other than those of the measurement functions by combining operands. Only power measurement functions can be assigned to the efficiency equation (see section 5.3 for details). However, by using user-defined functions, you can create equations consisting of measurement functions other than power measurement functions to determine ratios other than efficiency.

On the WT500, user-defined equations can use other user-defined equations with smaller numbers as operands. For example, the equation for user-defined function F3 can be set to F1() + F2(). This allows equations that would otherwise exceed 50 characters in length to be computed. This can be accomplished by for example setting equations in F1 and F2, and then adding or dividing those equations in F3. This feature is also convenient when defining multiple equations 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 equation 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 computed result will be displayed as “-----” (no data) or “Error.”

- **Operators**

The following operators can be used in equations.

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 log
LOG10	LOG10(U(E1,OR25))	Common log
EXP	EXP(U(E1,OR12))	Exponent
NEG	NEG(U(E1,OR12))	Negation

Usable Characters and Maximum String Lengths in Equations

- **String Length**
Up to 50 characters.
- **Usable Character Types**
Spaces and all characters that are displayed on the keyboard

- **Equation Examples**

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

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

$$\text{SQRT}(\text{SQR}(\text{U}(\text{E1},\text{ORT})) - \text{SQR}(\text{U}(\text{E2},\text{OR1})))$$

Note

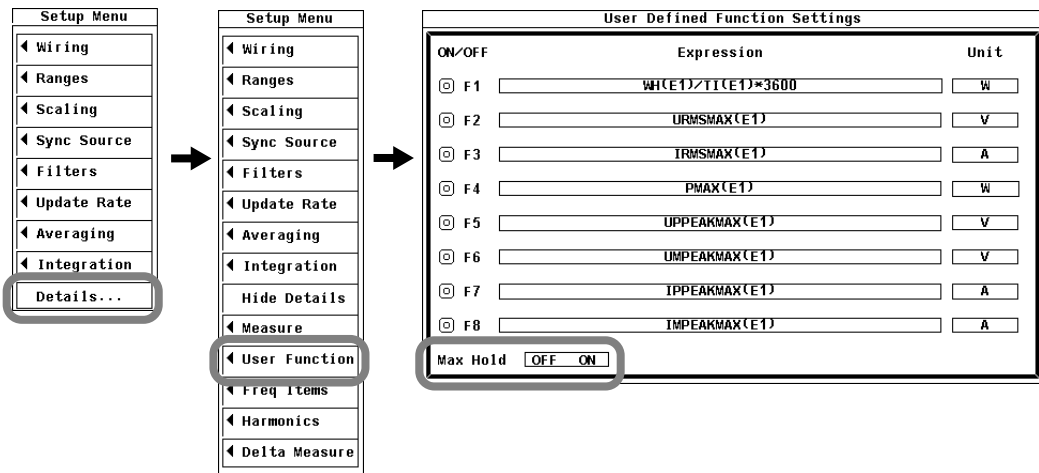
If an operand in an equation is undetermined, the computed result is displayed as “-----” (no data). This occurs when a delta computation measurement function is in the equation, but delta computation is turned OFF, or when a measurement function of an element that is not installed is in the equation.

5.14 Setting the MAX Hold Feature

Procedure

Selecting Whether or Not to Use the MAX Hold Feature in the Numeric Data Display

1. Press **SETUP** to display the Setup menu.
If the full Setup menu does not appear, proceed to step 2. If the full Setup menu appears, proceed to step 4.
2. Use the **cursor keys** to select Details.
3. Press **SET** to display the full Setup menu.
4. Use the **cursor keys** to select User Function.
5. Press **SET** to display the User-Defined Function Settings dialog box.
6. Use the **cursor keys** to select Max Hold.
7. Press **SET** to select ON or OFF.



Explanation**MAX Hold**

The maximum value of a type of numeric data can be held.

- You can determine the type of data whose maximum value will be held using a user-defined function. The operators for the measurement functions are shown below in this format: *measurement function: equation for defining the MAX hold.*

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

* To hold the MAX value of Urms, enter URMSMAX() in the equation for the user-defined function.

One symbol from E1 to E4 (Σ) can be entered between the parentheses of these functions: URMSMAX(), UMEANMAX(), UDCMAX(), URMEANMAX(), UACMAX(), IRMSMAX(), IMEANMAX(), IDCMAX(), IRMEANMAX(), and IACMAX().

- One symbol from E1 to E4 (Σ) can be entered between the parentheses of these functions: PMAX(), SMAX(), and QMAX().
- One symbol from E1 to E4 (Σ) can be entered between the parentheses of these functions: URMSMAX() and UMEANMAX().
- One symbol from E1 to E3 can be entered between the parentheses of the functions including and between UPPEAKMAX() to IMPEAKMAX().
- The maximum values of the data above are held while the MAX hold function is enabled.
- The values in numeric value lists and transmitted values are also held at their maximum levels.

Note

- When MAX hold functions have positive and negative values, the absolute values are compared to determine the maximum value.
- To reset held maximum values, turn MAX hold off, and then turn it on again.

5.15 Measuring the Average Active Power

Explanation

The equation for computing the average active power is specified using a user-defined function as follows:

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

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

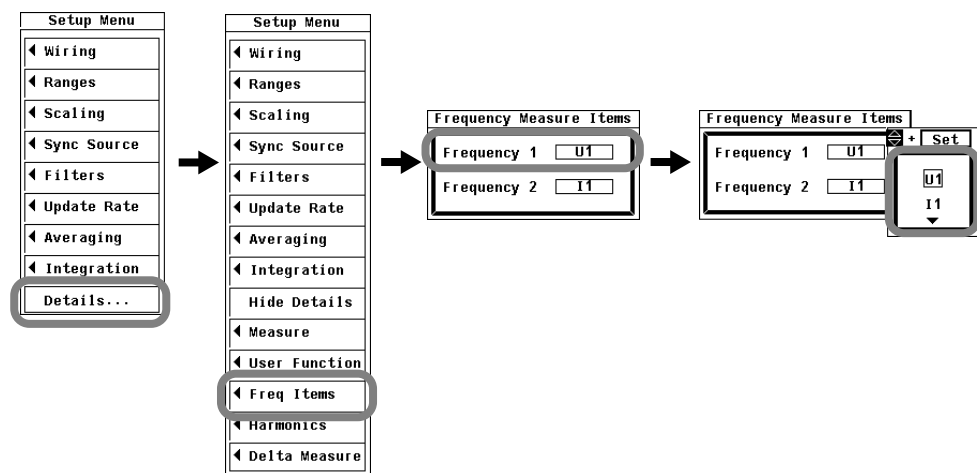
```
WH(E1)/(TI(E1)*3600)
```

The unit of TI values is seconds. For instructions on how to set user-defined functions, see section 5.13.

5.16 Selecting What Frequency to Measure

Procedure

1. Press **SETUP** to display the Setup menu.
If the full Setup menu does not appear, proceed to step 2. If the full Setup menu appears, proceed to step 4.
2. Use the **cursor keys** to select Details.
3. Press **SET** to display the full Setup menu.
4. Use the **cursor keys** to select Freq Items.
5. Press **SET** to display the Frequency Measure Items dialog box.
Only the input signals of installed elements appear.
6. Use the **cursor keys** to select Frequency1 or Frequency2.
7. Press **SET** to display the frequency selection box.
8. Use the **cursor keys** to select the input signal that you want to measure the frequency of.
9. Press **SET** to confirm the selection.



Explanation

You can measure two of the input element signal frequencies.

However, on models with the frequency measurement add-on option, the frequencies of all elements can be measured, so there is no need to set which input signals to measure. On those models, the Freq Items menu option will not appear when you press SETUP.

Note

- If the frequency measurement is not stable due to noise, try using the frequency filter explained in section 4.8.
- The frequency cannot be detected if the AC amplitude is small. For information about detectable frequency levels, see “Accuracy” under “Frequency Measurement” in section 14.6, “Functions.”
- The measured data for the frequencies of input signals whose frequencies are not measured is displayed as “-----” (no data).

5.17 Setting Delta Computation (Optional)

Procedure

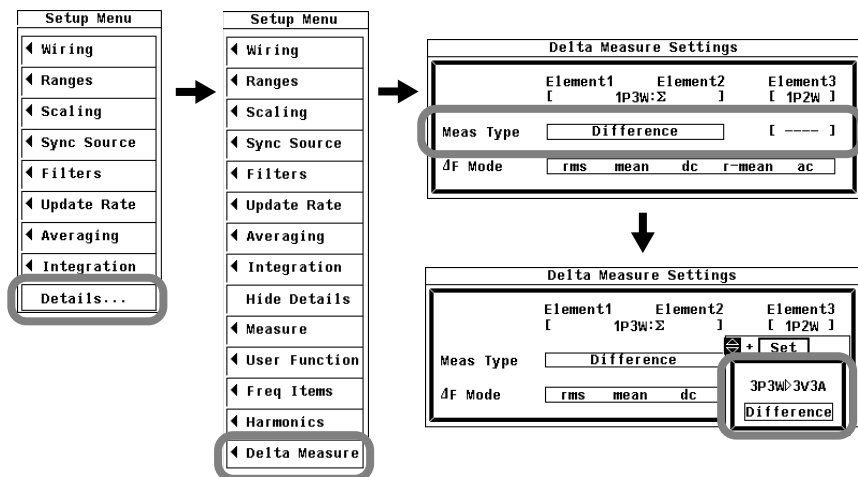
Selecting the Target Wiring Unit for Delta Computation

For information about selecting a wiring unit, see section 4.2, "Selecting a Wiring System."

(Depending on the wiring system, this operation may not be necessary.)

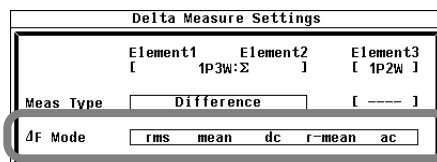
Selecting a Delta Computation Type

1. Press **SETUP** to display the Setup menu.
If the full Setup menu does not appear, proceed to step 2. If the full Setup menu appears, proceed to step 4.
2. Use the **cursor keys** to select Details.
3. Press **SET** to display the full Setup menu.
4. Use the **cursor keys** to select Delta Measure.
5. Press **SET** to display the Delta Measure Settings dialog box.
6. Use the **cursor keys** to select Meas Type.
(The menu varies depending on the wiring system.)
7. Press **SET** to confirm the selection.



Selecting a Delta Computation Mode

8. Use the **cursor keys** to select ΔF Mode.
9. Press **SET** to set the delta computation mode to rms, mean, dc, r-mean, or ac.



Explanation

In the normal measurement of U and I, the sum or difference of the instantaneous values (sampled data) of the voltage or current between the elements assigned to the target wiring unit for delta computation can be used to determine the measurement functions, ΔU and ΔI . This operation is called delta computation. For information about the equations involved, see appendix 10. The measurement period is the same as that described in “Measurement Period” in section 2.2, “Measurement Functions and Periods.”

Selecting the Delta Computation Type

You can select the delta computation type from the choices below. The selectable items vary depending on the selected wiring system.

Wiring System	Selectable delta computation types
1P3W	Difference or 3P3W>3V3A
3P3W	Difference or 3P3W>3V3A
3P4W	Star>Delta
3P3W(3V3A)	Delta>Star

- **Difference**

Computes the differential voltage and differential current between two elements.

When Difference is specified for wiring unit Σ

$\Delta F1_{rms}[U_{diff}]$, $\Delta F1_{mn}[U_{diff}]$, $\Delta F1_{dc}[U_{diff}]$, $\Delta F1_{rmn}[U_{diff}]$, $\Delta F1_{ac}[U_{diff}]$

$\Delta F2_{rms}[I_{diff}]$, $\Delta F2_{mn}[I_{diff}]$, $\Delta F2_{dc}[I_{diff}]$, $\Delta F2_{rmn}[I_{diff}]$, $\Delta F2_{ac}[I_{diff}]$

* rms, mn, dc, rmn, and ac are delta computation modes (see the next page).

- **3P3W>3V3A**

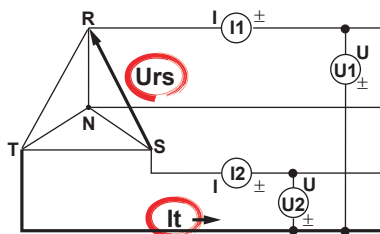
The data of a three-phase, three-wire system (3P3W) is converted to the data of a three-phase, three-wire system with a three-voltage, three-current method (3V3A).

When 3P3W>3V3A is specified for wiring unit Σ

$\Delta F1_{rms}[U_{rs}]$, $\Delta F1_{mn}[U_{rs}]$, $\Delta F1_{dc}[U_{rs}]$, $\Delta F1_{rmn}[U_{rs}]$, $\Delta F1_{ac}[U_{rs}]$

$\Delta F2_{rms}[I_t]$, $\Delta F2_{mn}[I_t]$, $\Delta F2_{dc}[I_t]$, $\Delta F2_{rmn}[I_t]$, $\Delta F2_{ac}[I_t]$

* rms, mn, dc, rmn, and ac are delta computation modes (see the next page).



- **Star>Delta**

Using the data from a three-phase, four-wire system, the data of a delta connection is computed from the data of a star connection (star-delta transformation).

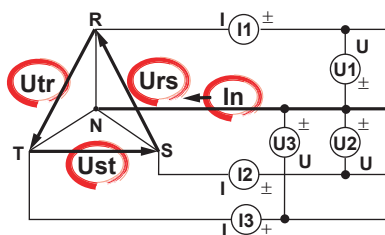
$\Delta F1_{rms}[U_{rs}]$, $\Delta F1_{mn}[U_{rs}]$, $\Delta F1_{dc}[U_{rs}]$, $\Delta F1_{rmn}[U_{rs}]$, $\Delta F1_{ac}[U_{rs}]$

$\Delta F2_{rms}[U_{st}]$, $\Delta F2_{mn}[U_{st}]$, $\Delta F2_{dc}[U_{st}]$, $\Delta F2_{rmn}[U_{st}]$, $\Delta F2_{ac}[U_{st}]$

$\Delta F3_{rms}[U_{tr}]$, $\Delta F3_{mn}[U_{tr}]$, $\Delta F3_{dc}[U_{tr}]$, $\Delta F3_{rmn}[U_{tr}]$, $\Delta F3_{ac}[U_{tr}]$

$\Delta F4_{rms}[I_n]$, $\Delta F4_{mn}[I_n]$, $\Delta F4_{dc}[I_n]$, $\Delta F4_{rmn}[I_n]$, $\Delta F4_{ac}[I_n]$

* rms, mn, dc, rmn, and ac are delta computation modes.



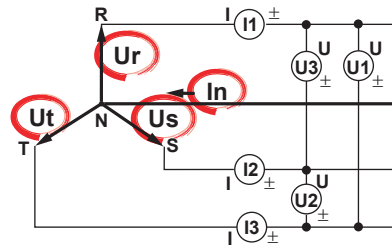
5.17 Setting Delta Computation (Optional)

- **Delta>Star**

Using the data from a three-phase, three-wire system that uses a three-voltage, three-current method, the data of a star connection is computed from the data of a delta connection (delta-star transformation). The center of the star connection is computed as the center of the delta connection. If the actual center of the star connection does not match the center of the delta connection, an error results.

$\Delta F1_{rms}[U_r]$, $\Delta F1_{mn}[U_r]$, $\Delta F1_{dc}[U_r]$, $\Delta F1_{rmn}[U_r]$, $\Delta F1_{ac}[U_r]$
 $\Delta F2_{rms}[U_s]$, $\Delta F2_{mn}[U_s]$, $\Delta F2_{dc}[U_s]$, $\Delta F2_{rmn}[U_s]$, $\Delta F2_{ac}[U_s]$
 $\Delta F3_{rms}[U_t]$, $\Delta F3_{mn}[U_t]$, $\Delta F3_{dc}[U_t]$, $\Delta F3_{rmn}[U_t]$, $\Delta F3_{ac}[U_t]$
 $\Delta F4_{rms}[I_n]$, $\Delta F4_{mn}[I_n]$, $\Delta F4_{dc}[I_n]$, $\Delta F4_{rmn}[I_n]$, $\Delta F4_{ac}[I_n]$

* rms, mn, dc, rmn, and ac are delta computation modes.



Selecting a Delta Computation Mode

You can select the voltage or current mode to be displayed as delta computation values from the following:

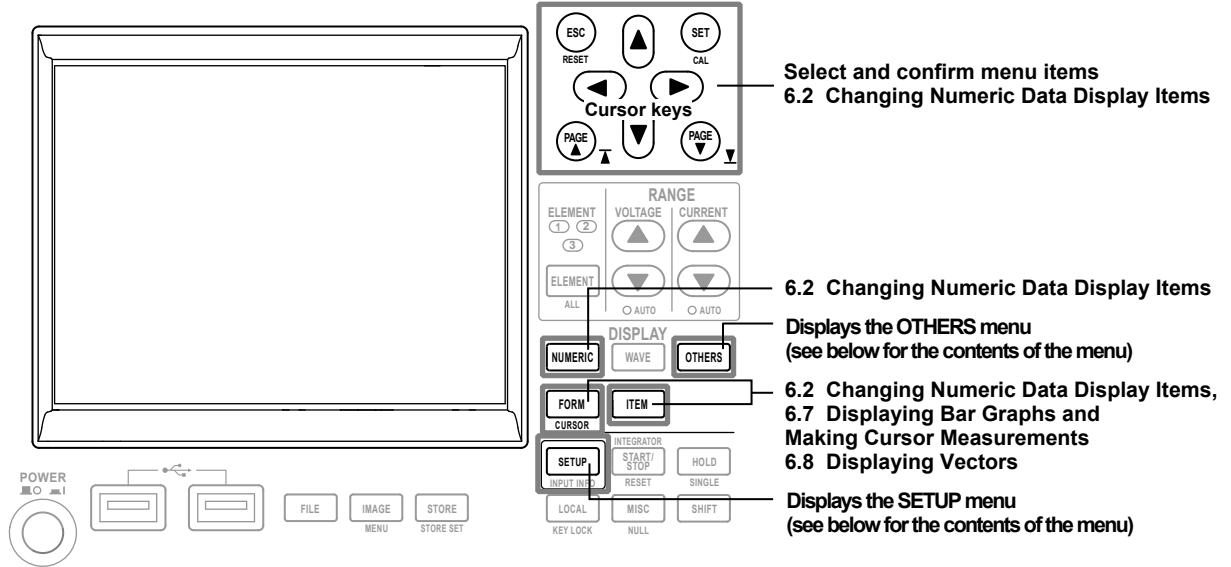
rms, mean, dc, r-mean, ac

Note

- We recommend that you set the measurement range and scaling (VT/CT ratio and coefficients) of the elements that are undergoing delta computation as closely as possible. Using different measurement ranges or scaling causes the measurement resolutions of the sampled data to be different. This results in errors.
- The numbers (1, 2, 3, and 4) that are attached to delta computation measurement function symbols have no relation to the element numbers. The computation of delta measurement functions $\Delta F1$ to $\Delta F4$ varies depending on the wiring system and the delta computation type. For details, see appendix 10.
- On models with a single element, this function does not work. Therefore, the setup menus do not appear.
- If the target wiring system for delta computation is a single-phase, two-wire system (1P2W), delta computation cannot be performed.

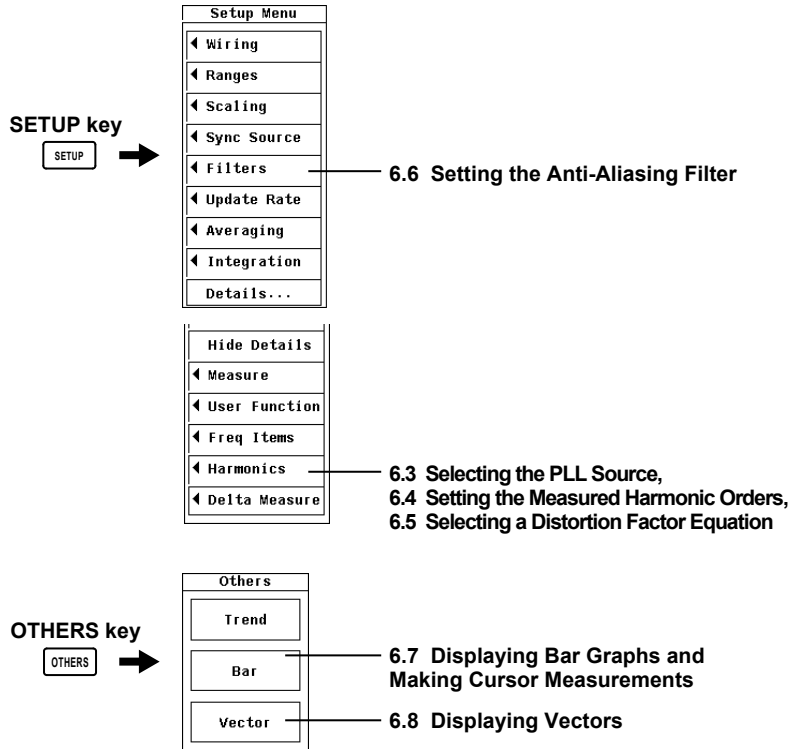
6.1 Panel Keys and Setup Menus Used in This Chapter

Panel Keys Used in This Chapter



Setup Menu Used in This Chapter

To set a parameter, access its menu by pressing the appropriate panel key. The setup menu and menu items used in this chapter are shown below, along with the sections that correspond to their operating instructions.



6.2 Changing Numeric Data Display Items

Make sure that the display mode is Numeric.

There are four ways that you can change numeric data display items. They are listed below, along with the page numbers for their corresponding operating instructions.

- By using the function select menu to change the displayed items.
- By selecting displayed items from a menu Page 6-3
- By selecting harmonic orders in ALL display Page 6-5
- By resetting the order of displayed items Page 6-5

Procedure

Using the Function Select Menu to Change the Displayed Items

You can change the display of wiring units; elements; and functions U, I, P, S, Q, λ , ϕ , WP, q, TIME, FU, FI, and η using the function select menu.

Selecting the Item to Change

1. Use the **cursor keys** to select the item that you want to change. The selected item is highlighted.

In the Single List and Dual List displays, move the cursor to the center or left of the screen.

Display Examples

• Single List display

Current cursor location

Normal Mode		Uover: ▾	Scaling: ▾	LineFilt: ▾	NULL: ▾	YOKOGAWA ▾
▾ + [SET]: change items		Lover: ▾	Average: ▾	FreqFilt: ▾		
PLL	U1	Or.	U1 [V]	hdF[%]	Or.	U1 [V]
Freq	Error	Rot.	0.14	dc	U1 [V]	hdF[%]
Urms1	0.00 V	1	0.00	3.567	2	0.01
Irms1	0.0000 A	3	0.01	4.416	4	0.01
P1	-0.00 W	5	0.01	8.528	6	0.02
S1	0.00 VA	7	0.13	93.038	8	0.02
Q1	0.00 var	9	0.01	7.014	10	0.01
λ 1	-----	11	0.00	2.913	12	0.01
ϕ 1	-----	13	0.01	3.684	14	0.01
		15	0.00	3.301	16	0.01
		17	0.01	6.348	18	0.00
		19	0.00	3.404	20	0.02
		21	0.02	12.633	22	0.01
Uthd1	99.936 %	23	0.00	1.740	24	0.00
Ithd1	99.630 %	25	0.00	2.741	26	0.00
Pthd1	99.565 %	27	0.00	2.877	28	0.00
		29	0.01	3.649	30	0.00
		31	0.00	2.139	32	0.01
		33	0.00	2.376	34	0.01
		35	0.00	1.169	36	0.00
		37	0.00	2.092	38	0.00
		39	0.00	1.452	40	0.00
				Integ:Reset		
				Time:-----		
				PAGE 1/2		
Update 10613(500msec)				2008/05/08 17:34:24		

• Dual List display

Current cursor location

Normal Mode		Uover: ▾	Scaling: ▾	LineFilt: ▾	NULL: ▾	YOKOGAWA ▾
▾ + [SET]: change items		Lover: ▾	Average: ▾	FreqFilt: ▾		
PLL	U1	Or.	U1 [V]	hdF[%]	I1 [A]	hdF[%]
Freq	Error	Rot.	0.07	-----	0.005	-----
Urms1	0.00 V	1	0.01	16.077	0.000	7.638
Irms1	0.000 A	2	0.01	8.324	0.000	5.387
P1	-0.000kW	3	0.01	6.961	0.000	3.478
S1	0.000kVA	4	0.01	16.902	0.000	1.831
Q1	0.000kvar	5	0.01	15.212	0.000	4.989
λ 1	Error	6	0.01	13.315	0.000	3.328
ϕ 1	Error	7	0.02	25.941	0.000	7.974
		8	0.02	20.742	0.000	6.766
		9	0.01	12.278	0.000	4.205
		10	0.01	12.675	0.000	4.553
		11	0.02	20.932	0.000	7.745
		12	0.00	4.534	0.000	8.233
		13	0.01	13.422	0.000	7.376
		14	0.00	5.600	0.001	9.675
		15	0.01	7.281	0.000	8.077
		16	0.01	11.604	0.000	0.704
		17	0.01	16.995	0.001	10.377
		18	0.01	14.291	0.000	0.868
		19	0.01	7.040	0.000	5.926
		20	0.00	4.422	0.000	8.675
				Integ:Reset		
				Time:-----		
				PAGE 1/3		
Update 15(500msec)				2008/05/08 17:32:54		

Changing a Measurement Function

2. Press **SET** to display the function select menu.
3. Use the **cursor keys** to select a group of measurement functions you want to display from U/I/P, S/Q/ λ / ϕ , WP/q/Time, FU/FI/ η , and rms/mean/dc/rmean/ac.
4. Press **SET**. For example, if U/I/P is selected, the measurement function that is displayed switches in this order each time you press SET: U > I > P.

When the display mode is set to Single List or Dual List, only the measurement functions that contain harmonic order data can be selected. Press U/I/P to select U, I, or P. Press S/Q/ λ / ϕ to select S, Q, λ , ϕ , ϕ U, or ϕ I.

Changing an Element or Wiring Unit

5. Use the **cursor keys** to select Element.
6. Press **SET** to select an element or wiring unit. Each time you press SET, the selected element or wiring unit changes in this order: 1 > 2 > 3 > Σ .

Change Item
Element
U/I/P
S/Q/ λ / ϕ
WP/q/TIME
FU/FL/ η
rms/mean/dc /rmean/ac

This ends the description of how to change displayed items using the function select menu.

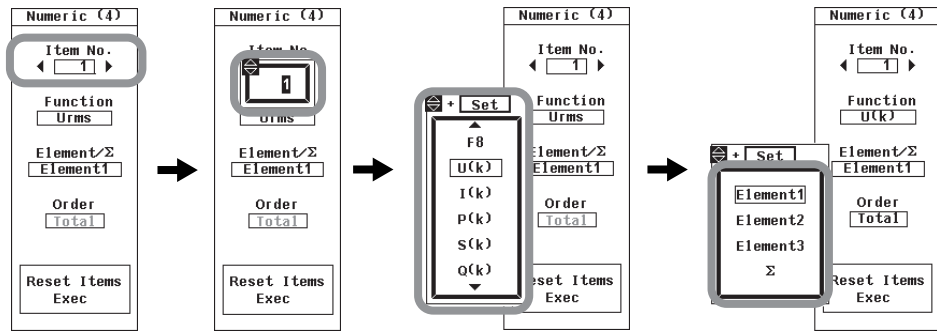
Selecting Displayed Items from a Menu

1. Press **ITEM** to display the Numeric menu.
- **Selecting the Item to Change**
 2. Use the **cursor keys** to select Item No.
 3. Press **SET** to display the Item No. selection box.
 4. Use the **cursor keys** to select the item that you want to change.
 5. Press **SET** or **ESC** to confirm the selection.
 - **Changing a Measurement Function**
 6. Use the **cursor keys** to select Function.
 7. Press **SET** to display the measurement function selection box.
 8. Use the **cursor keys** to select a measurement function from the list (which starts with None).
 9. Press **SET** or **ESC** to confirm the function selection. The symbol and numeric data for the selected measurement function appear in the highlighted area. In the Single List and Dual List displays, only the measurement functions that contain harmonic order data can be selected. (U, I, P, S, Q, λ , ϕ , ϕU , ϕI)

6.2 Changing Numeric Data Display Items

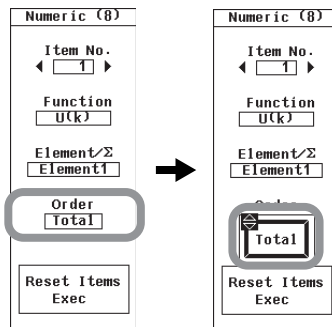
- **Changing an Element or Wiring Unit**

10. Use the **cursor keys** to select Element/ Σ .
11. Press **SET** to display the element or wiring unit selection box.
12. Use the **cursor keys** to select an element or wiring unit from the list (which starts with Element1).
13. Press **SET** or **ESC** to confirm the selection. The element number or wiring unit symbol for the selected element or wiring unit appears along with its corresponding numeric data in the highlighted area.



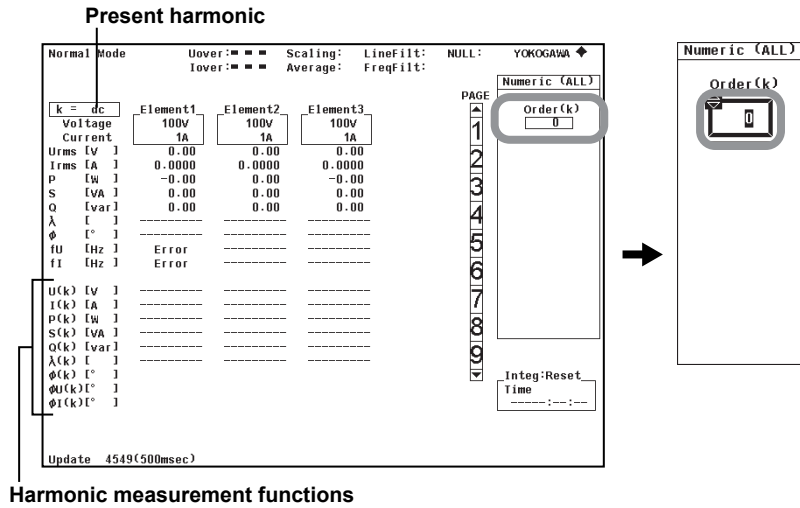
- **Changing a Harmonic Order**

14. Use the **cursor keys** to select Order.
 15. Press **SET** to display the harmonic order selection box.
 16. Use the **cursor keys** to select a harmonic order.
 17. Press **SET** or **ESC** to confirm the selection. The selected harmonic order appears along with its corresponding numeric data in the highlighted area. This ends the description of how to change displayed items using the menu.
- You do not need to set harmonic orders in the Single List or Dual List displays.



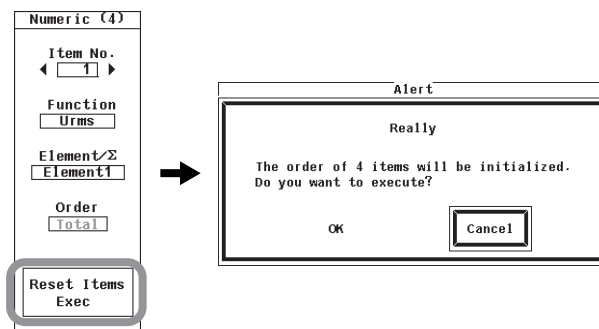
Selecting Harmonic Orders in the ALL Display

1. Press **PAGE** to display the harmonic order data page (page 6).
2. Press **ITEM**. The Numeric(ALL) menu appears.
3. Press **SET** to display the harmonic order selection box.
4. Use the **cursor keys** to select a harmonic order.
5. Press **SET** or **ESC** to close the harmonic order selection box.



Resetting the Displayed Item Order (In any display other than ALL, Single List, or Dual List)

1. Press **ITEM** to display the Numeric menu.
2. Use the **cursor keys** to select Reset Items Exec.
3. Press **SET**. An Alert dialog box appears.
4. Use the **cursor keys** to select OK.
5. Press **SET**. The order of every display item on every page will be reset. If you do not want to reset, select Cancel and press SET.



6.2 Changing Numeric Data Display Items

Explanation

The ways in which displayed items can be changed varies depending on the Numeric Form (number of displayed items) as described below.

Number of Displayed Items		Changing the Displayed Items
4 Items, 8 Items, 16 Items		No limitations
Matrix		No limitations
ALL Items		The displayed item cannot be changed independently. Scroll through the pages or use the cursor keys to change the displayed items. A harmonic order can be selected for the harmonic order data displayed on page 6.
Single List or Dual List	Measurement function display (left side of the screen)	The displayed item cannot be changed independently. Scroll through the pages or use the cursor keys to change the displayed items.
	Harmonic order data display (right side of the screen)	Only measurement functions that contain harmonic order data can be selected. (U, I, P, S, Q, λ , ϕ , ϕU , and ϕI)

When the Numeric Form (Number of displayed items) is Set to 4 Items, 8 Items, 16 Items, or Matrix

- **Changing a Measurement Function**
 - The items described in section 2.2, “Types of Harmonic Measurement Functions,” can be selected.
 - You can also choose not to display a measurement function (None).
- **Changing an Element or Wiring Unit**

You can select the element/wiring unit from the choices below. The selectable items vary depending on the number of elements installed in the WT500.
Element1, Element2, Element3, and Σ
- **Changing a Harmonic Order**

The harmonic order can be set to Total or from dc (0th) to the 50th harmonic.

When Numeric Form (Number of displayed items) Is Single List or Dual List

Harmonic order data can be displayed (on the right of the screen) using one of two kinds of lists. In Single List, the data of List Item No.1 is listed in two columns. In Dual List, the data of List ItemNo. 1 is listed in one column, and the data of List ItemNo. 2 is listed in another column.

You can select 1 or 2 as the list item number.

- **Changing a Measurement Function**

The following measurement functions can be changed.
(U, I, P, S, Q, λ , ϕ , ϕU , ϕI)
- **Changing an Element or Wiring Unit**

Same as “When the Numeric Form (Number of displayed items) is Set to 4 Items, 8 Items, 16 Items, or Matrix” on the previous page.

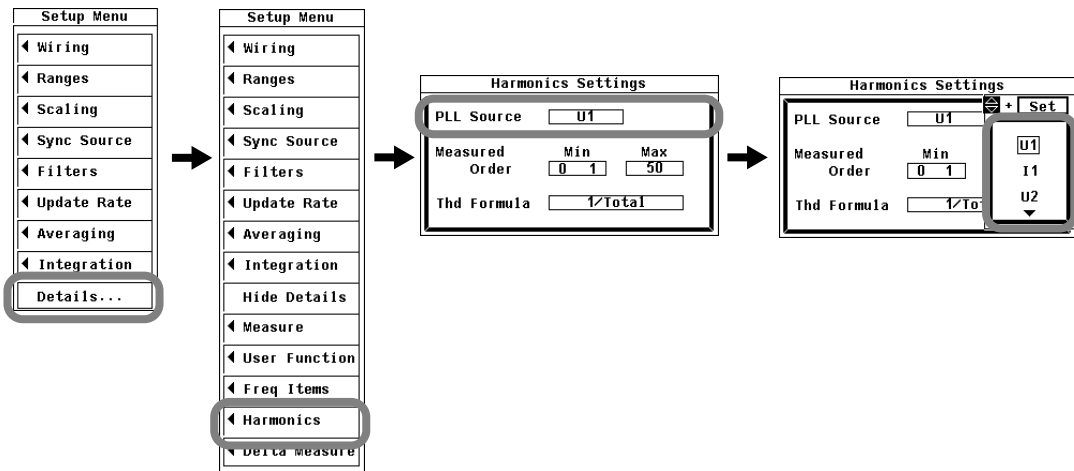
Note

- For information about measurement function symbol meanings, see section 2.2, “Types of Harmonic Measurement Functions.”
- “-----” or space is displayed if a measurement function is not selected or if there is no numeric data.
- The measured harmonic minimum value determined in section 6.5 (MinOrder) and the maximum harmonic order value determined automatically based on the PLL source frequency (see section 6.9 for details) determine the range of harmonics from which numeric data is determined. No numeric data is displayed for harmonic orders outside of this range.
- Harmonic orders to Total or from dc (0th) to the 50th harmonic can be displayed. However, only the data of harmonics up to the maximum harmonic order value determined automatically based on the PLL source frequency (see section 14.6 for details) is measured.
- 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, harmonic data is not measured, and “-----” (no data) is displayed. If this happens, decrease the data update rate. For example, if the fundamental frequency is 10 Hz (100-ms cycle), the analysis window width is 1 wave (see section 14.6 for details), and the data measurement interval is 100 ms. In this case, the time required for harmonic measurement is approximately 150 ms or greater (data measurement interval + data processing time). To measure and display harmonic data, set the data update rate to a value greater than or equal to 200 ms.
- Overload (“-OL-”) and zero are not displayed for harmonic orders from dc (0th order) to 50. For information about the display of zero and the overload indication in normal measurement, see section 5.2.
- If the power factor λ is greater than 1 and less than or equal to 2, λ returns 1. ϕ returns zero.
- If λ is greater than 2, λ and ϕ return errors (“Error” is displayed).

6.3 Selecting the PLL Source

Procedure

1. Press **SETUP** to display the Setup menu.
2. Use the **cursor keys** to select Harmonics.
3. Press **SET** to display the Harmonics Settings dialog box.
4. Use the **cursor keys** to select PLL Source.
5. Press **SET** to display the PLL source selection box.
6. Use the **cursor keys** to select a PLL source.
7. Press **SET** to confirm the selection.



Explanation

You can select a PLL (Phase Locked Loop) source to use to determine the fundamental period, which acts as the reference in the analysis of the harmonic orders.

Selecting the PLL Source

Select the PLL source from the choices below. The selectable items vary depending on the number of elements installed in the WT500.


U1, I1, U2, I2, U3, I3, and Ext Clk (external clock)*

* If you select "Ext Clk," harmonic measurement is performed using the frequency of the signal applied to the external clock input connector as the fundamental frequency.

When Setting the PLL Source to Ext Clk

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



EXT. CLK 

Item	Specification
Connector type	BNC connector
Frequency	10 Hz to 1.2 kHz
Input level	TTL
Input waveform	50% duty ratio rectangular wave

**CAUTION**

Applying a voltage outside of the range of 0 to 5 V to the external clock input connector (EXT CLK) can damage the WT500.

Note

- The synchronized measurement slave setting and the PLL source Ext Clk setting cannot be made at the same time because they both use the same connector (see section 12.6 for information about synchronized measurement).
- To connect a BNC cable to the external clock input/external start signal output connector (EXT CLK) when a GP-IB cable is connected to the GP-IB connector, first remove the GP-IB cable. Then connect the BNC cable. Finally, reconnect the GP-IB cable.
- Select a signal that has the same period as the target signal for harmonic measurement. 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 is small compared to the measurement range, the specifications may not be met. To achieve 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 less than or equal to 440 Hz and the signal contains high frequency components, we recommend that you turn the frequency filter on. This filter is only effective on the frequency measurement circuit.
- If the amplitude level of the signal applied to the element that is specified as the PLL source is small compared to the range, PLL synchronization may not be achieved. If the crest factor is set to 3, set the measurement range so that the amplitude level of the PLL source is at least 50%. If the crest factor is set to 6, 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 a few 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 the WT500 redetects the frequency.
- The synchronized measurement slave setting and the PLL source Ext Clk setting cannot be made at the same time because they both use the same connector.

6.4 Setting the Measured Harmonic Orders

Procedure

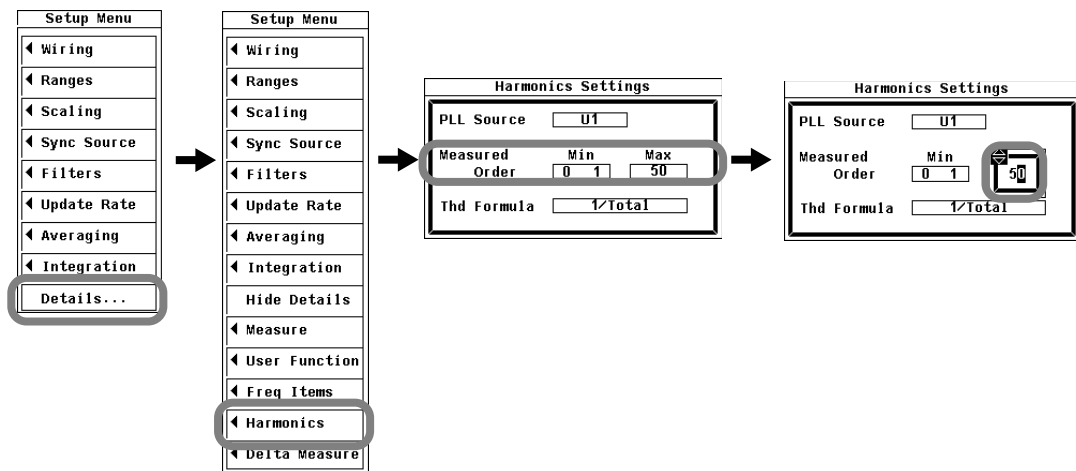
1. Press **SETUP** to display the Setup menu.
If the full Setup menu does not appear, proceed to step 2. If the full Setup menu appears, proceed to step 4.
2. Use the **cursor keys** to select Details.
3. Press **SET** to display the full Setup menu.
4. Use the **cursor keys** to select Harmonics.
5. Press **SET** to display the Harmonics Settings dialog box.

Selecting the Minimum Harmonic Order to Measure

6. Use the **cursor keys** to select Min next to Measured Order.
7. Press **SET** to select 0 or 1.

Setting the Maximum Harmonic Order to Measure

8. Use the **cursor keys** to select Max next to Measured Order.
9. Press **SET** to display the harmonic order entry box.
10. Use the **cursor keys** to select the maximum harmonic order to measure.
11. Press **SET** or **ESC** to close the harmonic order entry box.



Explanation

The harmonic measurement range can be specified. The harmonic orders specified here are used to determine the numeric data of the distortion factor. For information about how the distortion factor is determined, see section 14.4.

Selecting the Minimum Harmonic to Measure

You can select the minimum harmonic order to be measured from one of the choices below.

- 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. The 1st order (fundamental signal) is the first component used.

Setting the Maximum Harmonic Order to Measure

You can select a harmonic order from 1 to 50.

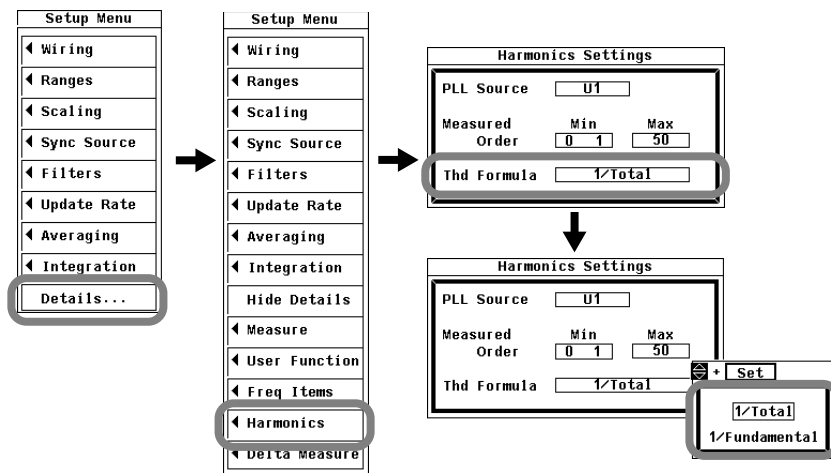
Note

- If the minimum harmonic order to measure is set to 1, the data of the DC component is not included when determining the distortion factor.
- Overload ("-OL-") and zero are not displayed for harmonic orders from dc (0th order) to 50. For information about the display of zero and the overload indication in normal measurement, see section 5.2.
- You can set the maximum harmonic order up to the 50th order, but the maximum harmonic order that is actually used to determine numeric data is the upper limit of harmonic analysis. The upper limit of harmonic analysis is either set to an automatically determined value or to the value that you set, whichever is smaller. It can go up to the 50th harmonic order. The numeric data corresponding to harmonic orders exceeding the upper limit is displayed as "-----" (no data).

6.5 Selecting a Distortion Factor Equation

Procedure

1. Press **SETUP** to display the Setup menu.
If the full Setup menu does not appear, proceed to step 2. If the full Setup menu appears, proceed to step 4.
2. Use the **cursor keys** to select Details.
3. Press **SET** to display the full Setup menu.
4. Use the **cursor keys** to select Harmonics.
5. Press **SET** to display the Harmonics Settings dialog box.
6. Use the **cursor keys** to select Thd Formula.
7. Press **SET** to display the distortion factor equation selection box.
8. Use the **cursor keys** to select 1/Total or 1/Fundamental.
9. Press **SET** to confirm the selection.



Explanation

When determining the harmonic measurement functions U_{hdf} , I_{hdf} , Ph_{df} , U_{thd} , I_{thd} , and P_{thd} , you can select to use one of the denominators described below as the denominator for the equation. For more information about the distortion factor equations, 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).

Note

The minimum and maximum harmonic orders to be measured are the values selected in section 6.3.

6.6 Setting the Anti-Aliasing Filter

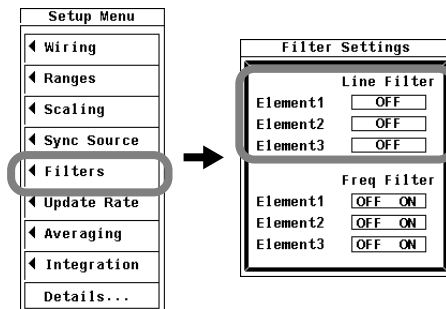
Procedure

When making harmonic measurements, the line filter is used as an anti-aliasing filter.

Selecting a Line Filter

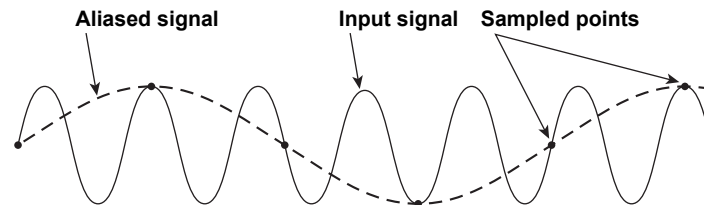
1. Press **SETUP** to display the Setup menu.
2. Use the **cursor keys** to select Filters.
3. Press **SET** to display the Filter Settings dialog box.
4. Use the **cursor keys** to select the Line Filter of the element that you want to set.
5. Press **SET** to display the cutoff frequency selection box.
6. Use the **cursor keys** to select a cutoff frequency.
7. Press **SET** to confirm the selection.

If any of the measured elements is set to a setting other than OFF, the LineFilt indicator at the top of the screen lights.



Explanation

When taking the FFT 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 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 measuring an input signal with a fundamental frequency of 50 Hz up to the 50th order, the frequency of the 50th order is 2.5 kHz. Thus, a 5.5-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.

The WT500 uses the filter used as a line filter in normal measurement as an anti-aliasing filter in harmonic measurement.

Selecting an Anti-Aliasing Filter (Line Filter)

- You can select from one of the following cutoff frequencies.
OFF, 500 Hz, and 5.5 kHz
- If any of the measured elements is set to a setting other than OFF, the LineFilt indicator at the top of the screen lights.
- Selecting OFF disables the anti-aliasing filter (line filter).
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 14.6.

Note

- The anti-aliasing filter (line filter) setting is common to all measurement functions. The filter setting does not change for different measurement functions.
 - Accuracy may not be defined depending on the measurement function. For example, the harmonic measurement in normal measurement mode assumes 50/60 Hz for the fundamental frequency. In this case, a 500-Hz anti-aliasing filter (line filter) would eliminate frequency components that are greater than or equal to 10th order, and would thus not be appropriate. Therefore, accuracy is not defined for the 500-Hz line filter.
 - If you select 500 Hz as the cutoff frequency, the anti-aliasing filter (line filter) is turned on automatically, and the FreqFilt indicator lights.
-

6.7 Displaying Bar Graphs and Making Cursor Measurements

Procedure

Displaying a Bar Graph

1. Press **OTHERS** to display the Others menu.
2. Use the **cursor keys** to select Bar.
3. Press **SET** to confirm the selection.

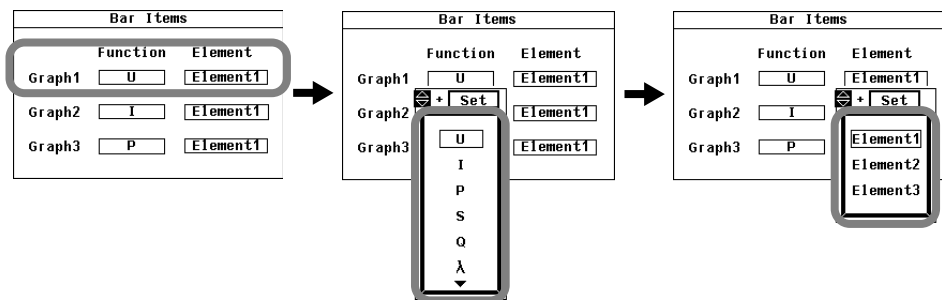


Changing a Measurement Function

4. Press **ITEM** to display the Bar Items menu.
5. Use the **cursor keys** to select the Function of the bar graph (Graph1 to Graph3) that you want to set.
6. Press **SET** to display the measurement function selection box.
7. Use the **cursor keys** to select a measurement function.
8. Press **SET**. The symbol for the selected function is displayed on the screen along with its bar graph.

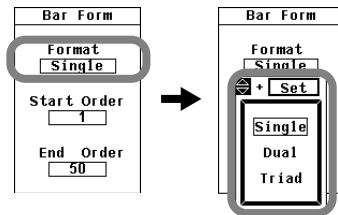
Changing the Graphed Element

9. Use the **cursor keys** to select the Element of the bar graph (Graph1 to Graph3) that you want to set.
10. Press **SET** to display the element selection box.
11. Use the **cursor keys** to select an element.
12. Press **SET**. The bar graph for the selected element appears on the screen.



Selecting the Number of Bar Graph Display Split Screens

13. Press **FORM** to display the Bar Form menu.
14. Use the **cursor keys** to select Format.
15. Press **SET** to display the split screen number selection box.
16. Use the **cursor keys** to select the number of split screens from Single, Dual, or Triad.
 - If you select Single, the bar graph assigned to Graph1 appears.
 - If you select Dual, the bar graphs assigned to Graph1 and Graph2 appear.
 - If you select Triad, the bar graphs assigned to Graph1 to Graph3 appear.
17. Press **SET**. The selected bar graphs appear on the screen.



Setting the Bar Graph Display Range

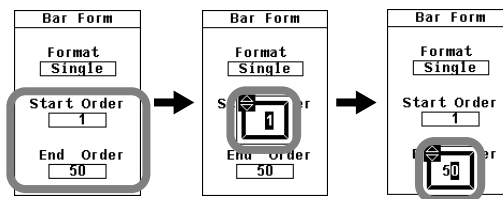
(The difference between the starting harmonic order and the ending harmonic order must be greater than or equal to 10.)

• **Setting the Starting Order**

18. Use the **cursor keys** to select Start Order.
19. Press **SET** to display the starting harmonic order selection box.
20. Use the **cursor keys** to set the bar graph starting order.
21. Press **SET** or **ESC** to close the the starting harmonic order entry box.

• **Setting the Ending Order**

18. Use the **cursor keys** to select End Order.
19. Press **SET** to display the ending harmonic order selection box.
20. Use the **cursor keys** to set the bar graph ending order.
21. Press **SET** or **ESC** to close the ending harmonic order selection box.



Measuring with Cursors

4. Press **SHIFT+FORM(CURSOR)** to display the Cursor menu.

- **Selecting Whether or Not to Use Cursor Measurement**

5. Use the **cursor keys** to select Bar Cursor.

6. Press **SET** to select ON or OFF. If you select ON, the results of cursor measurement are displayed.

- **Moving the Cursors**

7. Use the **cursor keys** to select Position C1 + or Position C2 x.

8. Press **SET** to display the cursor position selection box for Position C1 + or Position C2 x.

9. Use the **cursor keys** to set the position in terms of the harmonic order.

- Select Position C1 + to move the position of cursor +.
- Select Position C2 x to move the position of cursor x.

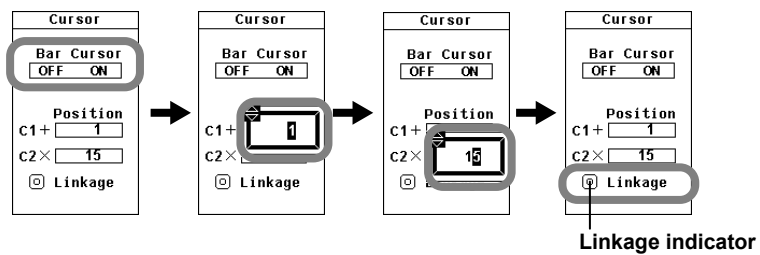
10. Press **SET** or **ESC** to close the cursor position selection box.

- **Linking Cursors**

11. Use the **cursor keys** to select Linkage.

12. Press **SET**. The linkage indicator lights and the cursor settings are linked.

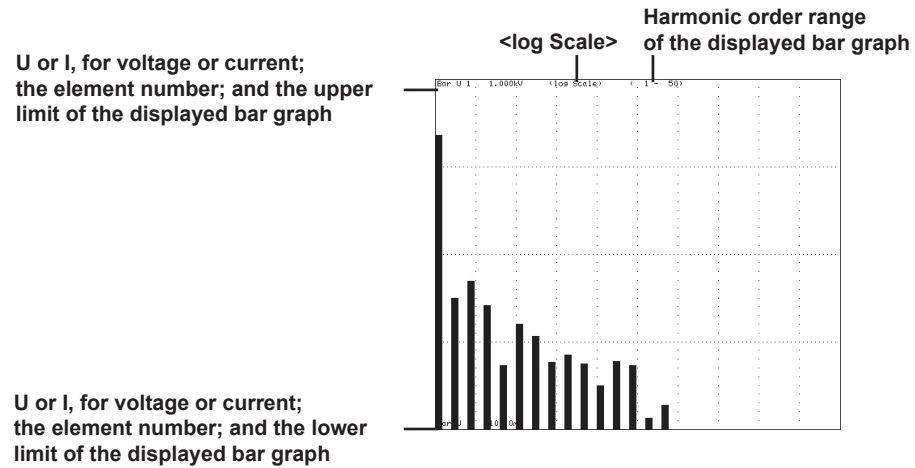
When Linkage is enabled, the distance between cursor + and cursor x is maintained. When you change the position of one cursor, the position of the other cursor also changes.



6.7 Displaying Bar Graphs and Making Cursor Measurements

Explanation

A display example is shown below. When the displayed measurement function is U, I, P, S, or Q, the vertical axis is in logarithmic scale. The words “log Scale” appear at the top of the screen.



Changing a Measurement Function

The following measurement functions can be changed.

(U, I, P, S, Q, λ , ϕ , ϕU , ϕI)

Changing an Element

You can select an element from one of the choices below. The selectable items vary depending on the number of elements installed in the WT500.

Element1, Element2, and Element3

Selecting Which Bar Graphs to Display

There are three bar graphs. You can set which bar graphs are displayed (from Graph1 to Graph3) by changing the number of split screens in the bar graph display.

Note

- If a value is negative on the log scale, 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. If this happens, decrease the data update rate. The details are the same as with harmonic data. For more information, see the “Note” part of section 6.2.

Setting the Bar Graph Display Range

- The bar graph display range is set in terms of harmonic orders.
- The display ranges of Graph1 to Graph3 are the same.
- The minimum harmonic order is 0 (DC). However, if the measurement function is set to ϕ , ϕU , or ϕI , the 0th order has no value. Thus, the 0th order is not displayed in the bar graph.
- If the measurement function is set to ϕU or ϕI , the 1st order has no value. Thus, the 1st order is not displayed in the bar graph.
- The maximum settable harmonic order is 50. However, bar graphs of orders that exceed the upper limit of harmonic analysis (see section 6.4 for details) are not displayed.

Cursor Measurement• **ON/OFF**

A cursor can be placed on the displayed bar graph to measure the value at that point.

- ON: Cursor measurement is performed.
- OFF: Cursor measurement is not performed.

• **Measured Items**

- Y1+: Y-axis value of cursor + of bar graph 1
- Y1x: Y-axis value of cursor x of bar graph 1
- $\Delta Y1$: Difference between the Y-axis values of cursor + and cursor x of bar graph 1
- Y2+: Y-axis value of cursor + of bar graph 2
- Y2x: Y-axis value of cursor x of bar graph 2
- $\Delta Y2$: Difference between the Y-axis values of cursor + and cursor x of bar graph 2
- Y3+: Y-axis value of cursor + of bar graph 3
- Y3x: Y-axis value of cursor x of bar graph 3
- $\Delta Y3$: Difference between the Y-axis values of cursor + and cursor x of bar graph 3

• **Moving the Cursors**

- Two cursors (+ and x) are displayed in each graph (Graph1 to Graph3).
- The cursor positions are set by harmonic order.
- The bar graph display indicates what harmonic order each cursor is located in. For example:
 - The location of cursor + is indicated in this format: "order+:2."
 - The location of cursor x is indicated in this format: "orderx:45."
- Cursors + and x are located in the same harmonic orders in each graph (Graph1 to Graph3).

Note

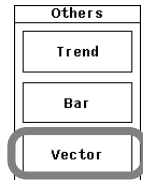
If immeasurable data exists, "****" is displayed in the measured value display area.

6.8 Displaying Vectors

Procedure

Displaying Vectors

1. Press **OTHERS** to display the Others menu.
2. Use the **cursor keys** to select Vector.
3. Press **SET** to confirm the selection.

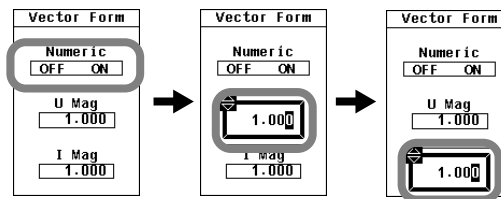


Selecting Whether or Not to Display Numeric Data

4. Press **FORM** to display the Vector Form menu.
5. Use the **cursor keys** to select Numeric.
6. Press **SET** to select ON or OFF.

Setting a Vector Zoom

7. Use the **cursor keys** to select U Mag or I Mag.
 - Select U Mag to zoom the vectors of the fundamental voltage signals U(1) of the elements that subject to harmonic measurement.
 - Select I Mag to zoom the vectors of the fundamental current signals I(1) of the elements that are subject to harmonic measurement.
8. Press **SET** to display the zoom factor entry box.
9. Use the **cursor keys** to set the zoom factor.
10. Press **SET** to confirm the selection.



Explanation

The phase and size (rms value) relationship between the fundamental signals U(1) and I(1) of each element in wiring unit Σ can be displayed using vectors. The positive vertical axis is set to zero (angle zero), and the vector of each input signal is displayed.

Note

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. If this happens, decrease the data update rate. The details are the same as with harmonic data. See the "Note" part of section 6.2.

Turning the Display of Numeric Data On or Off

You can select whether or not to display numeric data (by selecting ON or OFF). The signal sizes and the phase differences between the signals can be displayed along with the vector display. For information about phase difference display formats, see section 5.5.

Setting the Vector Zoom Factor

The size of the vectors can be changed.

- The zoom factor can be set in the range of 0.100 to 100.000.
- You can specify separate zoom factors for the fundamental signals U(1) and I(1).

Note

If all the wiring systems are single-phase, two-wire (1P2W) or if you are using the single input element model, the wiring unit Σ does not exist. Therefore, nothing is displayed in the vector display.

Vector Display Examples

When Displaying Numeric Data

(of the sizes of the signals and the phase differences between signals)

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 system with

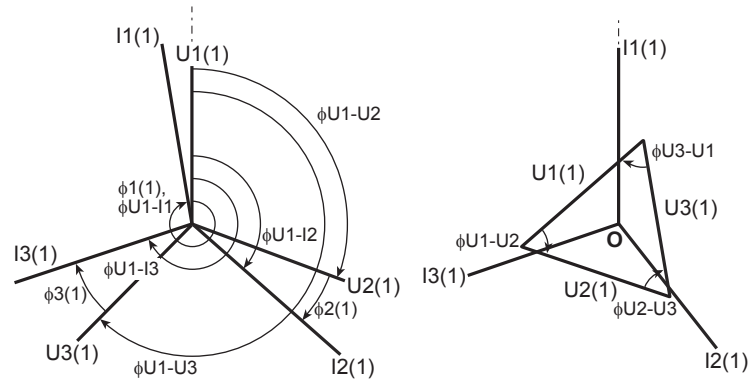
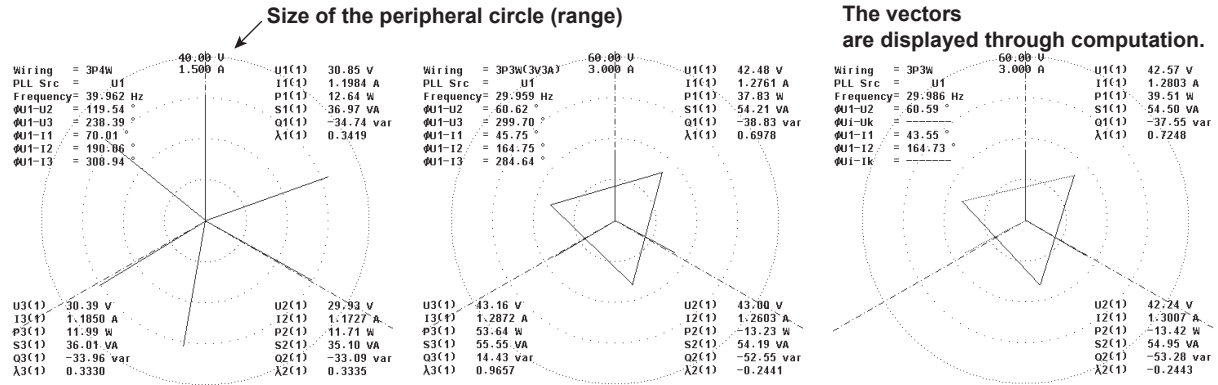
a three-voltage, three-current method

- U1(1), U2(1), and U3(1) are line voltages.
- I1(1), I2(1), and I3(1) are line currents.

For a 3P3W

(three-phase, three-wire system)

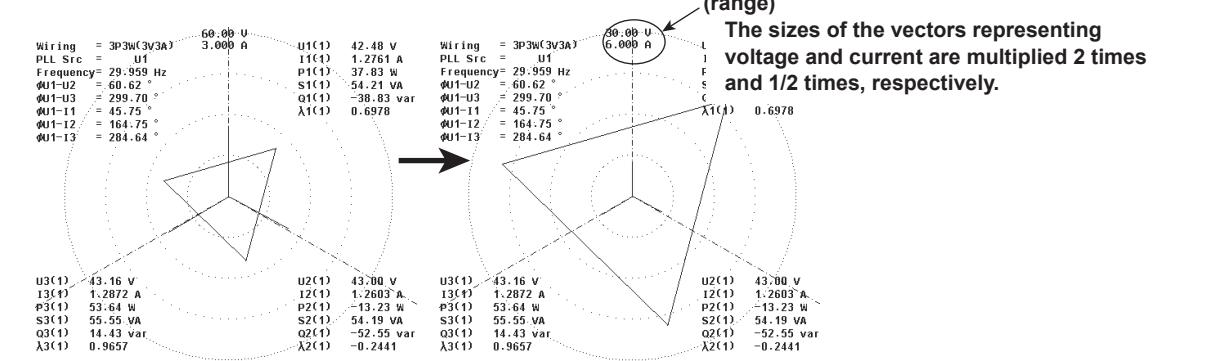
- U1(1), U2(1), and U3(1) are line voltages.
 - I1(1), I2(1), and I3(1) are line currents.
- However, U3(1) and I3(1) are not actually measured for the 3P3W system. The vectors are displayed through computation.



- By moving the vectors U1(1), U2(1), and U3(1) so that the starting points of all vectors are at the origin O, the phase relationship can be observed in the same fashion as the 3P4W system. For information about the relationship between the positions of the vectors after they have been moved, see "Vector Display of Harmonic Data" in section 7.1. (The WT500 does not provide a function for moving the vectors.)
- The phase difference between the line voltages can be determined from the phase difference measurement functions $\phi_{U1 - U2}$ and $\phi_{U1 - U3}$.
 $\phi_{U1 - U2} = \text{Measurement function } \phi_{U1 - U2}$
 $\phi_{U2 - U3} = (\phi_{U1 - U3}) - (\phi_{U1 - U2}) - 180$
 $\phi_{U3 - U1} = -(\phi_{U1 - U3})$

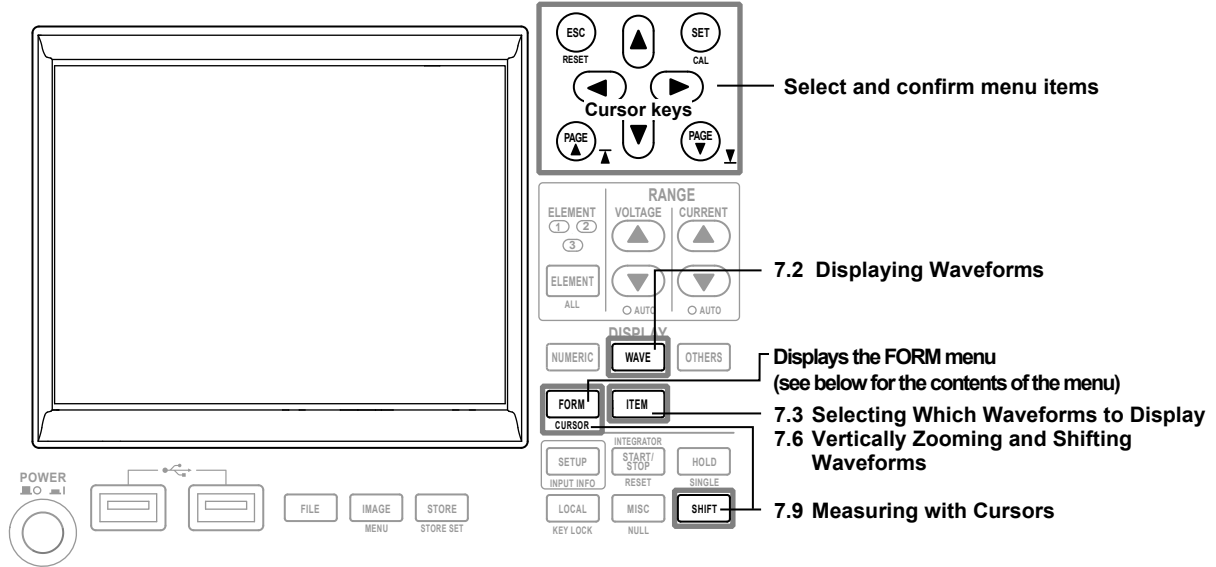
When the vector size is zoomed

Example in which the voltage is zoomed by a factor of 2 and the current by a factor of 1/2



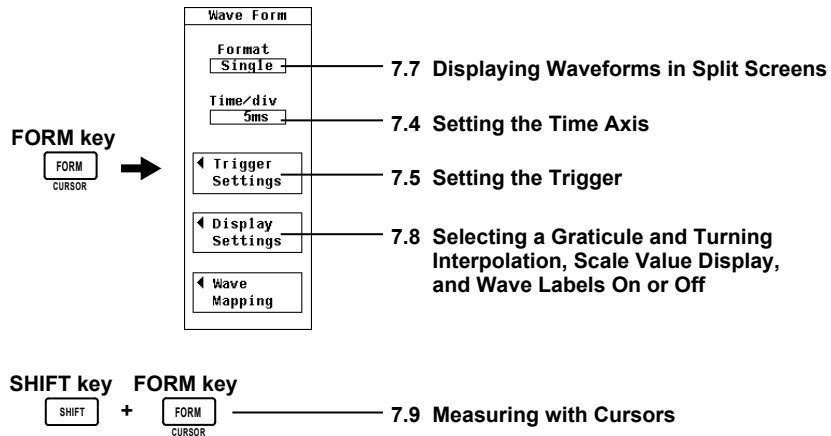
7.1 Panel Keys and Setup Menu Used in This Chapter

Panel Keys Used in This Chapter



Setup Menu Used in This Chapter

To set a parameter, access its menu by pressing the appropriate panel key. The setup menu and menu items used in this chapter are shown below, along with the sections that correspond to their operating instructions.



7.2 Displaying Waveforms

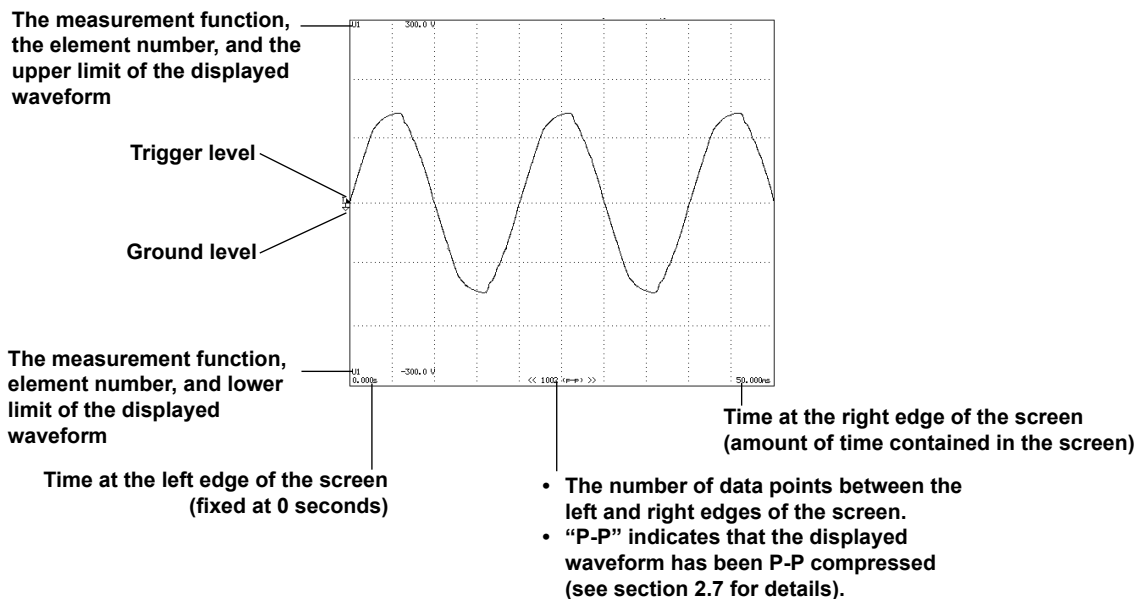
Procedure

Displaying Waveforms

1. Press **WAVE**. The waveform display appears.

Explanation

For an explanation of the waveform display feature itself, see section 2.7. A display example is shown below. For instructions on how to change displayed waveforms and their formats, see sections 7.3 to 7.9.



Measurement Mode during Waveform Display

When waveforms are displayed, the measurement mode indicated in the upper left of the screen is Normal Mode (Trg). After a trigger occurs (see section 7.4 for details), measurement takes place at the data update interval.

Note

- If you do not set the trigger level properly, the waveform display start point (the signal level on the left edge of the screen) may be unstable, or waveforms may not appear.
- Even when waveforms are displayed, during integration (including when integration is suspended), the measurement mode indication at the upper left of the screen is Normal Mode. In this mode, sampled data is updated automatically at a set interval, and the trigger feature does not function. 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.

7.3 Selecting Which Waveforms to Display

Procedure

1. Press **ITEM** to display the Wave Items menu.

Turning All Input Signal Waveform Displays On or Off

- **Turning All Waveform Displays On**

2. Use the **cursor keys** to select All ON.
3. Press **SET**. The indicators to the left of the input signals all light, and all of the waveforms are displayed.

- **Turning All Waveform Displays Off**

2. Use the **cursor keys** to select All OFF.
3. Press **SET**. The indicators to the left of the input signals all turn off, and none of the waveforms are displayed.

Turning Individual Input Signal Waveform Displays On or Off

2. Use the **cursor keys** to select an input signal.
3. Press **SET**. The indicator to the left of the selected input signal lights, and the waveform of that signal is displayed. If you press SET again, the indicator turns off, and the waveform of the selected input signal is no longer displayed.

Wave Items		
Display ON/OFF	Vertical Zoom	Vertical Position
<input checked="" type="checkbox"/> U1	x 1	0.000%
<input checked="" type="checkbox"/> I1	x 1	0.000%
<input checked="" type="checkbox"/> U2	x 1	0.000%
<input checked="" type="checkbox"/> I2	x 1	0.000%
<input checked="" type="checkbox"/> U3	x 1	0.000%
<input checked="" type="checkbox"/> I3	x 1	0.000%
<input type="checkbox"/> A11 ON		
<input type="checkbox"/> A11 OFF		

Indicators that tell whether the waveform displays of each input signal are on or off

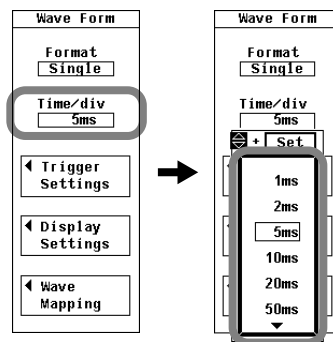
Explanation

Only the input signals of installed elements appear in the menu and can be turned on and off.

7.4 Setting the Time Axis

Procedure

1. Press **FORM** to display the Wave Form menu.
2. Use the **cursor keys** to select Time/div.
3. Press **SET** to display the time axis selection box.
4. Use the **cursor keys** to select a time axis. When the scale value display is set to ON (see section 7.8), the time at the left edge of the screen (which is fixed at zero seconds) appears in the lower left of the screen, and the time at the right edge of the screen appears in the lower right of the screen.
5. Press **SET** to confirm the selection.

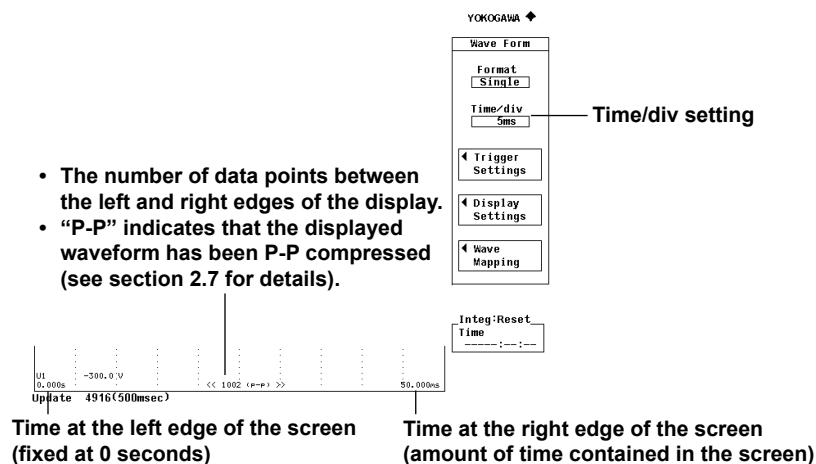


Explanation

For an explanation of the waveform display feature itself, see section 2.7.

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

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: 1 ms > 2 ms > 5 ms > 10 ms > 20 ms > 50 ms, the time corresponding to one screen changes in this order: 10 ms > 20 ms > 50 ms > 100 ms > 200 ms > 500 ms.



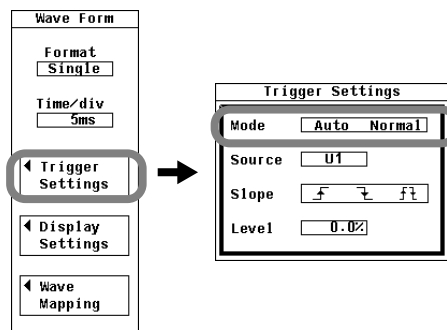
7.5 Setting the Trigger

Procedure

1. Press **FORM** to display the Wave Form menu.
2. Use the **cursor keys** to select Trigger Settings.
3. Press **SET** to display the Trigger Settings menu.

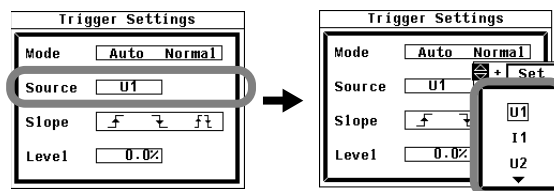
Selecting a Trigger Mode

4. Use the **cursor keys** to select Mode.
5. Press **SET** to select Auto or Normal.



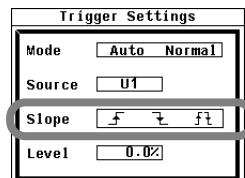
Selecting a Trigger Source

4. Use the **cursor keys** to select Source.
5. Press **SET** to display the trigger source selection box.
6. Use the **cursor keys** to select a waveform from the list (which starts with U1).
7. Press **SET** to confirm the trigger source selection.



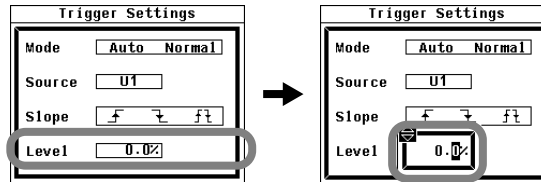
Selecting a Trigger Slope

4. Use the **cursor keys** to select Slope.
5. Press **SET** to select f, r, or fr.



Setting the Trigger Level

4. Use the **cursor keys** to select Level.
5. Press **SET** to display the trigger level entry box.
6. Use the **cursor keys** to set the trigger level.
7. Press **SET** or **ESC** to close the trigger level entry box.



Explanation

For an explanation of the trigger feature itself, see section 2.7.

A trigger is said to have “occurred” when the specified trigger condition is met and a waveform is displayed on the screen.

Selecting a Trigger Mode

The trigger mode specifies the conditions for updating the display. You can select one of the following options:

- Auto
 - If a trigger occurs within the timeout period (about 100 ms), the waveform display is updated.
 - If the timeout period elapses without a trigger occurring, the display is updated automatically.
 - If the period of the trigger signal is greater than 100 ms, the display is updated as the two conditions described above alternate. If this occurs, use Normal mode.
- Normal
 - The display is only updated when a trigger occurs.
 - If a trigger does not occur, the display is not updated.

Selecting a Trigger Source

You can set the trigger source (which is the signal that the WT500 searches for the trigger condition in) to one of the signals listed below. The selectable items vary depending on the number of elements installed in the WT500.

U1, I1, U2, I2, U3, I3, and Ext Clk (external clock)*

- * If you select Ext Clk as the trigger source, apply a signal that meets the specifications given on the following page. When Ext Clk is set as the trigger source, the trigger level setting is invalid.

When Setting the Trigger Source to Ext Clk

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



Item	Specification
Connector type	BNC connector
Input level	TTL
Minimum pulse width	1 μ s
Trigger delay time	within (1 μ s + 3 sample intervals)



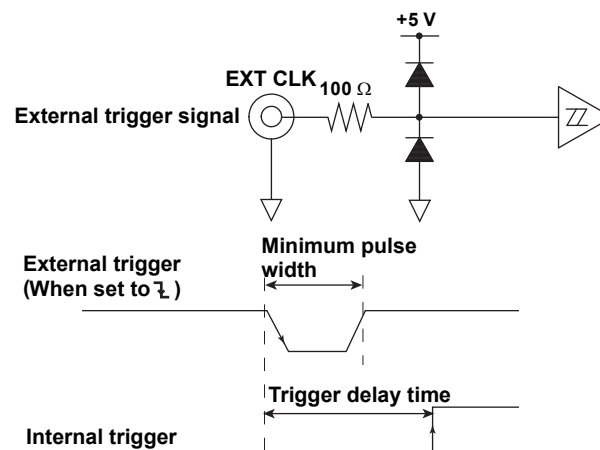
CAUTION

Applying a voltage outside of the range of 0 to 5 V to the external clock input connector (EXT CLK) can damage the WT500.

Note

- The synchronized measurement slave setting and the trigger source Ext Clk setting cannot be made at the same time because they both use the same connector (see section 12.6 for information about synchronized measurement).
- To connect a BNC cable to the external clock input/external start signal output connector (EXT CLK) when a GP-IB cable is connected to the GP-IB connector, first remove the GP-IB cable. Then connect the BNC cable. Finally, reconnect the GP-IB cable.

Input Circuit for the External Trigger Signal, and Time Chart



Selecting a Trigger Slope

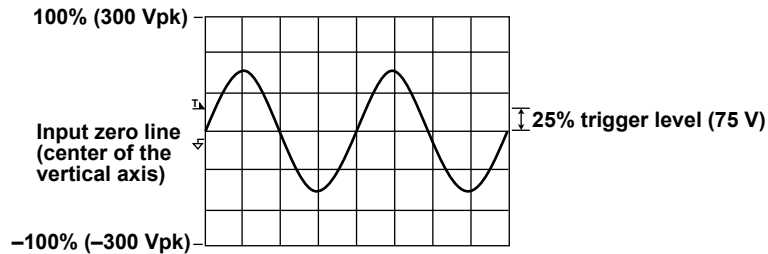
The upwards or downwards movement of a signal is referred to as slope. When a particular slope is used as a trigger condition, it is referred to as a trigger slope. You can select one of the following kinds of trigger slopes.

- \uparrow : A trigger occurs when the trigger source signal rises from a level lower than the trigger level to a level higher than the trigger level (rising edge).
- \downarrow : A trigger occurs when the trigger source signal falls from a level higher than the trigger level to a level lower than the trigger level (falling edge).
- $\uparrow\downarrow$: Triggers occur on both rising and falling edges.

Setting the Trigger Level

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

- The trigger level can be set to a value from 0.0 to $\pm 100.0\%$.
- 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% corresponds 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 of each element when the crest factor is set to 3, and six times when the crest factor is set to 6. When scaling is used, the upper and lower limits correspond to three or six times the scaled ranges.
- When the trigger source is set to Ext Clk, the trigger level setting is invalid.
- **Measurement range: 100 Vrms or 50 Vrms when the crest factor is set to 3 or 6, respectively.**
- **Trigger level: 25%**



Note

- To prevent noise-related errors, the trigger feature has a hysteresis of approximately 2% when the crest factor is set to 3. For example, when the trigger slope is set to \uparrow , a trigger will occur if the input signal level falls approximately 2% below the trigger level and then passes through the trigger level on a rising edge. The trigger feature has a hysteresis of approximately 4% when the crest factor is set to 6.
 - When integration is in progress or suspended, the trigger feature does not function. 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.
 - You cannot set the WT500 to the synchronized measurement slave setting and the trigger source Ext Clk setting at the same time because both settings use the same connector.
-

7.6 Vertically Zooming and Shifting Waveforms

Procedure

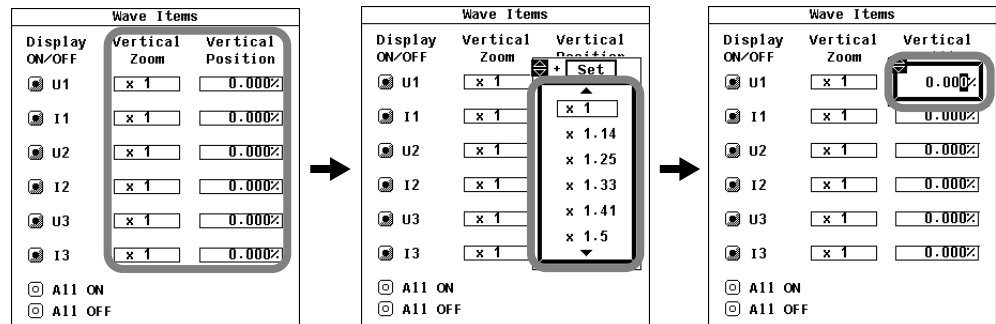
1. Press **ITEM** to display the Wave Items menu.

Zooming a Waveform

2. Use the **cursor keys** to select the measurement function zoom factor (in the Vertical Zoom column) that you want to set.
3. Press **SET** to display the zoom factor selection box.
4. Use the **cursor keys** to select a zoom factor.
5. Press **SET** to confirm the selection.

Shifting a Waveform Position

2. Use the **cursor keys** to select the measurement function vertical position (in the Vertical Position column) that you want to set.
3. Press **SET** to display the vertical position entry box.
4. Use the **cursor keys** to set the position as a percentage. A value of 100% is equivalent to three or six times the measurement range when the crest factor is set to 3 or 6, respectively.
5. Press **SET** or **ESC** to close the vertical position entry box.



Explanation

Zoom (Vertical only)

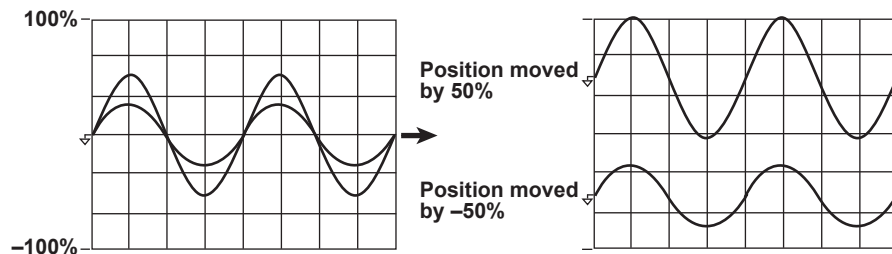
Each displayed waveform (voltage or current) can be scaled. You can select one of the following zoom factors:

- 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, or 100

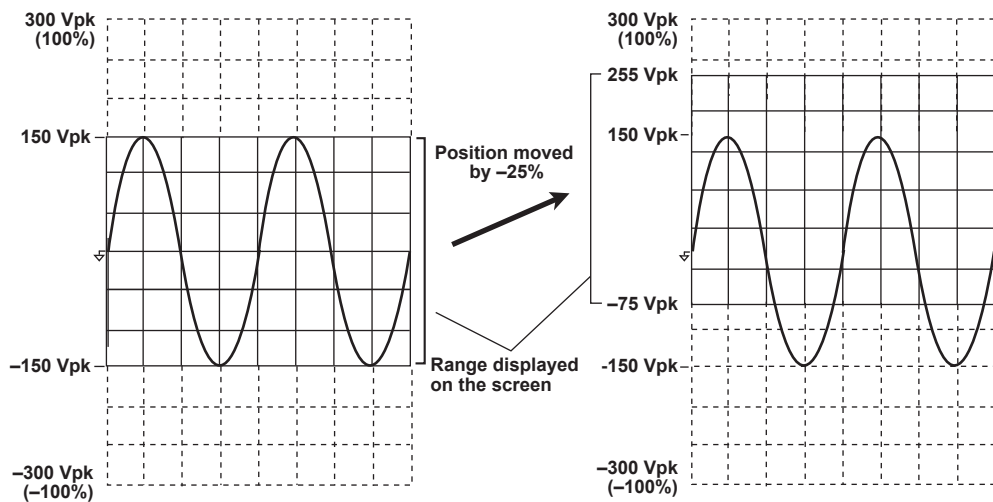
Shifting a Waveform Position (Vertically)

You can vertically shift the displayed position of a waveform. This is useful 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.

- The waveform position can be set to a value from 0.000 to $\pm 130.000\%$.
- When the zoom factor is set to 1, a value of 100% corresponds to half the height of the waveform display (which is three or six times the measurement range when the crest factor is set to 3 or 6, respectively). The upper and lower vertical display limits of the screen are 100% and -100% .



- 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 or six times the measurement range (or to $\pm 100\%$) when the crest factor is set to 3 or 6, respectively. You must take the zoom factor into account when setting a waveform's position. The following figure is an example of the display when the crest factor is set to 3.



Note

When you want to zoom in on 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 part of the waveform that you want to view to the center of the display.
3. Set the vertical zoom factor.

7.7 Displaying Waveforms in Split Screens

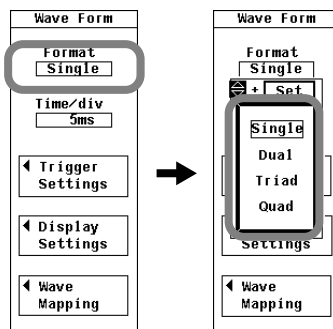
Procedure

1. Press **FORM** to display the Wave Form menu.

Selecting the Number of Split Screens

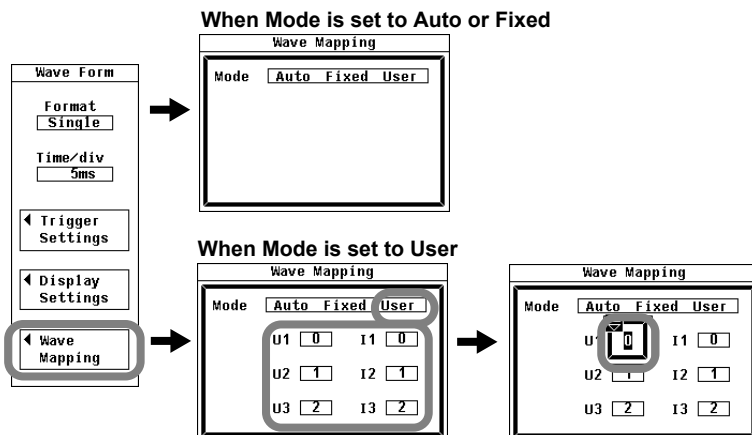
2. Use the **cursor keys** to select Format.
3. Press **SET** to display the split screen number selection box.
4. Use the **cursor keys** to select the number of split screens.
5. Press **SET** to confirm the selection.

You can also change the number of split screens by pressing WAVE. When you press WAVE, the number of split screens changes in this order: Single > Dual > Triad > Quad.



Selecting How Waveforms Are Assigned to Screens

6. Use the **cursor keys** to select Wave Mapping.
7. Press **SET** to display the Wave Mapping dialog box.
8. Press **SET** to select Auto, Fixed, or User. If you select User, proceed to step 10.
9. Use the **cursor keys** to select an input signal.
10. Press **SET** to display the display location selection box.
11. Use the **cursor keys** to select a number from 0 to 3.
12. Press **SET** or **ESC** to close the display location selection box.



Explanation

You can divide the screen equally into windows, and assign waveforms to those windows.

Selecting the Number of Split Screens

You can choose the number of split screens from one of the following options:

- Single: The screen is not split.
- Dual: Two split screens
- Triad: Three split screens
- Quad: Four split screens

Depending on the number of split screens, the number of displayed points in each screen changes as described below.

Single: 432 points, Dual: 216 points, Triad: 144 points, Quad: 108 points

Methods for Assigning Waveforms to Screens

- Auto
The waveforms whose displays are turned on (see section 7.2 for details) are assigned in order according to their element numbers, with an element's voltage waveform (U) coming before its current waveform (I).
- Fixed
Regardless of whether their displays are on or off, waveforms are assigned in order according to their element numbers, with an element's voltage waveform (U) coming before its current waveform (I).
- User
Waveforms can be assigned to windows by the user, regardless of whether their displays are on or off. Waveforms are assigned to screens by number. The screens are numbered from 0 to 3 in order from top to bottom.

7.8 Selecting a Graticule and Turning Interpolation, Scale Value Display, and Wave Labels On or Off

Procedure

1. Press **FORM** to display the Wave Form menu.
2. Use the **cursor keys** to select Display Settings.
3. Press **SET** to display the Display Settings dialog box.

Selecting Whether or Not to Use Interpolation

4. Use the **cursor keys** to select Interpolate.
5. Press **SET** to select $\cdot\cdot\cdot$ or \wedge .

Changing the Graticule

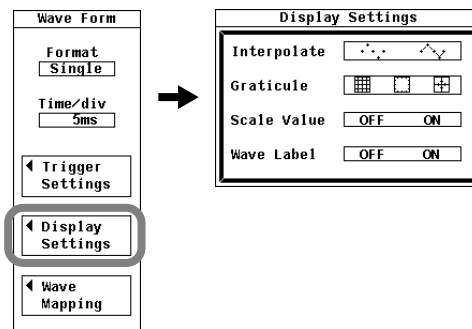
4. Use the **cursor keys** to select Graticule.
5. Press **SET** to select \square , \square or \oplus .

Selecting Whether or Not to Display the Scale Values

4. Use the **cursor keys** to select Scale Value.
5. Press **SET** to select ON or OFF.

Selecting Whether or Not to Display Waveform Labels

4. Use the **cursor keys** to select Wave Label.
5. Press **SET** to select ON or OFF.




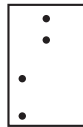
Explanation

For an explanation of the features themselves, see section 2.7.

Selecting Whether or Not to Use Interpolation


When there are less than 500 points of sampled data on the time axis, the displayed points (rasters) do not connect with each other. Numbers of sampled points below 500 are said to be within the interpolation range. The interpolation feature interpolates between points that are in the interpolation range. You can select one of the following options:

-  : No interpolation is performed.
 - Outside of the interpolation range



- Within the interpolation range



-  : The space between two data points is filled with a straight line.
 - Outside of the interpolation rangeThe spaces between vertically aligned dots are filled.



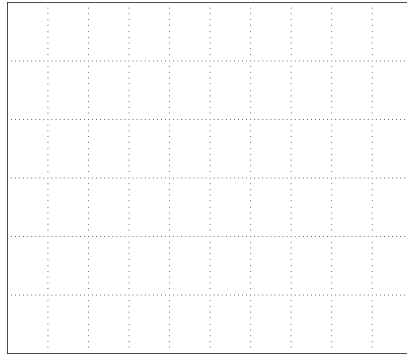
- Within the interpolation range




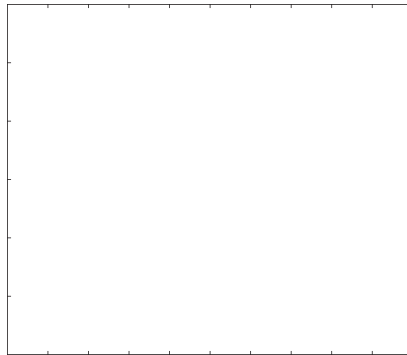
Changing the Graticule

You can choose one of the following graticule options:

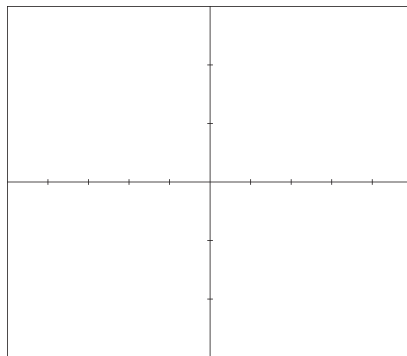
- : Grid



- : No grid or cross-hair



- : Cross-hair



7.8 Selecting a Graticule and Turning Interpolation, Scale Value Display, and Wave Labels On or Off

Turning the Display of the Scale Values On or Off

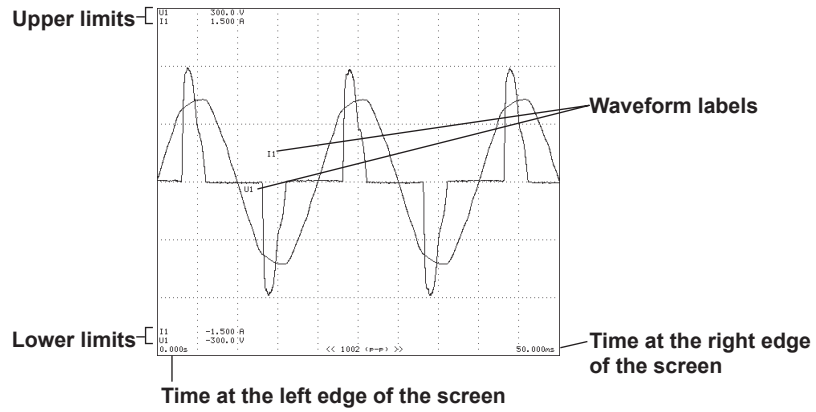
You can select whether or not to display the vertical axis upper and lower limits and the values at the right and left edges of the horizontal axis (time axis; see section 7.4 for details).

- ON
The scale values are displayed.
- OFF
The scale values are not displayed.

Turning the Display of Waveform Labels On or Off

You can choose whether or not to display waveform labels (input signal names).

- ON
Labels are displayed.
- OFF
Labels are not displayed.



7.9 Measuring with Cursors

Procedure

1. Press **SHIFT+FORM (CURSOR)** to display the Cursor menu.

Selecting Whether or Not to Use Cursor Measurement

2. Use the **cursor keys** to select Wave Cursor.
3. Press **SET** to select ON or OFF.
If you select ON, the results of cursor measurement are displayed.

Cursor	
Wave Cursor	OFF ON
Trace	
C1+	U1
C2×	I1
Position	
C1+	100
C2×	400
	<input type="checkbox"/> Linkage
Cursor Path	
	Max

Selecting the Waveforms to Measure Using Cursors

- **Selecting the Waveform to Measure Using Cursor +**
 4. Use the **cursor keys** to select C1+ under Trace.
 5. Press **SET** to display the waveform selection box.
 6. Use the **cursor keys** to select a waveform from the list (which starts with U1).
 7. Press **SET** to confirm the waveform selection.
- **Selecting the Waveform to Measure Using Cursor x**
 4. Use the **cursor keys** to select C2x under Trace.
 5. Press **SET** to display the waveform selection box.
 6. Use the **cursor keys** to select a waveform from the list (which starts with U1).
 7. Press **SET** to confirm the waveform selection.

Cursor		Cursor		Cursor	
Wave Cursor	OFF ON	Wave Cursor	OFF ON	Wave Cursor	OFF ON
Trace		Trace		Trace	
C1+	U1	C1+	U1	C1+	U1
C2×	I1	C2×	+ Set	C2×	I1
Position		Position		Position	
C1+	100	C1+	U1	C1+	U1
C2×	400	C2×	U2	C2×	I1
	<input type="checkbox"/> Linkage		<input type="checkbox"/> Linkage		<input type="checkbox"/> Linkage
Cursor Path		Cursor Path		Cursor Path	
	Max		Max		Max

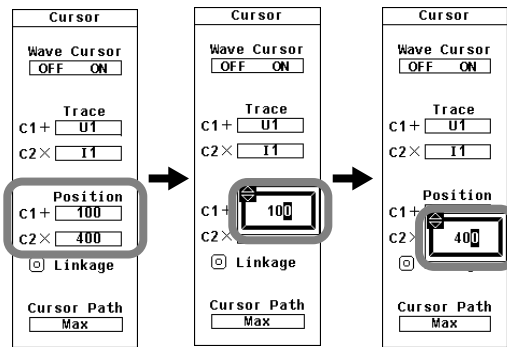
Moving the Cursors

• **Moving Cursor +**

- 8. Use the **cursor keys** to select C1+ under Position.
- 9. Press **SET** to display the cursor position entry box.
- 10. Use the **cursor keys** to set the cursor position.
- 11. Press **SET** or **ESC** to close the cursor position entry box.

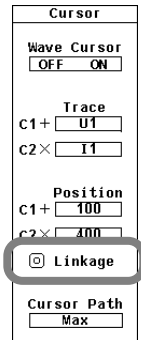
• **Moving Cursor x**

- 8. Use the **cursor keys** to select C2x under Position.
- 9. Press **SET** to display the cursor position entry box.
- 10. Use the **cursor keys** to set the cursor position.
- 11. Press **SET** or **ESC** to close the cursor position entry box.



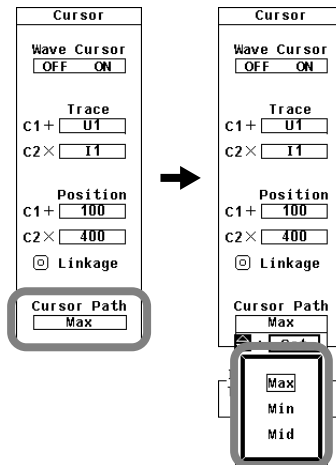
Linking the Cursor Positions

- 12. Use the **cursor keys** to select Linkage.
- 13. Press **SET** to turn Linkage on. The Linkage indicator lights.



Selecting a Cursor Path

14. Use the **cursor keys** to select Cursor Path.
15. Press **SET** to display the cursor path selection box.
16. Use the **cursor keys** to select one of the options from Max to Mid.
17. Press **SET** to confirm the selection.



Explanation

For an explanation of the cursor measurement feature itself, see section 2.7.

Turning Cursor Measurement On or Off

A cursor can be placed on the displayed waveform, and the value at the cursor location can be measured and displayed. The voltage or current at specific sections of the waveform and the data on the horizontal axis (X-axis) can be measured.

- ON: Cursor measurement is performed.
- OFF: Cursor measurement is not performed.

Selecting the Waveform to Measure

You can select the waveform to measure using cursors from one of the choices below. The selectable items vary depending on the number of elements installed in the WT500.

U1, I1, U2, I2, U3, and I3

Measurable Items

- Y+: Vertical value of cursor + (Y-axis value)
- Yx: Vertical value of cursor x (Y-axis value)
- ΔY : The difference between the Y-axis values of cursor + and cursor x
- X+: X-axis value of cursor + from the left edge of the screen
- Xx: X-axis value of cursor x from the left edge of the screen
- ΔX : The difference between the X-axis values of cursor + and cursor x
- $1/\Delta X$: Reciprocal of the difference between the X-axis values of cursor + and cursor x

Selecting a Cursor Path

Because the WT500 uses P-P compression on sampled data (see section 2.7 for details), 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 one of the options below.

- 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.

Moving the Cursors

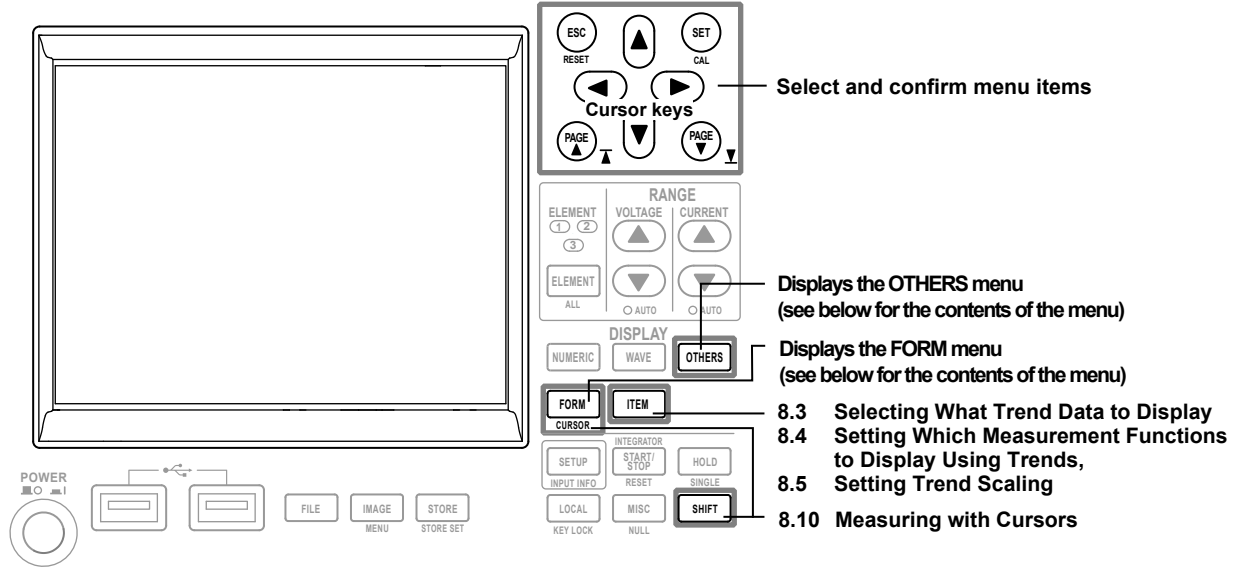
- Cursors move along the selected waveform.
- Cursors can be moved anywhere between the left and right edges of the display.
- The unit of cursor movement is the amount of time contained in one screen \div 500.
- When the cursor positions are linked, increasing or decreasing the setting for one cursor will increase or decrease the setting for the other cursor by the same amount.

Note

- If a cursor encounters immeasurable data, "****" is displayed in the measured value display area.
 - ΔY can be measured even when the units of the cursors are different. The measured result will not have a unit.
 - The range of the vertical axis that can be measured using cursors is within $\pm 300\%$ when the crest factor is set to 3 and within $\pm 600\%$ when the crest factor is set to 6.
-

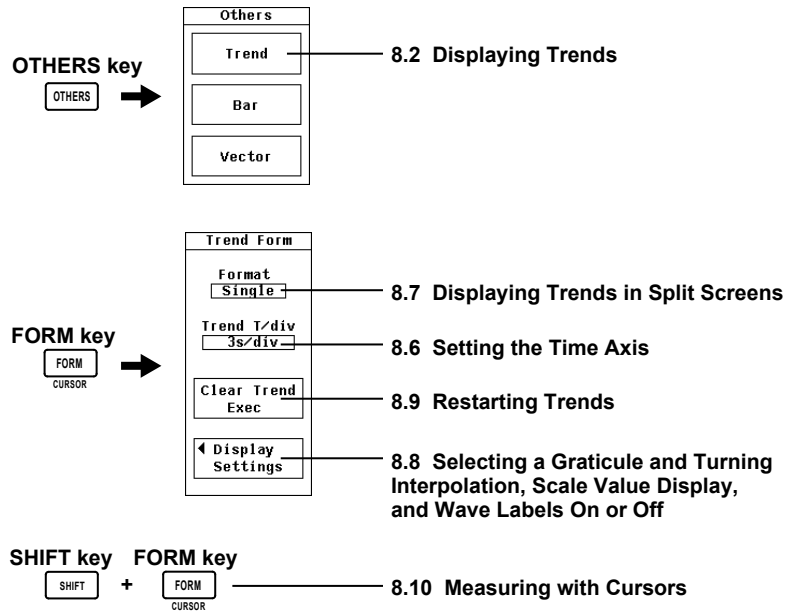
8.1 Panel Keys and Setup Menus Used in This Chapter

Panel Keys Used in This Chapter



Setup Menus Used in This Chapter

To set a parameter, access its menu by pressing the appropriate panel key. The setup menus and menu items used in this chapter are shown below, along with the sections that correspond to their operating instructions.



8.2 Displaying Trends

Procedure

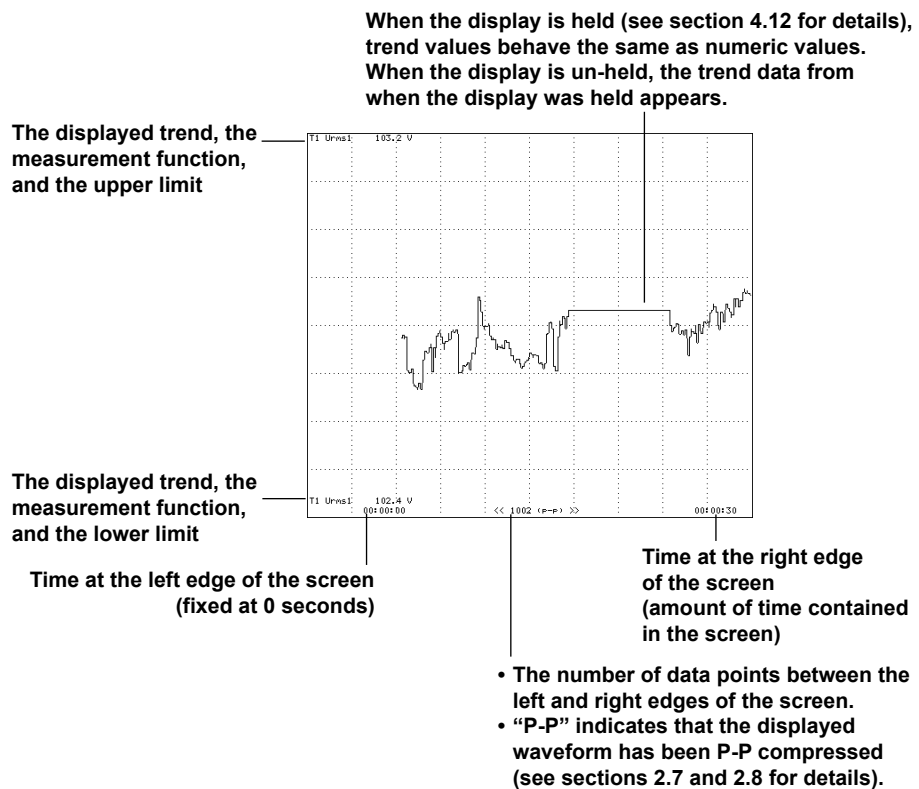
Displaying Trends

1. Press **OTHERS** to display the Others menu.
2. Use the **cursor keys** to select Trend.
3. Press **SET** to confirm the selection.



Explanation

A display example is shown below. As shown in the figure below, the horizontal axis represents time.



8.3 Selecting What Trend Data to Display

Procedure

1. Press **ITEM** to display the Trend Items menu.

Turning All Trend Displays On or Off

- **Turning All Trend Displays On**

2. Use the **cursor keys** to select All ON.
3. Press **SET**. The indicators to the left of the trend symbols all light, and all of the trends are displayed.

- **Turning All Trend Displays Off**

2. Use the **cursor keys** to select All OFF.
3. Press **SET**. The indicators to the left of the trend symbols all turn off, and none of the trends are displayed.

Turning Individual Trend Displays On or Off

2. Use the **cursor keys** to select a trend symbol.
3. Press **SET**. The indicator to the left of the selected trend symbol lights, and the trend that corresponds to the symbol is displayed. If you press SET again, the indicator turns off, and the trend is no longer displayed.

Trend Items					
Display ON/OFF	Function	Element/ Σ	Order	Scaling	Manual Upper/Lower
<input checked="" type="checkbox"/> T1	Urms	Element1	Total	Auto	[-1.000E+02 1.000E+02]
<input checked="" type="checkbox"/> T2	Urms	Element1	Total	Auto	[-1.000E+02 1.000E+02]
<input checked="" type="checkbox"/> T3	P	Element1	Total	Auto	[-1.000E+02 1.000E+02]
<input checked="" type="checkbox"/> T4	S	Element1	Total	Auto	[-1.000E+02 1.000E+02]
<input checked="" type="checkbox"/> T5	Q	Element1	Total	Auto	[-1.000E+02 1.000E+02]
<input checked="" type="checkbox"/> T6	A	Element1	Total	Auto	[-1.000E+02 1.000E+02]
<input checked="" type="checkbox"/> T7	ϕ	Element1	Total	Auto	[-1.000E+02 1.000E+02]
<input checked="" type="checkbox"/> T8	regU	Element1	Total	Auto	[-1.000E+02 1.000E+02]
<input type="checkbox"/> All ON					
<input type="checkbox"/> All OFF					

Indicators that tell whether the trend displays are on or off

Explanation

You can turn the displays of trends 1 to 8 (T1 to T8) on or off. For instructions on how to set the measurement functions whose trends are displayed by T1 to T8, see section 8.4.

8.4 Setting Which Measurement Functions to Display Using Trends

Procedure

1. Press **ITEM** to display the Trend Items menu.

Selecting a Measurement Function

2. Use the **cursor keys** to select a function (in the Function column).
3. Press **SET** to display the measurement function selection box.
4. Use the **cursor keys** to select a measurement function.
5. Press **SET** to confirm the selection.

The first screenshot shows the 'Trend Items' menu with the following data:

Display ON/OFF	Function	Element/Σ	Order	Scaling	Manual Upper/Lower
<input checked="" type="checkbox"/> T1	Urms	Element1	Total	Auto	-1.000E+02
<input checked="" type="checkbox"/> T2	Irms	Element1	Total	Auto	-1.000E+02
<input checked="" type="checkbox"/> T3	P	Element1	Total	Auto	-1.000E+02
<input checked="" type="checkbox"/> T4	S	Element1	Total	Auto	-1.000E+02
<input checked="" type="checkbox"/> T5	Q	Element1	Total	Auto	-1.000E+02
<input checked="" type="checkbox"/> T6	λ	Element1	Total	Auto	-1.000E+02
<input checked="" type="checkbox"/> T7	φ	Element1	Total	Auto	-1.000E+02
<input checked="" type="checkbox"/> T8	FreqU	Element1	Total	Auto	-1.000E+02
<input type="checkbox"/> A11 ON					
<input type="checkbox"/> A11 OFF					

The second screenshot shows the 'Set' dialog box for T1 with the following data:

Function	Element/Σ	Order	Scaling	Manual Upper/Lower
Urms	Element1	Total	Auto	-1.000E+02
Umn	Element1	Total	Auto	-1.000E+02
Udc	Element1	Total	Auto	-1.000E+02
Urms	Element1	Total	Auto	-1.000E+02
Uac	Element1	Total	Auto	-1.000E+02
Irms	Element1	Total	Auto	-1.000E+02

Selecting an Element or Wiring Unit

6. Use the **cursor keys** to select an element or wiring unit (in the Element/Σ column).
7. Press **SET** to display the element and wiring unit selection box.
8. Use the **cursor keys** to select an element or wiring unit.
9. Press **SET** to confirm the selection.

The first screenshot shows the 'Trend Items' menu with the following data:

Display ON/OFF	Function	Element/Σ	Order	Scaling	Manual Upper/Lower
<input checked="" type="checkbox"/> T1	Urms	Element1	Total	Auto	-1.000E+02
<input checked="" type="checkbox"/> T2	Irms	Element1	Total	Auto	-1.000E+02
<input checked="" type="checkbox"/> T3	P	Element1	Total	Auto	-1.000E+02
<input checked="" type="checkbox"/> T4	S	Element1	Total	Auto	-1.000E+02
<input checked="" type="checkbox"/> T5	Q	Element1	Total	Auto	-1.000E+02
<input checked="" type="checkbox"/> T6	λ	Element1	Total	Auto	-1.000E+02
<input checked="" type="checkbox"/> T7	φ	Element1	Total	Auto	-1.000E+02
<input checked="" type="checkbox"/> T8	FreqU	Element1	Total	Auto	-1.000E+02
<input type="checkbox"/> A11 ON					
<input type="checkbox"/> A11 OFF					

The second screenshot shows the 'Set' dialog box for T1 with the following data:

Element/Σ	Order	Scaling	Manual Upper/Lower
Element1	Total	Auto	-1.000E+02
Element2	Total	Auto	-1.000E+02
Element3	Total	Auto	-1.000E+02
Σ	Total	Auto	-1.000E+02

Selecting a Harmonic Order (Only on models with the harmonic measurement option)

10. Use the **cursor keys** to select Order.
11. Press **SET** to display the harmonic order selection box.
12. Use the **cursor keys** to select a harmonic order.
13. Press **SET** or **ESC** to close the harmonic order selection box.

Select a harmonic measurement function

The image shows two screenshots of the 'Trend Items' menu. The first screenshot shows the 'Order' column with a selection box around 'Total'. The second screenshot shows the 'Order' column with a selection box around 'Total' and a dropdown arrow, indicating the selection process.

Display ON/OFF	Function	Element	Order	Scaling	Manual Upper/Lower
<input checked="" type="checkbox"/> T1	U(k)	Element1	Total	Auto	=1.000E+02
<input checked="" type="checkbox"/> T2	I rms	Element1	Total	Auto	=1.000E+02
<input checked="" type="checkbox"/> T3	P	Element1	Total	Auto	=1.000E+02
<input checked="" type="checkbox"/> T4	S	Element1	Total	Auto	=1.000E+02
<input checked="" type="checkbox"/> T5	Q	Element1	Total	Auto	=1.000E+02
<input checked="" type="checkbox"/> T6	λ	Element1	Total	Auto	=1.000E+02
<input checked="" type="checkbox"/> T7	φ	Element1	Total	Auto	=1.000E+02
<input checked="" type="checkbox"/> T8	Frequ	Element1	Total	Auto	=1.000E+02
<input type="checkbox"/> All ON					
<input type="checkbox"/> All OFF					

Explanation

You can select what functions you want to display the trends of. You can set functions for eight trends from T1 to T8.

Selecting a Measurement Function

The types of measurement functions that can be selected are the functions described in “Types of Measurement Functions Used in Normal Measurement” and “Measurement Functions Used in Harmonic Measurement (Optional)” in section 2.2, in “User-Defined Functions” in section 2.5, in “Integration Functions” in section 2.6, and in “Delta Computation (Optional)” in section 5.17.

Selecting an Element or Wiring Unit

- You can select an element/wiring unit from the choices below. The selectable items vary depending on the number of elements installed in the WT500.
Element1, Element2, Element3, or Σ
- If an element in the selected wiring unit does not exist, because there is no data, the trend will not be displayed. For example, if an element assigned to Σ does not exist, trends are not displayed for Σ measurement functions.

Selecting a Harmonic Order (Only on models with the harmonic measurement option)

You can set the harmonic order to Total or to a harmonic from dc (0th) to the 50th harmonic.

Note

- For the meanings of the displayed measurement function symbols, see section 2.2, “Measurement Functions and Measurement Periods”; section 2.5, “Computation”; section 2.6, “Integration”; and appendix 1, “Symbols and Determination of Measurement Functions.”
 - For information about wiring unit Σ , see section 4.2, “Selecting a Wiring System.”
 - If there is no numeric data, a trend will not be displayed.
 - You can set the harmonic order to Total or from dc (0th) to the 50th harmonic. However, only the data of harmonics up to the maximum harmonic order value, which is determined automatically based on the PLL source frequency (see section 6.4 for details), is measured.
 - If you change one of the trend measurement functions, the displays of all trends up to that point are cleared, and the trends start over from the right edge of the screen.
 - When the trend of a user-defined function (F1 to F8) is displayed, the trend will not be cleared even if you change the function’s equation.
 - When the trend of a delta computation function ($\Delta F1$ to $\Delta F4$) is displayed, the trend will not be cleared even if you change the delta computation mode. (The delta computation feature is an option.)
-

8.5 Setting Trend Scaling

Procedure

1. Press **ITEM** to display the Trend Items menu.

Selecting Auto or Manual Scaling

2. Use the **cursor keys** to select Scaling.
3. Press **SET** to display the scaling selection box.
4. Use the **cursor keys** to select Auto or Manual.
5. Press **SET** to confirm the selection.
If you select Manual, proceed to step 6.

Trend Items					
Display ON/OFF	Function	Element/Σ	Order	Scaling	Manual Upper/Lower
<input checked="" type="checkbox"/> T1	Urms	Element1	Total	Auto	=1.000E+02
<input checked="" type="checkbox"/> T2	Irms	Element1	Total	Auto	=1.000E+02
<input checked="" type="checkbox"/> T3	P	Element1	Total	Auto	=1.000E+02
<input checked="" type="checkbox"/> T4	S	Element1	Total	Auto	=1.000E+02
<input checked="" type="checkbox"/> T5	Q	Element1	Total	Auto	=1.000E+02
<input checked="" type="checkbox"/> T6	Λ	Element1	Total	Auto	=1.000E+02
<input checked="" type="checkbox"/> T7	φ	Element1	Total	Auto	=1.000E+02
<input checked="" type="checkbox"/> T8	Frequ	Element1	Total	Auto	=1.000E+02
<input type="checkbox"/> A11 ON					
<input type="checkbox"/> A11 OFF					

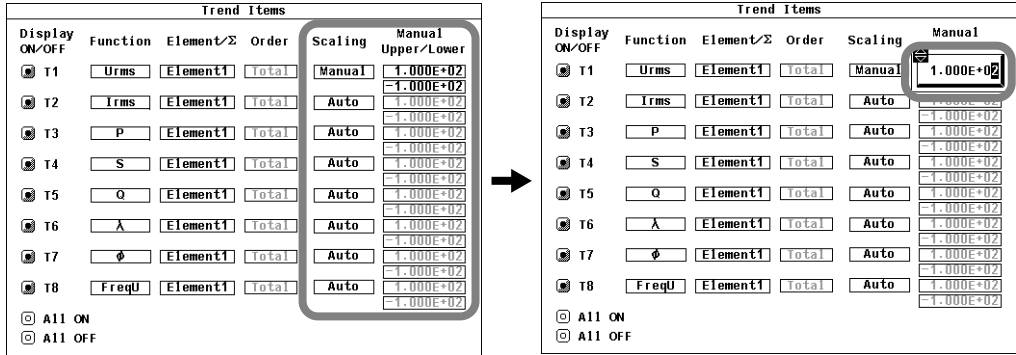
Trend Items					
Display ON/OFF	Function	Element/Σ	Order	Scaling	Manual Upper/Lower
<input checked="" type="checkbox"/> T1	Urms	Element1	Total	Auto	Set
<input checked="" type="checkbox"/> T2	Irms	Element1	Total	Auto	Auto
<input checked="" type="checkbox"/> T3	P	Element1	Total	Auto	Manual
<input checked="" type="checkbox"/> T4	S	Element1	Total	Auto	=1.000E+02
<input checked="" type="checkbox"/> T5	Q	Element1	Total	Auto	=1.000E+02
<input checked="" type="checkbox"/> T6	Λ	Element1	Total	Auto	=1.000E+02
<input checked="" type="checkbox"/> T7	φ	Element1	Total	Auto	=1.000E+02
<input checked="" type="checkbox"/> T8	Frequ	Element1	Total	Auto	=1.000E+02
<input type="checkbox"/> A11 ON					
<input type="checkbox"/> A11 OFF					

Setting the Upper Limit for Manual Scaling

6. Use the **cursor keys** to select the upper limit that you want to set (the top value in the row of the trend that you want to set in the Manual Upper/Lower column).
7. Press **SET** to display the scaling value entry box.
8. Use the **cursor keys** to set the upper limit.
9. Press **SET** or **ESC** to close the scaling value entry box.

Setting the Lower Limit for Manual Scaling

10. Use the **cursor keys** to select the lower limit that you want to set (the bottom value in the row of the trend that you want to set in the Manual Upper/Lower column).
11. Press **SET** to display the scaling value entry box.
12. Use the **cursor keys** to set the lower limit.
13. Press **SET** or **ESC** to close the scaling value entry box.



Explanation

Setting Trend Scaling

You can set the upper and lower limits of the trend display. You can select the method for setting those limits from the choices below.

- Auto
 - The upper and lower limits of the display are automatically determined based on the maximum and minimum displayed trend data values.
- Manual
 - The upper and lower display limits can be set manually.

Using Manual Scaling to Set the Upper and Lower Display Limits

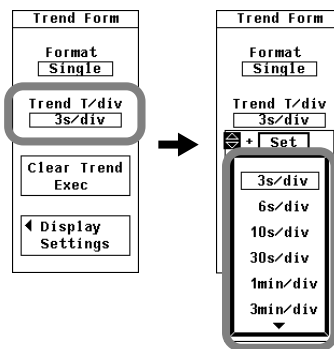
You can set the upper and lower limits within the range of -9.999E+30 to 9.999E+30.

8.6 Setting the Time Axis

Procedure

1. Press **FORM** to display the Trend Form menu.
2. Use the **cursor keys** to select Trend T/div.
3. Press **SET** to display the time axis selection box.
4. Use the **cursor keys** to select a time axis.
5. Press **SET** to confirm the selection.

When the scale value display is set to ON (see section 7.8 for details), the time at the left edge of the screen (which is fixed at zero seconds) appears in the lower left of the screen, and the time at the right edge of the screen appears in the lower right of the screen.



Explanation

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

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 rate and the time axis (T/div). For example, if the data update rate is 100 ms and you set T/div to 3s/div, the trend display is updated every second. If you set the data update rate to 5 s and T/div to 3s/div, the trend display is updated every 5 seconds, and the trend data is displayed as a line graph, with each point separated by five seconds. If you set T/div to 1 day the trend display will be updated once every 1728 seconds regardless of the data update rate.

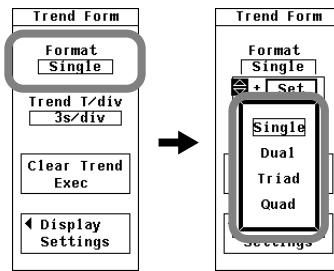
Note

- When you adjust the time axis setting, trend display data acquisition starts over. The trend display up to that point is cleared, and the trends start over from the right edge of the screen.
- One division (1 div) on the trend display is equivalent to 50 rasters. For example, if you set T/div to 1 day, one raster is 1728 s (which is equal to 1day/50), the trend data update interval is 1728 s, and the displayed data is P-P compressed. For information about rasters and P-P compression, see section 2.7.

8.7 Displaying Trends in Split Screens

Procedure

1. Press **FORM** to display the Trend Form menu.
2. Use the **cursor keys** to select Format.
3. Press **SET** to display the split screen number selection box.
4. Use the **cursor keys** to select the number of split screens.
5. Press **SET** to confirm the selection.



Explanation

You can assign trends to different split screens.

Selecting the Number of Split Screens

You can choose the number of split screens from one of the options listed below. The options are the same as those available in the waveform display (see section 7.7 for details).

- Single: The screen is not split.
- Dual: Two split screens
- Triad: Three split screens
- Quad: Four split screens

Depending on the number of split screens, the number of displayed points in each screen changes as described below.

Single: 432 points, Dual: 216 points, Triad: 144 points, Quad: 108 points

Methods for Assigning Waveforms to Screens

Trends whose displays are turned on (see section 8.3 for details) are assigned in numeric order (T1 to T8) to the split screens. The assignment method corresponds to the Auto option in the waveform display.

8.8 Selecting a Graticule and Turning Interpolation, Scale Value Display, and Wave Labels On or Off

Procedure

1. Press **FORM** to display the Trend Form menu.
2. Use the **cursor keys** to select Display Settings.
3. Press **SET** to display the Display Settings menu.

Selecting Whether or Not to Use Interpolation

4. See the instructions in “Selecting Whether or Not to Use Interpolation” in section 7.8.

Changing the Graticule

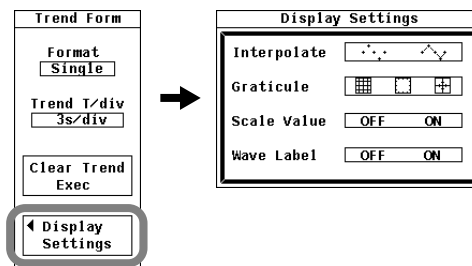
4. See the instructions in “Changing the Graticule” in section 7.8.

Selecting Whether or Not to Display the Scale Values

4. See the instructions in “Selecting Whether or Not to Display the Scale Values” in section 7.8.

Selecting Whether or Not to Display Waveform Labels

4. See the instructions in “Selecting Whether or Not to Display Waveform Labels” in section 7.8.



Explanation

Selecting Whether or Not to Use Interpolation

See the explanation “Selecting Whether or Not to Use Interpolation” in section 7.8.

Changing the Graticule

See the explanation in “Changing the Graticule” in section 7.8.

Turning the Display of the Scale Values On or Off

See the explanation in “Turning the Display of the Scale Values On or Off” in section 7.8.

Turning the Display of Waveform Labels On or Off

See the explanation in “Turning the Display of Waveform Labels On or Off” in section 7.8.

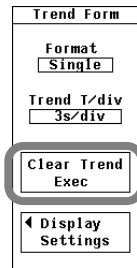
Note

The settings in this section are the same as the waveform display settings (see chapter 7 for details). If you change these settings in the trend display, the settings also change in the waveform display. For example, if you set the display of the scale values to OFF in the trend display, the display of the scale values will also be set to OFF in the waveform display.

8.9 Restarting Trends

Procedure

1. Press **FORM** to display the Trend Form menu.
2. Use the **cursor keys** to select Clear Trend Exec.
3. Press **SET**. The trends restart.



Explanation

When you restart trends, the trends up to that point are cleared.

In addition to when you execute Clear Trend Exec, trends will also restart when:

- The measurement function of a trend is adjusted.
- The trend display time axis (horizontal axis) is adjusted.
- Integration is started or reset.

8.10 Measuring with Cursors

Procedure

1. Press **SHIFT+FORM (CURSOR)**. The Cursor menu appears.

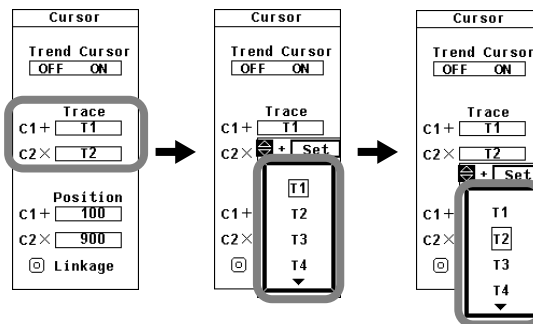
Selecting Whether or Not to Use Cursor Measurement

2. Use the **cursor keys** to select Trend Cursor.
3. Press **SET** to select ON or OFF.
If you select ON, the results of cursor measurement are displayed.

Cursor	
Trend Cursor	OFF ON
Trace	
C1+	T1
C2×	T2
Position	
C1+	100
C2×	900
☐ Linkage	

Selecting the Trends to Measure Using Cursors

- **Selecting the Trend to Measure Using Cursor +**
 4. Use the **cursor keys** to select C1+ under Trace.
 5. Press **SET** to display the trend selection box.
 6. Use the **cursor keys** to select one of the trends from T1 to T8.
 7. Press **SET** to confirm the trend selection.
- **Selecting the Trend to Measure Using Cursor x**
 4. Use the **cursor keys** to select C2x under Trace.
 5. Press **SET** to display the trend selection box.
 6. Use the **cursor keys** to select one of the trends from T1 to T8.
 7. Press **SET** to confirm the trend selection.



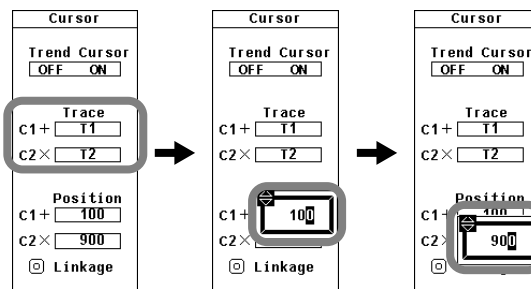
Moving the Cursors

• **Moving Cursor +**

8. Use the **cursor keys** to select C1+ under Position.
9. Press **SET** to display the cursor position entry box.
10. Use the **cursor keys** to set the cursor position.
11. Press **SET** or **ESC** to close the cursor position entry box.

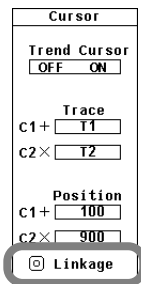
• **Moving Cursor x**

8. Use the **cursor keys** to select C2x under Position.
9. Press **SET** to display the cursor position entry box.
10. Use the **cursor keys** to set the cursor position.
11. Press **SET** or **ESC** to close the cursor position entry box.



Linking the Cursor Positions

12. Use the **cursor keys** to select Linkage.
13. Press **SET** to turn Linkage on. The Linkage indicator lights.



Explanation**Turning Cursor Measurement On or Off**

A cursor can be placed on the displayed trend, and the value at the cursor location can be measured and displayed. The vertical axis (Y-axis) and horizontal axis (X-axis) data of each trend can be measured.

- ON: Cursor measurement is performed.
- OFF : Cursor measurement is not performed.

Selecting the Trend to Measure

You can select the trend to measure from trends T1 to T8.

Moving the Cursors

- Cursors move along the selected trend.
- You can select the cursor position relative to the left edge of the screen in points, with the left edge itself being 0 points and the right edge being 1001 points.
- You can move through the displayed data one point at a time.
- When the cursor positions are linked, increasing or decreasing the setting for one cursor will increase or decrease the setting for the other cursor by the same amount.

Measurable Items

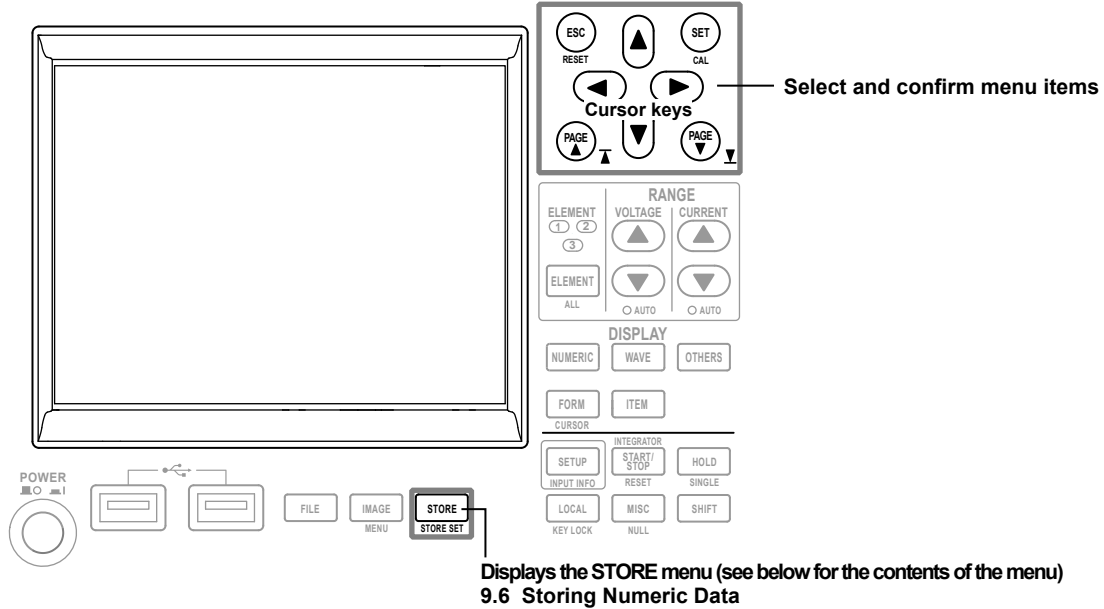
- Y+: Vertical value of cursor + (Y-axis value)
- Yx: Vertical value of cursor x (Y-axis value)
- ΔY : The difference between the Y-axis values of cursor + and cursor x
- X+: X-axis value of cursor + from the left edge of the screen
With the left edge of the screen being 0 seconds, the time between the left edge of the screen and cursor + is indicated.
- Xx: X-axis value of cursor x from the left edge of the screen
With the left edge of the screen being 0 seconds, the time between the left edge of the screen and cursor x is indicated.
- ΔX : The difference between the X-axis values of cursor + and cursor x
- D+: The date and time at cursor +
The date and time of measurement are displayed in this format: *Year/Month/Day Hour:Minute:Second.*
- Dx: The date and time at cursor x
The date and time of measurement are displayed in this format: *Year/Month/Day Hour:Minute:Second.*

Note

- If a cursor encounters immeasurable data, "****" is displayed in the measured value display area.
- ΔY can be measured even when the units of the cursors are different. The measured result will not have a unit.

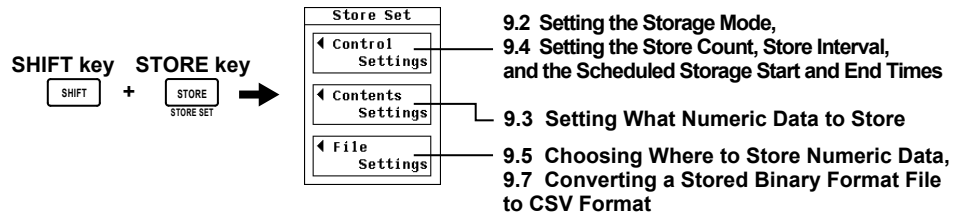
9.1 Panel Keys and Setup Menus Used in This Chapter

Panel Keys Used in This Chapter



Setup Menus Used in This Chapter

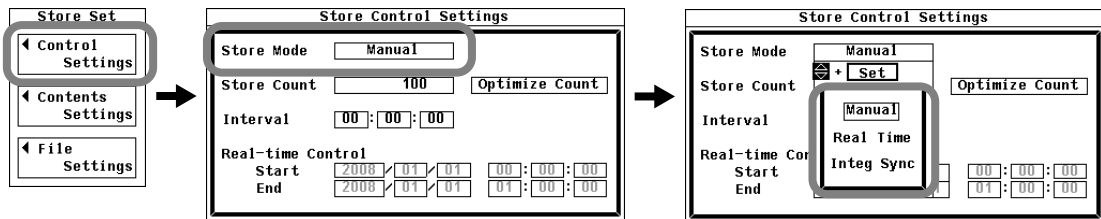
To set a parameter, access its menu by pressing the appropriate panel key. The setup menus and menu items used in this chapter are shown below, along with the sections that correspond to their operating instructions.



9.2 Setting the Storage Mode

Procedure

1. Press **SHIFT+STORE (STORE SET)** to display the Store Set menu.
2. Use the **cursor keys** to select Control Settings.
3. Press **SET** to display the Store Control Settings menu.
4. Use the **cursor keys** to select Store Mode.
5. Press **SET** to display the storage mode selection box.
6. Use the **cursor keys** to select a storage mode.
7. Press **SET** to confirm the selection.



Explanation

Before you can start storing numeric data, you must set the storage mode, store count, store interval, and the scheduled storage start and end times. This section discusses the storage mode. For information about the store count, store interval, and the scheduled storage start and end times, see section 9.4. For information about how to start the storage operation, see section 9.5.

Storage Mode

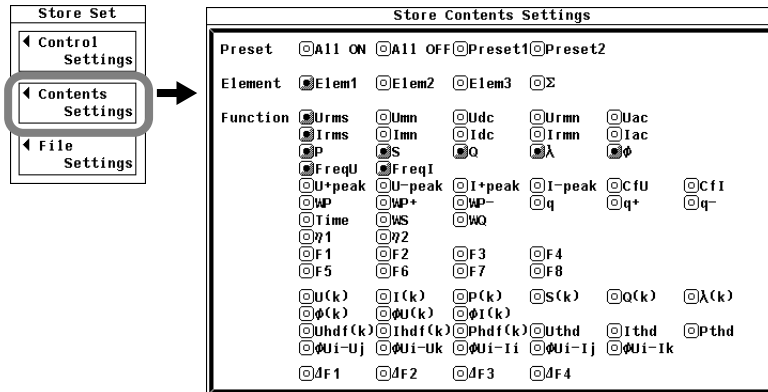
You can choose from one of the following methods for starting and stopping storage.

- **Manual**
When you press STORE, numeric data is stored for the number of times specified by the store count at the rate specified by the store interval.
- **Real Time**
After you press STORE, numeric data storage starts at the scheduled storage start time and continues at the rate specified by the store interval for the number of times specified by the store count (or until the scheduled storage end time is reached).
- **Integ Sync**
 - Storage is synchronized with integration. After you press STORE, numeric data storage starts at the same time as integration and continues at the rate specified by the store interval for the number of times specified by the store count (or until integration stops).
 - If you set the integration timer (see section 5.8 and 5.9 for details) so that it is an integer multiple of the store interval, you can store the final integrated value each time that the integration timer expires and integration resets.

9.3 Setting What Numeric Data to Store

Procedure

1. Press **SHIFT+STORE** (**STORE SET**) to display the Store Set menu.
2. Use the **cursor keys** to select Contents Settings.
3. Press **SET** to display the Store Contents Setting menu.



Selecting What Types of Numeric Data to Store

• Selecting All Numeric Data Types

4. Use the **cursor keys** to select All ON (next to Preset).
5. Press **SET**. The indicators to the left of all elements and measurement functions light to show that they are subject to the storage operation.

• Unselecting All Numeric Data Types

4. Use the **cursor keys** to select All OFF (next to Preset).
5. Press **SET**. The indicators to the left of all elements and measurement functions turn off to show that they are not subject to the storage operation.

• Selecting a Preset Group of Numeric Data Types

4. Use the **cursor keys** to select Preset1 or Preset2 (in the Preset row).
5. Press **SET**. The indicators to the left of the elements and measurement functions that have been preset to Preset1 or Preset2 light to show that they are subject to the storage operation.

Items Selected by Preset1

Store Contents Settings	
Preset	<input type="radio"/> A11 ON <input type="radio"/> A11 OFF <input checked="" type="radio"/> Preset1 <input type="radio"/> Preset2
Element	<input checked="" type="radio"/> Elem1 <input checked="" type="radio"/> Elem2 <input checked="" type="radio"/> Elem3 <input type="radio"/> Σ
Function	<input checked="" type="radio"/> Urms <input checked="" type="radio"/> Umn <input checked="" type="radio"/> Udc <input checked="" type="radio"/> Urmn <input checked="" type="radio"/> Uac <input checked="" type="radio"/> Irms <input checked="" type="radio"/> Imn <input checked="" type="radio"/> Idc <input checked="" type="radio"/> Irmn <input checked="" type="radio"/> Iac <input checked="" type="radio"/> P <input checked="" type="radio"/> S <input checked="" type="radio"/> Q <input checked="" type="radio"/> Λ <input checked="" type="radio"/> φ <input checked="" type="radio"/> FreqU <input checked="" type="radio"/> FreqI <input checked="" type="radio"/> U+peak <input checked="" type="radio"/> U-peak <input checked="" type="radio"/> I+peak <input checked="" type="radio"/> I-peak <input checked="" type="radio"/> CfU <input checked="" type="radio"/> CfI <input checked="" type="radio"/> WP <input checked="" type="radio"/> WP+ <input checked="" type="radio"/> WP- <input checked="" type="radio"/> q <input checked="" type="radio"/> q+ <input checked="" type="radio"/> q- <input checked="" type="radio"/> Time <input checked="" type="radio"/> WS <input checked="" type="radio"/> WQ <input checked="" type="radio"/> η1 <input checked="" type="radio"/> η2 <input checked="" type="radio"/> F1 <input checked="" type="radio"/> F2 <input checked="" type="radio"/> F3 <input checked="" type="radio"/> F4 <input checked="" type="radio"/> F5 <input checked="" type="radio"/> F6 <input checked="" type="radio"/> F7 <input checked="" type="radio"/> F8 <input checked="" type="radio"/> U(k) <input checked="" type="radio"/> I(k) <input checked="" type="radio"/> P(k) <input checked="" type="radio"/> S(k) <input checked="" type="radio"/> Q(k) <input checked="" type="radio"/> Λ(k) <input checked="" type="radio"/> φ(k) <input checked="" type="radio"/> φU(k) <input checked="" type="radio"/> φI(k) <input checked="" type="radio"/> UhdF(k) <input checked="" type="radio"/> IhdF(k) <input checked="" type="radio"/> PhdF(k) <input checked="" type="radio"/> Uthd <input checked="" type="radio"/> Ithd <input checked="" type="radio"/> Pthd <input checked="" type="radio"/> φUi-Uj <input checked="" type="radio"/> φUi-Uk <input checked="" type="radio"/> φUi-Ii <input checked="" type="radio"/> φUi-Ij <input checked="" type="radio"/> φUi-Ik <input checked="" type="radio"/> dF1 <input checked="" type="radio"/> dF2 <input checked="" type="radio"/> dF3 <input checked="" type="radio"/> dF4

Items Selected by Preset2

Store Contents Settings	
Preset	<input type="radio"/> A11 ON <input type="radio"/> A11 OFF <input type="radio"/> Preset1 <input checked="" type="radio"/> Preset2
Element	<input type="radio"/> Elem1 <input type="radio"/> Elem2 <input type="radio"/> Elem3 <input type="radio"/> Σ
Function	<input type="radio"/> Urms <input type="radio"/> Umn <input type="radio"/> Udc <input type="radio"/> Urmn <input type="radio"/> Uac <input type="radio"/> Irms <input type="radio"/> Imn <input type="radio"/> Idc <input type="radio"/> Irmn <input type="radio"/> Iac <input type="radio"/> P <input type="radio"/> S <input type="radio"/> Q <input type="radio"/> Λ <input type="radio"/> φ <input type="radio"/> FreqU <input type="radio"/> FreqI <input type="radio"/> U+peak <input type="radio"/> U-peak <input type="radio"/> I+peak <input type="radio"/> I-peak <input type="radio"/> CfU <input type="radio"/> CfI <input type="radio"/> WP <input type="radio"/> WP+ <input type="radio"/> WP- <input type="radio"/> q <input type="radio"/> q+ <input type="radio"/> q- <input type="radio"/> Time <input type="radio"/> WS <input type="radio"/> WQ <input type="radio"/> η1 <input type="radio"/> η2 <input type="radio"/> F1 <input type="radio"/> F2 <input type="radio"/> F3 <input type="radio"/> F4 <input type="radio"/> F5 <input type="radio"/> F6 <input type="radio"/> F7 <input type="radio"/> F8 <input type="radio"/> U(k) <input type="radio"/> I(k) <input type="radio"/> P(k) <input type="radio"/> S(k) <input type="radio"/> Q(k) <input type="radio"/> Λ(k) <input type="radio"/> φ(k) <input type="radio"/> φU(k) <input type="radio"/> φI(k) <input type="radio"/> UhdF(k) <input type="radio"/> IhdF(k) <input type="radio"/> PhdF(k) <input type="radio"/> Uthd <input type="radio"/> Ithd <input type="radio"/> Pthd <input type="radio"/> φUi-Uj <input type="radio"/> φUi-Uk <input type="radio"/> φUi-Ii <input type="radio"/> φUi-Ij <input type="radio"/> φUi-Ik <input type="radio"/> dF1 <input type="radio"/> dF2 <input type="radio"/> dF3 <input type="radio"/> dF4

- **Setting Numeric Data Types One by One**
 4. Use the **cursor keys** to select the element or measurement function that you want to set.
 5. Press **SET**. If the indicator to the left of the element or measurement function that you selected lights, its corresponding numeric data is subject to the storage operation. If the indicator turns off, its corresponding numeric data is not subject to the storage operation.

Explanation

Selecting What Numeric Data Types to Store

You can choose whether or not to store the numeric data of the items in the Store Contents Setting menu.

- You can select to store the numeric data of any of the elements or wiring units installed in the WT500.
- The numeric data of the measurement functions described in “Types of Measurement Functions” and “Types of Measurement Functions Used in Harmonic Measurement” in section 2.2 can be stored.

Note

- For the meanings of the displayed measurement function symbols, see section 2.2, “Measurement Functions and Measurement Periods”; section 2.5, “Computation”; section 2.6, “Integration”; and appendix 1, “Symbols and Determination of Measurement Functions.”
 - You can only select wiring unit Σ when it has been selected according to the procedure described in section 4.2, “Selecting a Wiring System.”
 - For items with no numeric data, “NAN” (no data) is stored.
 - When integration is not taking place, the integrated value will be stored as “NAN” (no data), because no integrated value exists. The integration time will also be stored as “NAN” (no data).
 - The maximum harmonic order that can be stored is determined by the maximum harmonic order set in the harmonic measurement (option) menu. For harmonic orders with no numeric data, “NAN” (no data) is stored.
 - $\Delta F1$ to $\Delta F4$ are stored according to the delta computation mode selected in the delta computation settings (optional). For details, see section 5.17.
-

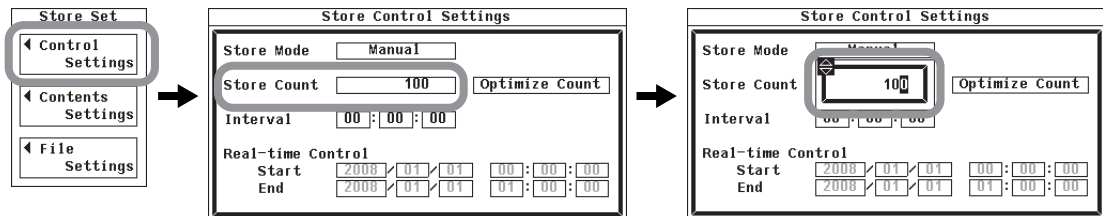
9.4 Setting the Store Count, Store Interval, and the Scheduled Storage Start and End Times

Procedure

1. Press **SHIFT+STORE (STORE SET)** to display the Store Set menu.
2. Use the **cursor keys** to select Control Settings.
3. Press **SET** to display the Store Control Settings menu.

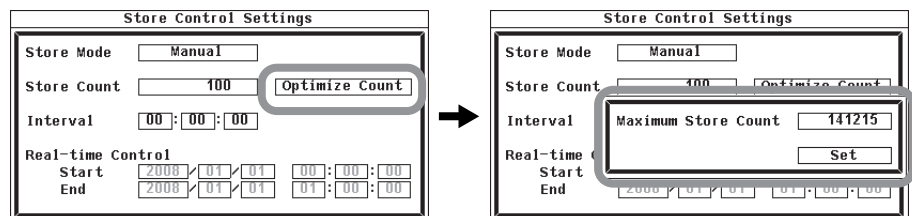
Setting the Store Count

4. Use the **cursor keys** to select Store Count.
5. Press **SET** to display the store count entry box.
6. Use the **cursor keys** to set the store count.
7. Press **SET** or **ESC** to close the store count entry box.



Checking the Maximum Store Count and Optimizing the Store Count

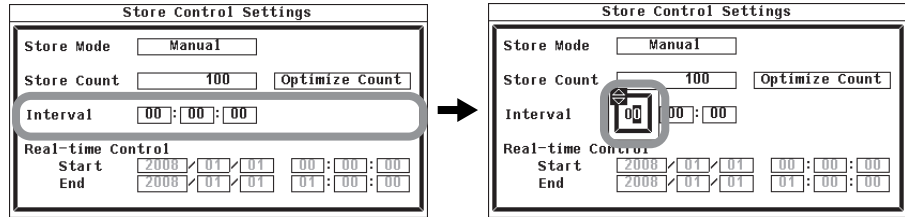
8. Use the **cursor keys** to select Optimize Count.
9. Press **SET**. The Optimize Count dialog box appears, and the maximum store count is displayed.
If the displayed maximum store count value is less than the value that you set in step 6, proceed to step 10. Otherwise, proceed to step 16.
10. Use the **cursor keys** to select Maximum Store Count.
11. Press **SET** to display an entry box.
12. Use the **cursor keys** to set the store count to a value that is less than or equal to the maximum store count as necessary.
13. Press **SET** or **ESC** to close the entry box.
14. Use the **cursor keys** to select Set.
15. Press **SET**.



9.4 Setting the Store Count, Store Interval, and the Scheduled Storage Start and End Times

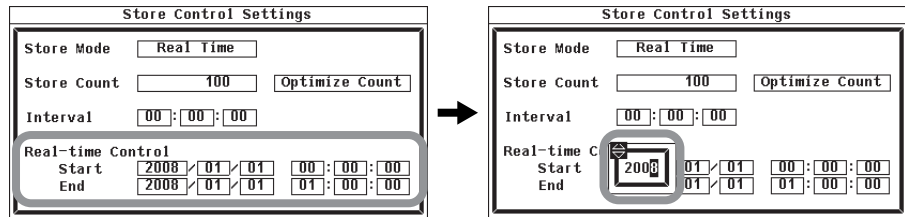
Setting the Store Interval

16. Use the **cursor keys** to select one of the Interval boxes (hour, minute, or second).
17. Press **SET** to display an entry box.
18. Use the **cursor keys** to set the hour, minute, or second that you selected in step 16.
For instructions on how to use the cursor keys to enter the values, see section 3.14, "Entering Values and Character Strings."
19. Press **SET** or **ESC** to close the entry box.
20. Repeat steps 16 to 19 to set the hour, minute, and second.



Setting the Scheduled Storage Start and End Times (Only when the storage mode is set to Real Time)

8. Use the **cursor keys** to select one of the Real-time Control storage start time boxes (year, month, day, hour, minute, or second).
9. Press **SET** to display an entry box.
10. Use the **cursor keys** to set the year, month, date, hour, minute, or second that you selected in step 8.
11. Press **SET** or **ESC** to close the entry box.
12. Repeat steps 8 to 11 to set the year, month, date, hour, minute, and second.
13. Use the **cursor keys** to select one of the Real-time Control storage end time boxes (year, month, day, hour, minute, or second).
14. Repeat steps 9 to 12 to set the year, month, date, hour, minute, and second.



Explanation

Before you can start storing numeric data, you must set the storage mode, store count, store interval, and the scheduled storage start and end times. This section discusses the store count, the store interval, and the scheduled storage start and end times. For instructions on how to set the storage mode, see section 9.2. For instructions on how to start the storage operation, see section 9.6.

Setting the Store Count

- The store count can be set to a value from 1 to 9999999.
- The store operation will end before the set store count is reached if the maximum amount of storable data (1 GB) is exceeded.

Checking the Maximum Store Count and Optimizing the Store Count

The data types selected in section 9.3 are used to compute and display the maximum number of times that numeric data can be stored in the available memory. If you change the displayed maximum store count as necessary and then confirm the setting, the actual store count will change.

- You can set the store count to a value from 1 to the computed maximum store count.

Setting the Store Interval

You can set the interval at which numeric data is stored.

- You can set the interval hour, minute, and second within the following range. If you set the interval to 00:00:00, the numeric data will be stored at the numeric data update rate.
00:00:00 to 99:59:59
- If you set the integration timer (see section 5.8 and 5.9 for details) so that it is an integer multiple of the store interval, you can store the final integrated value each time that the integration timer expires and integration resets.

Setting the Scheduled Storage Start and End Times

You can set the year, month, day, hour, minute, and second of the storage start and end times. Be sure to set the storage end time to a time after the storage start time.

The start and end times can be set within the following ranges:

Year: Any four-digit Gregorian calendar value
Hour:Minute:Second 00:00:00 to 23:59:59

Note

- When the CSV file conversion method is set to Auto (see section 9.5 for details) and the storage medium is USB memory, the maximum store count is computed with the available memory for stored numeric data (.wts and .hds files) set to 20% of the available USB memory.
- You can set the day for the scheduled start or end time in February to a value as high as the 31st day. If you do so, an error message appears when storage is executed (see section 9.4 for details). Reset the scheduled start or end time.
- The WT500 recognizes leap years when it executes the storage operation.
- If you choose to store data through USB and the write speed of the connected USB 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. If this occurs, the storage condition indicator displays an asterisk (see "Explanation" in section 9.6 for details). You can prevent the loss of numeric data during storage by:
 - Lowering the numeric data update rate.
 - Reducing the number of stored data types.
 - Using faster USB memory.

9.5 Choosing Where to Store Numeric Data

CAUTION

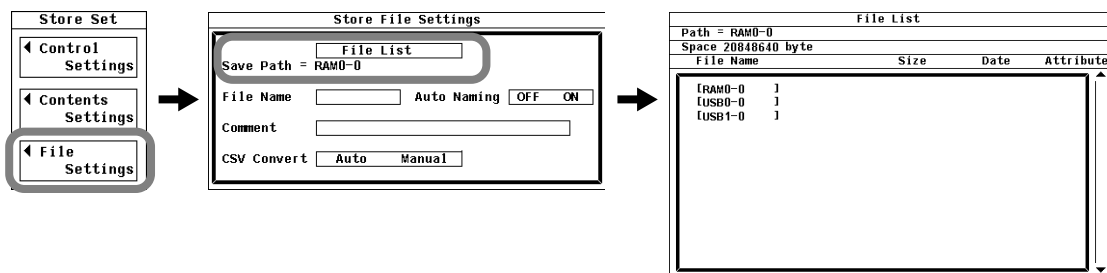
Do not remove USB memory or turn off the power when the screen icon that indicates USB access or USB memory access indicators are blinking. If you do, the USB memory may be damaged, and its data may be corrupted.

Procedure

1. Press **SHIFT+STORE (STORE SET)** to display the Store Set menu.
2. Use the **cursor keys** to select File Settings.
3. Press **SET** to display the Store File Settings dialog box.

Selecting a Storage Medium

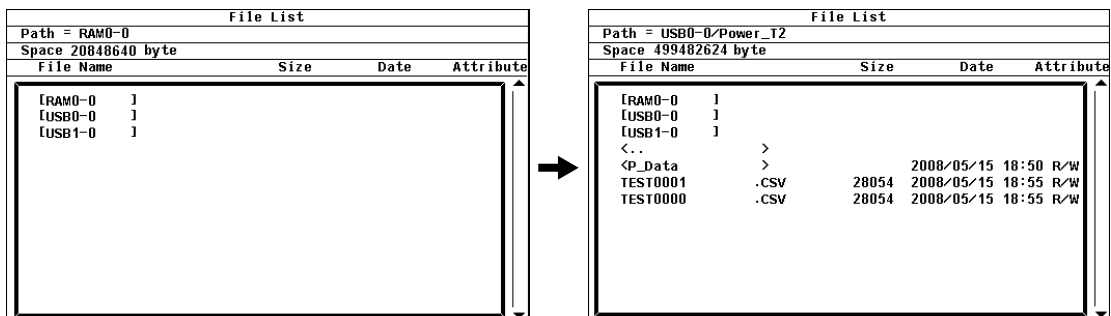
4. Use the **cursor keys** to select File List.
5. Press **SET** to display the File List dialog box.
6. Use the **cursor keys** to select the storage medium (displayed using brackets) that you want to save to.
7. Press **SET** to confirm the storage media selection.



Selecting a Directory

(Follow these procedures if the storage medium has directories.)

8. Use the **cursor keys** to select the directory (displayed using < >) that you want to save to.
9. Press **SET** to confirm the directory selection.
 - The selected storage medium and directory appear in the upper left of the File List dialog box after "Path=."
 - Select <..> and press **SET** to move up to the parent directory.
10. Press **ESC** to close the File List dialog box.

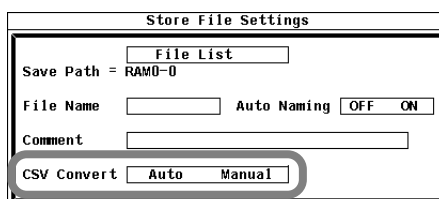


Setting Comments and the Name of the File that You Want to Save to

11. Use the **cursor keys** to select File Name.
12. Press **SET**. A keyboard appears on the screen.
13. Use the keyboard to enter the file name.
For instructions on how to use the keyboard, see section 3.14, "Entering Values and Character Strings."
14. Use the **cursor keys** to select Auto Naming.
15. Press **SET** to select ON or OFF.
16. Use the **cursor keys** to select Comment.
17. Press **SET**. A keyboard appears on the screen.
Enter text just as you did in File Name.

Selecting Automatic CSV File Conversion

18. Use the **cursor keys** to select CSV Convert.
19. Press **SET** to select Auto or Manual.



The screenshot shows a menu titled "Store File Settings". It contains several options: "File List" (highlighted), "Save Path = RAM0-0", "File Name" (with an input field), "Auto Naming" (with "OFF" and "ON" options), "Comment" (with an input field), and "CSV Convert" (with "Auto" and "Manual" options). The "CSV Convert" option and its sub-options are circled in red.

Explanation

About Stored Data Saving

- Stored data is saved to files in binary format (with .wts extensions).
- Measurement conditions, settings, and other information about the stored data are saved in binary format to header files (with .hds extensions).
- Up to 1 GB of data can be stored if the storage medium is set to USB memory.
- The capacity of the internal RAM disk is 20 MB.

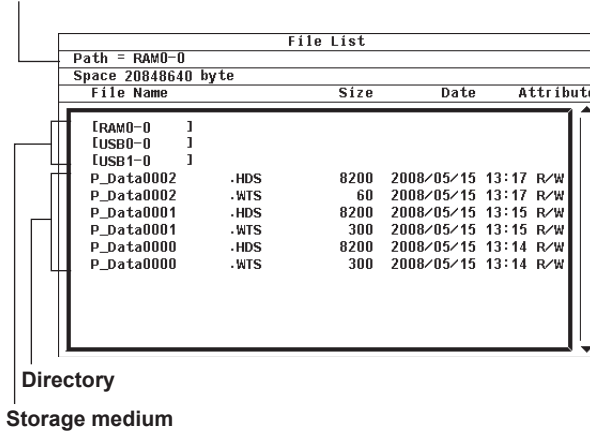
File Extensions

Data Type	Extension	Size (in bytes)
ASCII	.csv	Approximately 3 K (when storing the data types specified by Preset1 for one element 10 times)
Binary	.wts	When the integration time is not included Approximately $(4 \times D_n + 16) \times \text{store count}$ When the integration time is included Approximately $(4 \times D_n + 16 + 16 \times T_i) \times \text{store count}$ where D_n = the number of stored numeric data types the number of stored numeric data types = the no. of measurement functions \times (no. of elements + no. of wiring units) T_i = the number of stored integration times (the number of elements).
	.hds	Approximately 8KB

Selecting the Storage Medium and Directory

The storage medium and directory that will be saved to are displayed in the File List dialog box.

Currently selected storage medium and directory



Media Type Display Examples

- [RAM0-0]: The internal RAM disk
- [USB0-0]: USB memory with an ID number of 0
- [USB1-0]: USB memory with an ID number of 1

File Names and Comments

- You must enter a file name. You do not need to enter a comment.
- You cannot enter a file name if there is another file in the same directory with that name (no overwriting).

Usable Characters and Maximum String Lengths

Setting	Max. Length	Usable Characters
File name	1 to 8 characters	0-9, A-Z, %, _, parentheses, and minus signs
Comment	0 to 25 characters	Spaces and all characters that are displayed on the keyboard

Auto Naming Feature

If you set Auto Naming to ON, the WT500 will automatically assign a four digit number to the files that it saves, from 0000 to 0999. You can set a common file name to put before the number (by specifying it in File Name; the name can have up to eight characters).

Selecting Automatic CSV File Conversion

You can automatically create ASCII CSV files from stored numeric data (.wts) and header (.hds) files.

Auto: After numeric data is stored, it is automatically converted into an ASCII (.csv) file.

- When the numeric data storage medium is the internal RAM disk (“[RAM0-0]”), the CSV file is created on the USB memory device whose ID number is 0.
- If the numeric data storage medium is USB memory (“[USB0-0]” or “[USB1-0]”), the CSV file is created in the same directory as the numeric data files that it is converted from.

Manual: ASCII (.csv) files are not automatically created. After storage has finished, you can select stored numeric data files and convert them to CSV files. For information about converting files to CSV format, see section 9.7, “Converting a Stored Binary Format File to CSV Format.”

Note

- When you save numeric data, places without numeric values either contain blank spaces or one of these strings: NAN, +INF, -INF, or ERROR. (The places that contain blank spaces are in functions such as the ones for the 0th and 1st harmonic orders of fU and fI, where the screen display is also blank.)
 - Up to 1000 files and directories can be displayed in the file list. If there are more than a total of 1000 files and directories in a given directory, the file list for that directory will only display 1000 files and directories. There is no way to set which files and directories are displayed.
 - Files without archive attributes are not displayed in the File List window. Do not clear the archive attributes of files on your PC that were saved using the WT500.
 - File paths can be displayed using up to 41 characters. If a path exceeds 41 characters, an ellipsis appears at the end of the character string.
 - File names are not case-sensitive. Comments are case-sensitive. The following file names cannot be used due to MS-DOS limitations:
AUX, CON, PRN, NUL, CLOCK, COM1 to COM9, and LPT1 to LPT9
 - A directory can contain up to 1000 files. To save more than 1000 files, either start saving to a different directory, or move already saved files to a different directory.
 - If there are a large number of files on a single directory, the amount of time that it takes to write to and read files becomes longer. If this happens, start saving files to a directory with less files, or move the files in the save destination to a different directory.
 - Larger numeric data files take longer to store. The storage of a new file does not start until the storage of the preceding file finishes. When files are large and take a long time to store, data loss may occur. If this occurs, the storage condition indicator displays an asterisk (see "Explanation" in section 9.6 for details).
 - If you choose to store data through USB and the write speed of the connected USB 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. If this occurs, the storage condition indicator displays an asterisk (see "Explanation" in section 9.6 for details). You can prevent the loss of numeric data during storage by:
 - Lowering the numeric data update rate.
 - Reducing the number of stored data types.
 - Using faster USB memory.
 - Please be aware that the number of times that you can write to USB memory is limited.
-

9.6 Storing Numeric Data

Procedure

If you are storing numeric data for the first time after turning the power switch on, proceed to step 1. If you have stored numeric data in the past, proceed to step 3 to initialize storage.

Starting the Storage Operation

1. Press **STORE**. Depending on the storage mode (see section 9.2 for details), storage will start under one of the following conditions:
 - In Manual Mode
Storage starts immediately. The store key lights, and “Store:Start” appears in the upper left of the screen.
 - In Real Time Mode
The WT500 enters into a storage-ready state. The STORE key blinks, and “Store:Ready” appears in the upper left of the screen. Storage starts at the scheduled storage start time. The store key lights, and “Store:Start” appears in the upper left of the screen.
 - In Integration Synchronization (Integ Sync) Mode
The WT500 enters into a storage-ready state. The STORE key blinks, and “Store:Ready” appears in the upper left of the screen. Storage starts when integration starts. The store key lights, and “Store:Start” appears in the upper left of the screen.

Manually Stopping the Storage Operation

2. After starting storage, you can press **STORE** again to stop storage. The STORE key light turns off.

Automatically Stopping the Storage Operation

2. Depending on the storage mode, storage will stop, and the STORE key light will turn off under one of the following conditions:
 - In Manual Mode
Storage will stop when the store count is reached, when there is no more available memory, or when the maximum amount of storable data (1 GB) has been stored. “Store:Stop” appears in the upper left of the screen.
 - In Real Time Mode
Storage will stop when the store count has been reached, at the scheduled storage end time, or when the maximum amount of storable data has been stored. “Store:Stop” appears in the upper left of the screen.
 - In Integration Synchronization Mode
Storage will stop when the store count has been reached, when integration stops, or when the maximum amount of storable data has been stored. “Store:Stop” appears in the upper left of the screen.

Resetting the Storage Operation

3. After storage has stopped, press **STORE** again.
The storage condition indicator is cleared.

Note

Stored files are retained when you reset a storage operation.

Explanation

Before you can start storing numeric data, you must set the storage mode, store count, store interval, and the scheduled storage start and end times. This section explains how to start and end storage. For instructions on how to set the storage mode, see section 9.2. For instructions on how to set the store count, store interval, and storage start and end times, see section 9.4.

Storage-Related Display Indications

When storage is started or stopped, the storage condition and store count appear at the left of the screen.

When storage is in progress	When the WT500 is ready to store	After storage has stopped
<pre>Normal Mode Uover: == == Store:Start 4 Iover: == == [Icon] + [SET] : change items</pre>	<pre>Normal Mode Uover: == == Store:Ready 0 Iover: == == [Icon] + [SET] : change items</pre>	<pre>Normal Mode Uover: == == Store:Stop 46 Iover: == == [Icon] + [SET] : change items</pre>
<p>Number of times storage has taken place Store condition</p>		

Starting the Storage Operation

- Storage will start under different conditions depending on the storage mode (see section 9.2 for storage mode details). For details, see the storage start instructions earlier in this section.
- You cannot start storage if the storage operation has not been reset.
- You do not need to reset the storage operation the first time you start storage after turning the power on.

Stopping the Storage Operation

- You can use the STORE key to stop storage manually.
- Storage will stop under different conditions depending on the storage mode. For details, see the storage stop instructions earlier in this section.

Resetting the Storage Operation

After you have stopped storage, you must reset the storage operation in order to start storing again.

How Numeric Data Is Stored

Numeric data is either stored to USB memory or to the internal RAM disk. When you turn off the WT500 power, the contents of the internal RAM disk are lost. If you choose to store numeric data to the internal RAM disk, save it to USB memory before you turn off the WT500.

Note

- During storage, no icons appear to indicate that storage medium is being accessed.
- For items with no numeric data, "NAN" (no data) is stored.
- When integration is not taking place, the integrated value will be stored as "NAN" (no data), because no integrated value exists. The integration time will also be stored as "NAN" (no data).
- The maximum harmonic order that can be stored is determined by the maximum harmonic order set in the harmonic measurement (option) menu. For harmonic orders with no numeric data, "NAN" (no data) is stored.
- If you hold the display by pressing HOLD during storage, the numeric values when you pressed HOLD are stored. However, during integration, values being measured are stored.
- If the store interval is set to 00:00:00 and you hold the display by pressing HOLD during storage, storage stops. Storage does not stop during integration.

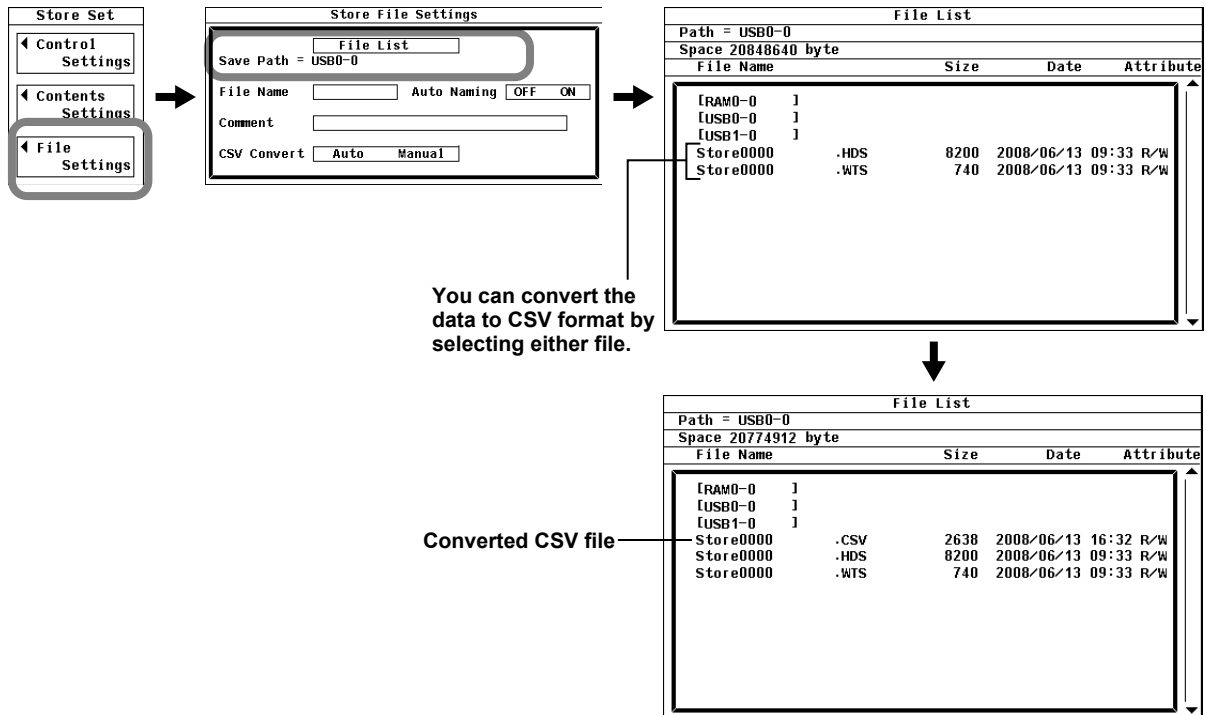
9.7 Converting a Stored Binary Format File to CSV Format

Procedure

1. Press SHIFT+STORE (STORE SET) to display the Store Set menu.
2. Use the cursor keys to select File Settings.
3. Press SET to display the Store File Settings dialog box.

Converting to CSV Format

4. Use the cursor keys to select File List.
5. Press SET to display the File List dialog box.
6. Use the cursor keys to select the stored data file that you want to convert to a CSV file.
* You can select either a stored data file (.WTS extension) or a header file (.HDS extension).
7. Press SET to confirm the selection and to convert the selected file into a CSV file.



Explanation

Converting to CSV Format

After storage has finished, you can select stored numeric data files and convert them to CSV files.

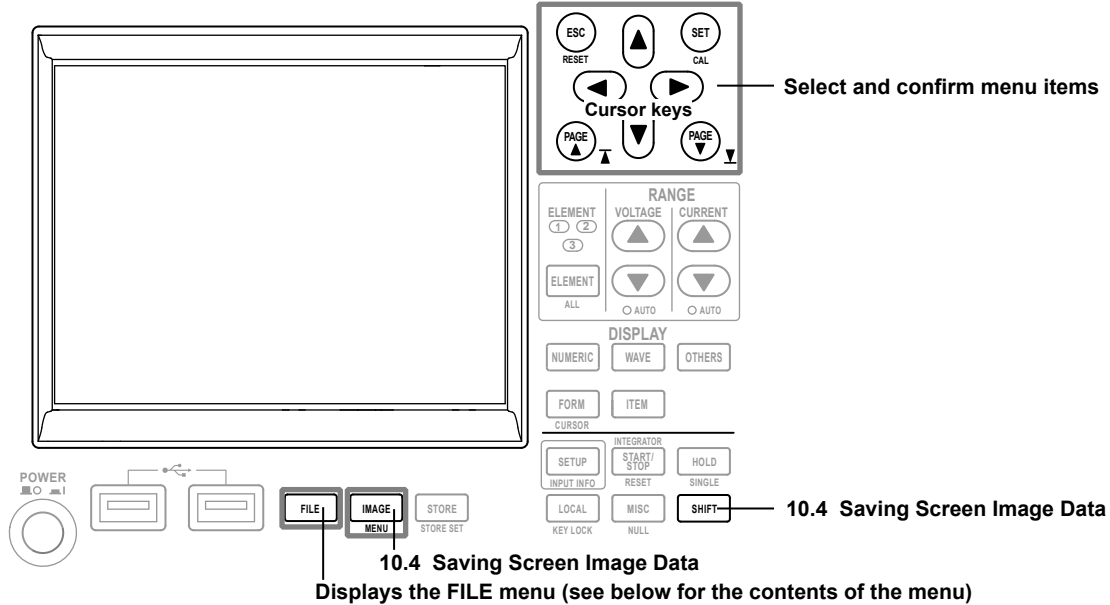
- When you convert data that is stored on the internal RAM disk (“[RAM0-0]”), the CSV file is created in the root directory of the USB memory device whose ID number is 0.
- When you convert data that is stored to USB memory (“[USB 0-0]” or “[USB1-0]”), the CSV file is created in the same directory as the numeric data files that it is converted from.

Note

CSV files are created from a pair of files that consists of a stored numeric 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, the WT500 may malfunction and the storage medium may be damaged.

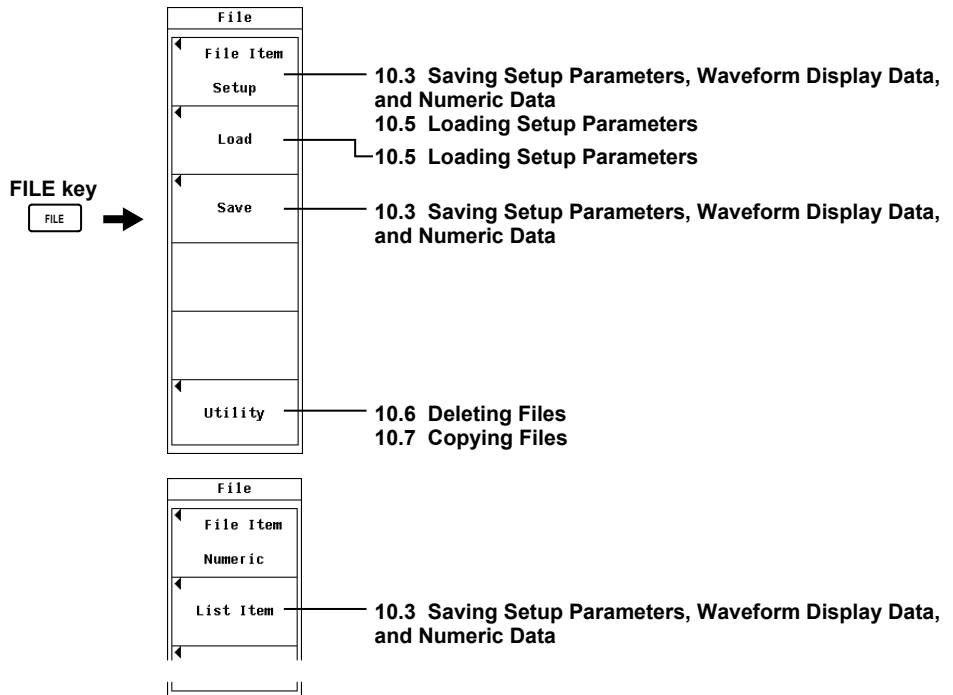
10.1 Panel Keys and Setup Menus Used in This Chapter

Panel Keys Used in This Chapter



Setup Menus Used in This Chapter

To set a parameter, access its menu by pressing the appropriate panel key. The setup menus and menu items used in this chapter are shown below, along with the sections that correspond to their operating instructions.



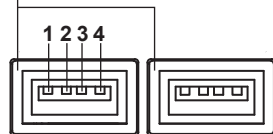
10.2 About USB Memory

USB PERIPHERAL Interface Specifications

Item	Specification
Connector type	USB type A (receptacle)
Electrical and mechanical specifications	USB 2.0
Data rate	480 Mbps max.
Power supply	5 V, 500 mA* (for each port)
Ports	2

* You cannot connect devices whose maximum current consumption exceeds 100 mA to two different ports on the WT500 at the same time.

Ports



Pin No.	Signal Name
1	VBUS: +5V
2	D-: -Data
3	D+: +Data
4	GND: Ground

Usable USB Storage Devices

The WT500 can use USB flash memory (that meets the USB Mass Storage Class specifications).

Connecting USB Memory

Connect USB memory to the WT500 directly, not through a USB hub. You can connect or disconnect USB memory at any time regardless of whether the WT500 is on or off (hot-plugging is supported). Whether you connect to the left or right USB port, the port that you connect USB memory to first is recognized as storage medium [USB0-0]. When the power switch is on, the USB memory is detected and enabled approximately few seconds after it is connected (the time varies depending on the USB memory). The detected USB memory is automatically assigned an ID number (of 2 or greater).

Note

- Do not connect USB devices other than USB keyboards or USB memory to the USB PERIPHERAL ports.
- The WT500 has two USB PERIPHERAL ports. However, USB devices whose maximum current consumption exceeds 100 mA cannot be connected simultaneously to the two ports.
- With certain types of USB memory, the instrument may not start if you turn ON the power while the memory is connected.

CAUTION

- Do not remove USB memory or turn off the power when the memory is being accessed. If you do so, the data on the USB memory may be corrupted.
- An icon in the upper left of the screen indicates when USB memory is being accessed. However, this icon does not appear when USB memory is being accessed through the storage feature.

General USB Handling Precautions

Follow the general handling precautions that are included with your USB memory.

10.3 Saving Setup Parameters, Waveform Display Data, and Numeric Data

Procedure

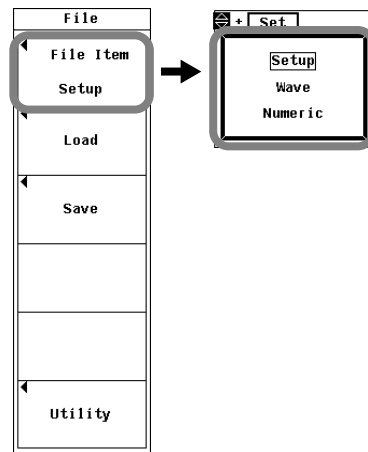
1. Press **FILE** to display the File menu.

Selecting the Type of Data That You Want to Save

2. Use the **cursor keys** to select File Item.
3. Press **SET** to display the data type selection box.
4. Use the **cursor keys** to select a data type from Setup to Numeric.
5. Press **SET** to confirm the selection.

If you select Setup or Wave, proceed to step 11 in “Executing or Canceling the Save Operation” on page 10-6.

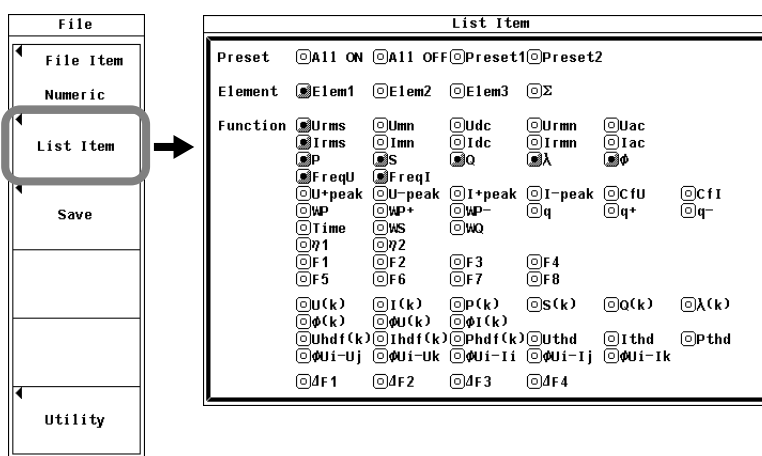
If you select Numeric, proceed to “Selecting What Numeric Data to Save” on page 10-5.



Selecting What Numeric Data to Save

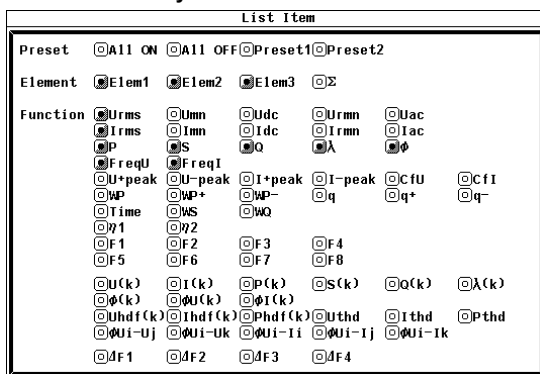
Selecting What Types of Numeric Data to Save

6. Use the **cursor keys** to select List Item.
 7. Press **SET** to display the List Item dialog box.
- **Selecting All Numeric Data Types**
 8. Use the **cursor keys** to select All ON (next to Preset).
 9. Press **SET**. The indicators to the left of all elements and measurement functions light to show that they will be saved.
 - **Unselecting All Numeric Data Types**
 8. Use the **cursor keys** to select All OFF (in the Preset row).
 9. Press **SET**. The indicators to the left of all elements and measurement functions turn off to show that they will not be saved.

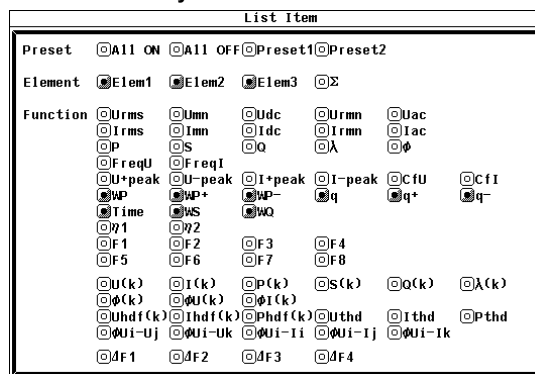


- **Selecting a Preset Group of Numeric Data Types**
 8. Use the **cursor keys** to select Preset1 or Preset2 (in the Preset row).
 9. Press **SET**. The indicators to the left of the elements and measurement functions that have been preset to Preset1 or Preset2 light to show that they will be saved.

Items Selected by Preset1



Items Selected by Preset2



10.3 Saving Setup Parameters, Waveform Display Data, and Numeric Data

- **Setting Numeric Data Types One by One**

8. Use the **cursor keys** to select the element or measurement function that you want to set.
9. Press **SET**. If the indicator to the left of the element or measurement function that you selected lights, its corresponding numeric data will be saved. If the indicator turns off, its corresponding numeric data will not be saved.

Executing or Canceling the Save Operation

10. Press **ESC** to close the List Item dialog box.
11. Use the **cursor keys** to select Save.
12. Press **SET** to display the Save menu.
13. Use the **cursor keys** to select File List.
14. Press **SET** to display the File List dialog box.

Selecting a Storage Medium

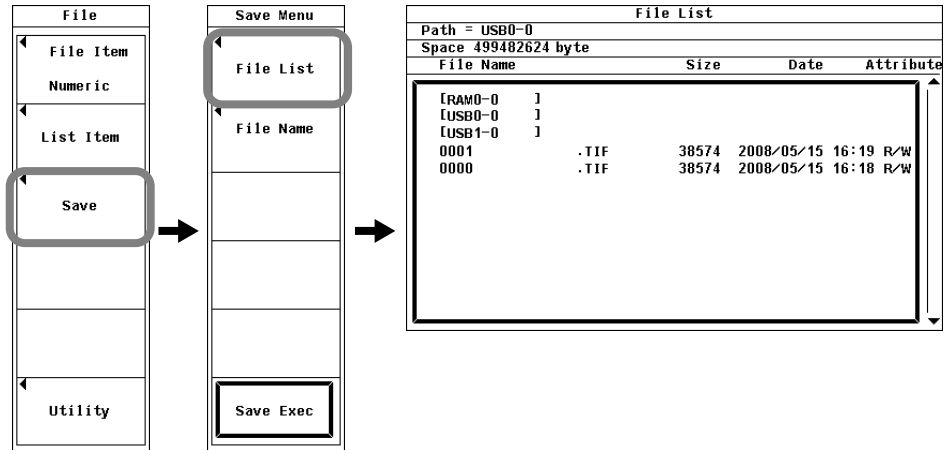
15. Use the **cursor keys** to select the storage medium (displayed using brackets) that you want to save to.
16. Press **SET** to confirm the selection.

Selecting a Directory

(Follow these procedures if the storage medium has directories.)

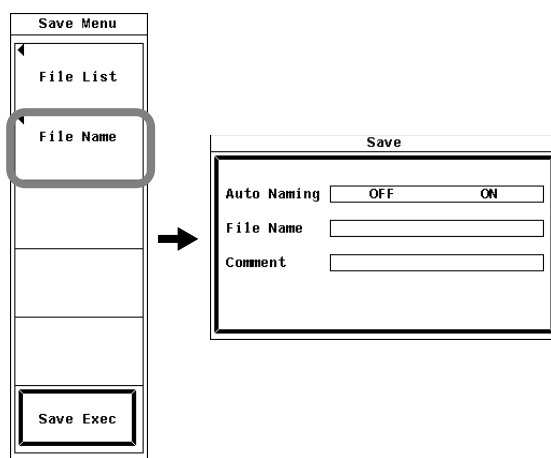
17. Use the **cursor keys** to select the directory (displayed using < >) that you want to save to.
18. Press **SET** to confirm the selection.

The selected storage medium and directory appear in the upper left of the File List dialog box after "Path=".



Setting Comments and the Name of the File that You Want to Save to

19. Use the **cursor keys** to select File Name.
20. Press **SET** to display the Save dialog box.
21. Use the **cursor keys** to select Auto Naming.
22. Press **SET** to select ON or OFF.
23. Use the **cursor keys** to select File Name.
24. Press **SET**. A keyboard appears on the screen.
25. Use the keyboard to enter the file name.
For instructions on how to use the keyboard, see section 3.14, "Entering Values and Character Strings."
26. Enter text into Comment just as you did in File Name.
27. Press **ESC** to close the Save dialog box.

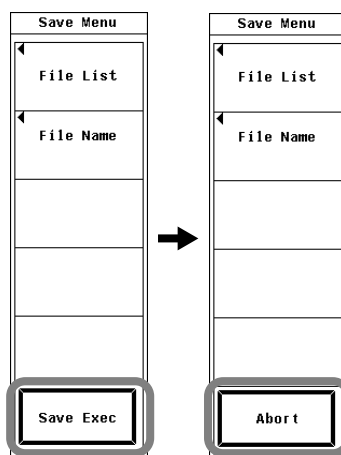


Saving

28. Use the **cursor keys** to select Save Exec.
29. Press **SET**. Data is saved to the specified path (indicated after "Path ="). The Save Exec menu item changes to Abort.

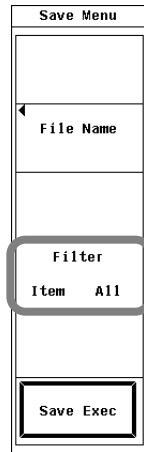
Aborting the Save Operation

30. Use the **cursor keys** to select Abort.
31. Press **SET**. The save operation is aborted. The Abort menu item changes to Save Exec.




10.3 Saving Setup Parameters, Waveform Display Data, and Numeric Data

32. Use the **cursor keys** to select File List.
33. Press **SET** to display the File List dialog box.
34. Use the **cursor keys** to select Filter.
35. Press **SET** to select Item or All.



Explanation**CAUTION**

Do not remove USB memory or turn off the power when  that indicates USB access or USB memory access indicators are blinking. If you do, the USB memory may be damaged, and its data may be corrupted.

You can save setup parameters, waveform display data, and numeric data.

Saving Setup Parameters

You can save setup parameters if you select Setup in the File Item menu.

- **Setup Parameters That Are Saved**
The current setup parameters for each key are saved. The date, time, and communication setup parameters are not saved.
- **File Size**
The size of a single setup parameter file is approximately 24 KB.
- **Extension**
Setup parameter files are saved with a .set extension.

Saving Waveform Display Data

You can save waveform display data if you select Wave in the File Item menu.

- **Waveform Display Data That Is Saved**
The waveform display data that is saved is the data that corresponds to U1 to U3 and I1 to I3 displayed on the screen (see section 7.3 for details).
- **Data Format**
 - Waveform display data is saved in ASCII format.
 - You can analyze the data on a PC.
 - You cannot load the data using the WT500.

Note

The waveform display data that the WT500 saves is not the sampled waveform data that is acquired at the WT500 sample rate (of approximately 100 kS/s). The sampled waveform data is P-P compressed (see the notes in section 2.7 for details) into 1002 points to create the waveform display data that appears on the screen and that the WT500 saves.

- **Extension and File Size**

Data Type	Extension	Size (in bytes)
ASCII	.csv	Approximately 15 KB (when there is one displayed waveform)

10.3 Saving Setup Parameters, Waveform Display Data, and Numeric Data

Saving Numeric Data

You can save numeric data if you select Numeric in the File Item menu.

- **Data Format**
 - Numeric data is saved in ASCII format.
 - You can analyze the data on a PC.
 - You cannot load the data using the WT500.

- **Extension and File Size**

Data Type	Extension	Size (in bytes)
ASCII	.csv	Approximately 2K (when storing the data types specified by Preset1 for one element)

- **Selecting What Numeric Data to Save**

You can select what types of numeric data to save.

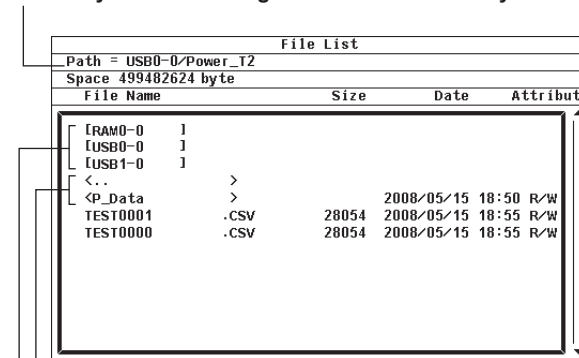
- You can select to store the numeric data of any of the elements or wiring units installed in the WT500.
- You can choose to save any of the measurement functions listed below.
 - Measurement functions used in normal measurement (see section 2.2 for details)
 - Measurement functions used in harmonic measurement (optional)
- When you save numeric data, places without numeric data will be blank or contain one of the following strings:
NAN, +INF, -INF, or ERROR.*

* The places that contain blank spaces are in functions such as the ones for the 0th and 1st harmonic orders of ϕU and ϕI , where the screen display is also blank.

Selecting the Storage Medium and Directory

Media that can be stored to and read from are displayed in the File List dialog box.

Currently selected storage medium and directory



Directory

Storage medium

Storage Medium Display Example

[RAM0-0]: Internal RAM disk

[USB0-0]: USB memory with an ID number of 0

[USB1-0]: USB memory with an ID number of 0

File Names and Comments

- You must enter a file name. You do not need to enter a comment.
- You cannot enter a file name if there is another file in the same directory with that name (no overwriting).

Usable Characters and Maximum String Lengths

Setting	Max. Length	Usable Characters
File name	1 to 8 characters	0-9, A-Z, %, _, parentheses, and minus signs
Comment	0 to 25 characters	Spaces and all characters that are displayed on the keyboard

Auto Naming Feature

If you set Auto Naming to ON, the WT500 will automatically assign a four digit number to the files that it saves, from 0000 to 0999. You can set a common file name to put before the number (by specifying it in File Name; the name can have up to eight characters).

Selecting Which Files to Display in the File List Dialog Box

You can select which types of files to display in the File List dialog box.

- Item
The only files in the selected directory that appear are those of the type set for the File Item option in the File menu. If File Item is set to Setup, only files with the .set extension appear. If File Item is set to Wave or Numeric, only files with the .csv extension appear.
- All
All of the files in the selected directory appear.

Properties


See “Properties” under “Explanation” in section 10.6.

Note

- For the meanings of the displayed measurement function symbols, see section 2.2, “Measurement Functions and Measurement Periods”; section 2.5, “Computation”; section 2.6, “Integration”; and appendix 1, “Symbols and Determination of Measurement Functions.”
- You can only select wiring unit Σ when it has been selected according to the procedure described in section 4.2, “Selecting a Wiring System.”
- The maximum harmonic order that can be saved is determined by the maximum harmonic order set in the harmonic measurement (option) menu.
- File paths can be displayed using up to 41 characters. If a path exceeds 41 characters, an ellipsis appears at the end of the character string.
- File names are not case-sensitive. Comments are case-sensitive. The following file names cannot be used due to MS-DOS limitations:
AUX, CON, PRN, NUL, CLOCK, COM1 to COM9, and LPT1 to LPT9
- A directory can contain up to 1000 files. To save more than 1000 files, either start saving to a different directory, or move already saved files to a different directory.
- If there are a large number of files on a single directory, the amount of time that it takes to write to and read files becomes longer. If this happens, start saving files to a directory with less files, or move the files in the save destination to a different directory.
- Because the header files saved by the WT500 use a format that is common to YOKOGAWA measurement devices, they contain some data that is not used by the WT500.
- The WT500 cannot load setup parameters that have been saved by a product with an incompatible firmware version.

10.4 Saving Screen Image Data

CAUTION

Do not remove USB memory or turn off the power when  that indicates USB access or USB memory access indicators are blinking. If you do, the USB memory may be damaged, and its data may be corrupted.

Procedure

1. Press **SHIFT+IMAGE (MENU)** to display the Screen Image Output Settings menu.

Selecting a Data Format

2. Use the **cursor keys** to select Format.
3. Press **SET** to display the data format selection box.
4. Use the **cursor keys** to select one of the following data formats: TIFF, BMP, Post Script, PNG, or JPEG.
5. Press **SET** to confirm the selection.

Selecting a Color Mode

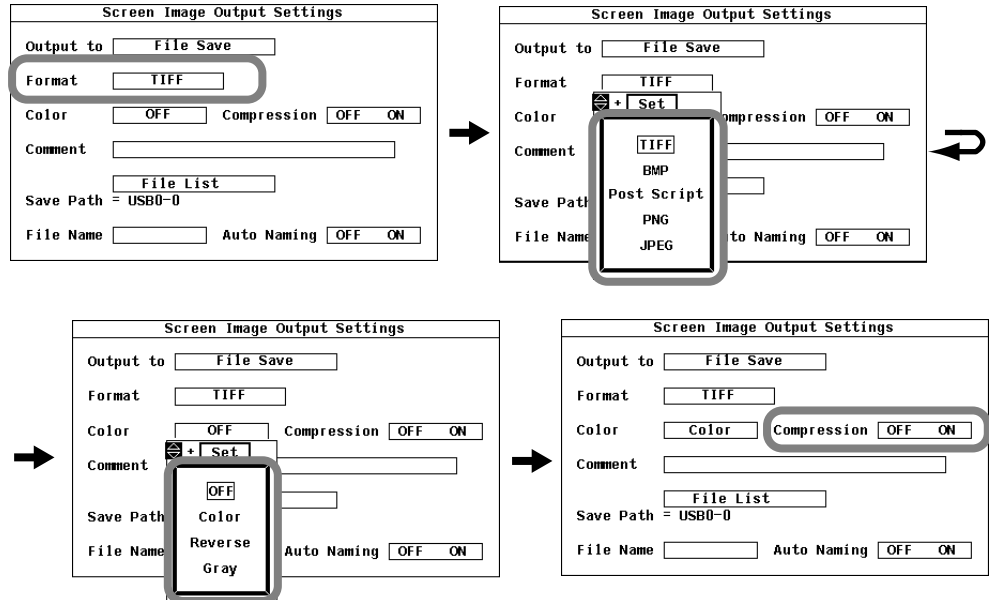
(You can only select a color mode if you selected TIFF, BMP, PNG, or JPEG in step 4.)

6. Use the **cursor keys** to select Color.
7. Press **SET** to display the color mode selection box.
8. Use the **cursor keys** to select one of the following color modes: Color, Reverse (white background), Gray (grayscale), or OFF.
9. Press **SET** to confirm the selection.

Selecting Whether or Not to Compress Data

(You can only select to compress data if you selected Color, Reverse, or Gray in step 4 and BMP in step 8.)

10. Use the **cursor keys** to select Compression.
11. Press **SET** to select ON or OFF.

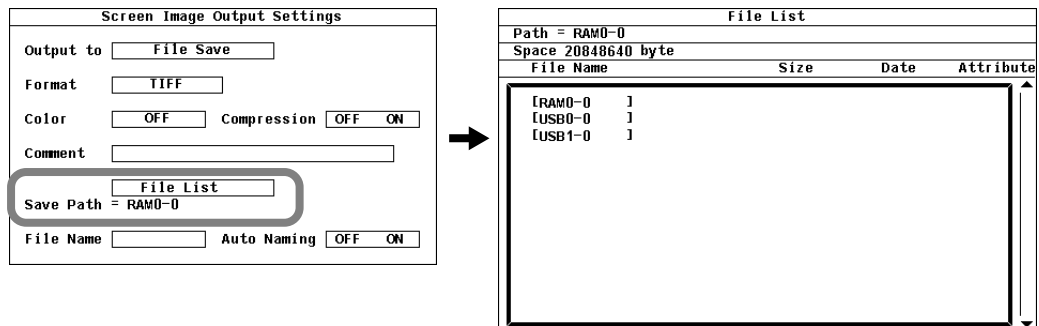


Entering a Comment

12. Use the **cursor keys** to select Comment.
13. Press **SET**. A keyboard appears on the screen.
14. Use the keyboard to enter a comment.
For instructions on how to use the keyboard, see section 3.14, "Entering Values and Character Strings."

Selecting a Storage Medium and Directory

15. Use the **cursor keys** to select File List next to Save Path.
16. See "Selecting a Storage Medium" and "Selecting a Directory" under "Procedure" in section 9.5.
17. Press **ESC** to close the File List dialog box.



Setting the File Name

18. Use the **cursor keys** to select File Name.
19. Press **SET**. A keyboard appears on the screen.
20. Use the keyboard to enter the file name.
For instructions on how to use the keyboard, see section 3.14, "Entering Values and Character Strings."
21. Use the **cursor keys** to select Auto Naming.
22. Press **SET** to select ON or OFF.
23. Press **ESC** to close the Screen Image Output Settings menu.

Screen Image Output Settings	
Output to	File Save
Format	TIFF
Color	OFF
Compression	OFF ON
Comment	
	File List
Save Path =	RAM0-0
File Name	
Auto Naming	OFF ON

Executing or Canceling the Save Operation

Perform the following steps in the display that you want to save an image of. Press **IMAGE**. Screen image data is saved to the specified path (indicated after "Path ="). If you press **IMAGE** again during the save operation, the operation will be cancelled. An icon appears in the upper left of the screen during the save operation.

Explanation

You can save screen image data.

Data Formats and Extensions

You can save screen image data to one of the following formats. The table below shows the approximate file sizes of each format and the extensions that are automatically assigned to them.

Format	Extension	Size (in bytes; values are for reference)		
		OFF	Color	Color (with compression)
TIFF	.tif	Approximately 40 KB	Approximately 310 KB	—
BMP	.bmp	Approximately 40 KB	Approximately 310 KB	Approximately 30 KB
Post Script	.ps	Approximately 80 KB	—	—
PNG	.png	Approximately 5 KB	Approximately 10 KB	—
JPEG	.jpg	Approximately 40 KB	Approximately 50 KB	—

Color Modes

You can select a color mode when the data format is TIFF, BMP, PNG, or JPG.

- Color: 256 colors
- Reverse: White background, black letters, colored waveforms
- Gray: 16 shades of gray
- OFF: Black and white

Turning Data Compression On or Off

You can turn data compression on and off when the data format is BMP and the color mode is Color, Reverse, or Gray.

- OFF: Data is not compressed.
- ON: Data is compressed using RLE.

File Names and Comments

See “File Names and Comments” under “Explanation” in section 10.3.

Selecting the Storage Medium and Directory

See “Selecting the Storage Medium and Directory” under “Explanation” in section 10.3.

Auto Naming Feature


See “Auto Naming Feature” under “Explanation” in section 10.3.

Note

- Up to 1000 files and directories can be displayed in the file list. If there are more than a total of 1000 files and directories in a given directory, the file list for that directory will only display 1000 files and directories. There is no way to set which files and directories are displayed.
- If there are a large number of files on a single directory, the amount of time that it takes to write to and read files becomes longer. If this happens, start saving files to a directory with less files, or move the files in the save destination to a different directory.
- If you change file name extensions through a PC or some other means, the WT500 will not be able to load the files.
- Files without archive attributes are not displayed in the File List window. Do not clear the archive attributes of files on your PC that were saved using the WT500.
- File paths can be displayed using up to 41 characters. If a path exceeds 41 characters, an ellipsis appears at the end of the character string.
- File names are not case-sensitive. Comments are case-sensitive. The following file names cannot be used due to MS-DOS limitations:
AUX, CON, PRN, NUL, CLOCK, COM1 to COM9, and LPT1 to LPT9

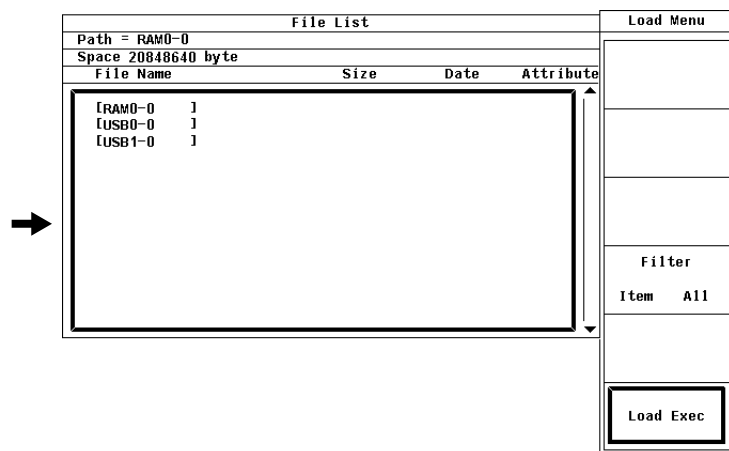
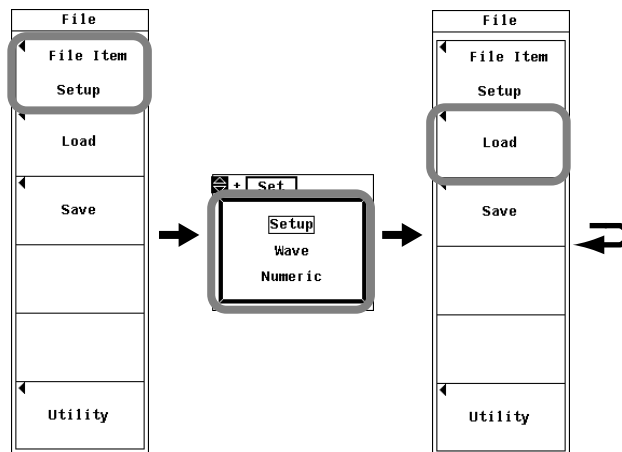
10.5 Loading Setup Parameters and Displaying File Properties

CAUTION

Do not remove USB memory or turn off the power when  that indicates USB access or USB memory access indicators are blinking. If you do, the USB memory may be damaged, and its data may be corrupted.

Procedure

1. Press **FILE** to display the File menu.
2. Use the **cursor keys** to select File Item.
3. Press **SET** to display the function selection box.
4. Use the **cursor keys** to select Setup.
5. Press **SET** to confirm the selection.
6. Use the **cursor keys** to select Load.
7. Press **SET** to display the File List dialog box and the Load menu.



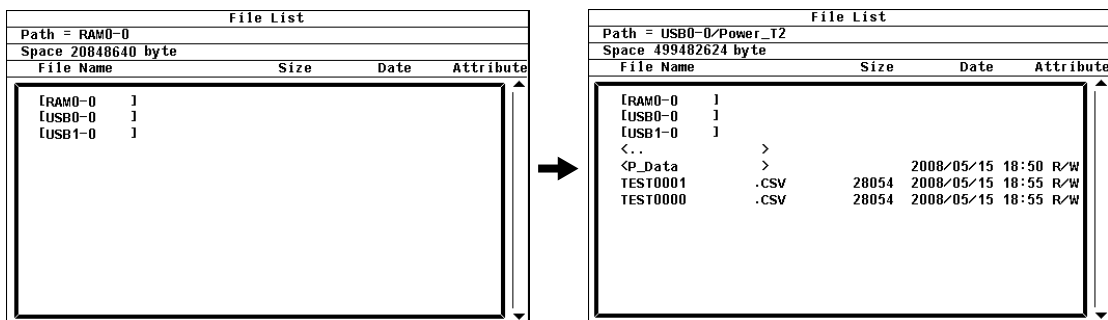
Selecting the Storage Medium to Load From

8. Use the **cursor keys** to select the storage medium (displayed using brackets) that you want to load from.
9. Press **SET** to confirm the selection.

Selecting the Directory to Load From

(Follow these procedures if the storage medium has directories.)

10. Use the **cursor keys** to select the directory (displayed using < >) that you want to load from.
11. Press **SET** to confirm the selection.
 - The selected storage medium and directory appear in the upper left of the File List dialog box after “Path=.”
 - Select <..> and press **SET** to move up to the parent directory.



Selecting a File to Load

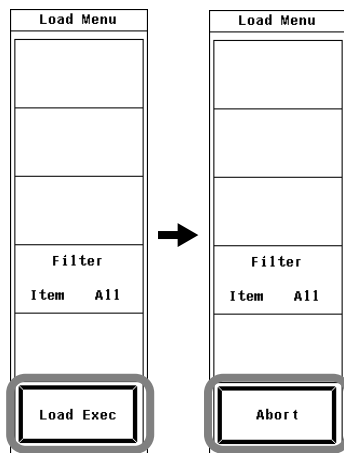
12. Use the **cursor keys** to select the file you want to load.

Loading

13. Use the **cursor keys** to select Load Exec.
14. Press **SET**. The selected file is loaded from the directory displayed after “Path =.” The Load Exec menu item changes to Abort.

Aborting a Load Operation

15. Use the **cursor keys** to select Abort.
16. Press **SET**. Loading stops. The Abort menu item changes to Load Exec.



Explanation

You can load setup parameters that have been saved by the WT500.

Selecting the Storage Medium and Directory


See “Selecting the Storage Medium and Directory” under “Explanation” in section 10.3.

Note

- Executing any operation other than Abort during a load or save operation will result in an error.
 - Up to 1000 files and directories can be displayed in the file list. If there are more than a total of 1000 files and directories in a given directory, the file list for that directory will only display 1000 files and directories. There is no way to set which files and directories are displayed.
 - If you change the file name extension of a setup parameter file through a PC or some other means, the WT500 will not be able to load the file.
 - Files without archive attributes are not displayed in the File List window. Do not clear the archive attributes of files on your PC that were saved using the WT500.
 - File paths can be displayed using up to 41 characters. If a path exceeds 41 characters, an ellipsis appears at the end of the character string.
 - File names are not case-sensitive. Comments are case-sensitive. The following file names cannot be used due to MS-DOS limitations:
AUX, CON, PRN, NUL, CLOCK, COM1 to COM9, and LPT1 to LPT9
 - When a file's setup parameters are loaded, the settings of each key are changed to match the loaded settings, and they cannot be changed back. We recommend that you save the current setup parameters before loading different setup parameters.
 - The date, time, and communication setup parameters are not saved. So even if you load setup parameters from a file, the date, time, and communication settings will not change.
 - The WT500 cannot load setup parameters that have been saved by a product with an incompatible firmware version.
 - The WT500 cannot load setup parameters that were saved by an instrument with a different product version, element configuration, or with different options.
-

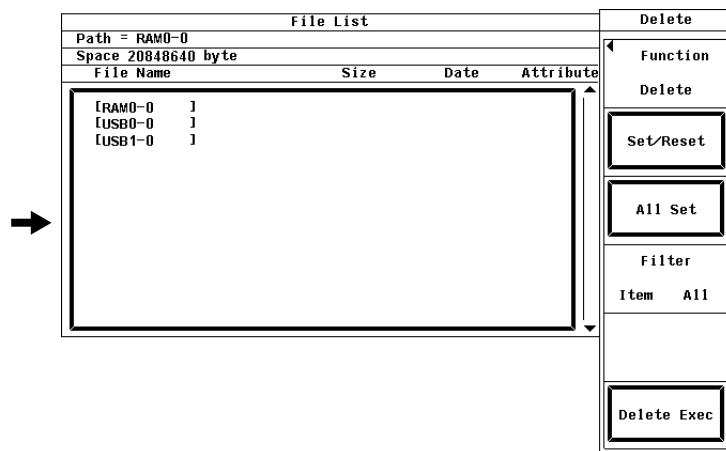
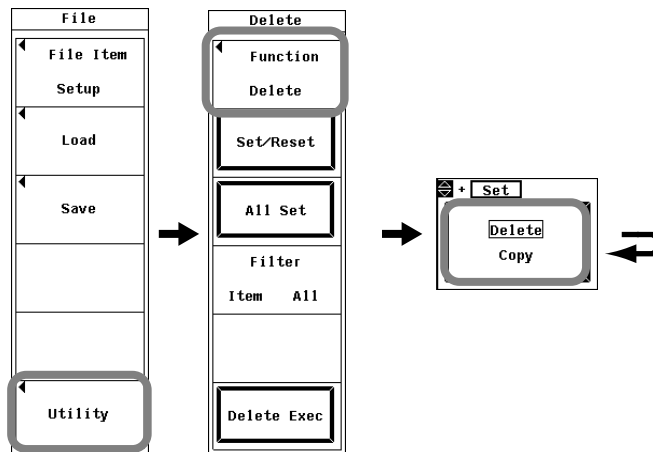
10.6 Deleting Files

CAUTION

Do not remove USB memory or turn off the power when  that indicates USB access or USB memory access indicators are blinking. If you do, the USB memory may be damaged, and its data may be corrupted.

Procedure

1. Press **FILE** to display the File menu.
2. Use the **cursor keys** to select Utility.
3. Press **SET** to display the Utility menu and the File List dialog box.
4. Use the **cursor keys** to select Function.
5. Press **SET** to display the function selection box.
6. Use the **cursor keys** to select Delete.
7. Press **SET** to display the Delete menu.



Selecting a Storage Medium and Directory

8. See “Selecting the Storage Medium to Load From” and “Selecting the Directory to Load From” under “Procedure” in section 10.5.

Selecting Which Files to Display in the File List Dialog Box

9. See “Selecting Which Files to Display in the File List Dialog Box” under “Procedure” in section 10.5.

Deleting Files One by One

10. Use the **cursor keys** to select the file you want to delete.
11. Use the **cursor keys** to select Set/Reset. If an asterisk appears next to the file, it will be deleted when you execute the delete operation. If the asterisk next to a file disappears, it will not be deleted when you execute the delete operation.
Proceed to step 16.

Deleting All of the Files in a Directory or Storage Medium

10. Use the **cursor keys** to select a file, directory, or storage media.
11. Use the **cursor keys** to select All Set.
12. Press **SET**. Asterisks will appear next to all of the files in the displayed directory, and these files will be deleted when you execute the delete operation. The All Set menu item changes to All Reset. Even if an asterisk appears next to the name of a directory, the directory will not be deleted.
13. Use the **cursor keys** to select All Reset.
14. Press **SET**. The asterisks next to the files in the displayed directory will disappear, and these files will not be deleted when you execute the delete operation. The All Reset menu item changes to All Set.

Executing the Delete Operation

15. Use the **cursor keys** to select Delete Exec.
16. Press **SET** to delete every file that has an asterisk next to it.

File List			
Path = USB0-0/P_Data/TEST1			
Space 499482624 byte			
File Name	Size	Date	Attribute
[RAM0-0]			
[USB0-0]			
[USB1-0]			
<.. >			
* Data0000	.SET	24672	2008/05/16 12:05 R/W

Delete	
Function	Delete
Set/Reset	
All Set	
Filter	
Item	All
Delete Exec	

File that will be deleted

Set/Reset — Selects a single file to delete

All Set — Selects a group of files to delete

Delete Exec — Executes the delete operation

Explanation**Selecting the Storage Medium and Directory**

See “Selecting the Storage Medium and Directory” under “Explanation” in section 10.3.

Selecting Which Files to Display in the File List Dialog Box

See “Selecting Which Files to Display in the File List Dialog Box” under “Explanation” in section 10.3.

Selecting Which Files to Delete


- A file with an asterisk next to it will be deleted when you execute the delete operation.
- There are two ways to select the files that will be deleted:
 - One at a time
You can put a single asterisk next to a file by using Set/Reset.
 - As a group
You can use All Set to select all of the files in the current directory. Asterisks will appear next to the file names. Asterisks will also appear next to directory names, but the directories will not be deleted.

Note

-
- Deleted data cannot be recovered. Be careful not to delete the wrong files.
 - Deletion will stop if an error occurs while the WT500 is deleting files.
 - Up to 1000 files and directories can be displayed in the file list. If there are more than a total of 1000 files and directories in a given directory, the file list for that directory will only display 1000 files and directories. There is no way to set which files and directories are displayed.
 - Files without archive attributes are not displayed in the File List window. Do not clear the archive attributes of files on your PC that were saved using the WT500.
 - File paths can be displayed using up to 41 characters. If a path exceeds 41 characters, an ellipsis appears at the end of the character string.
-

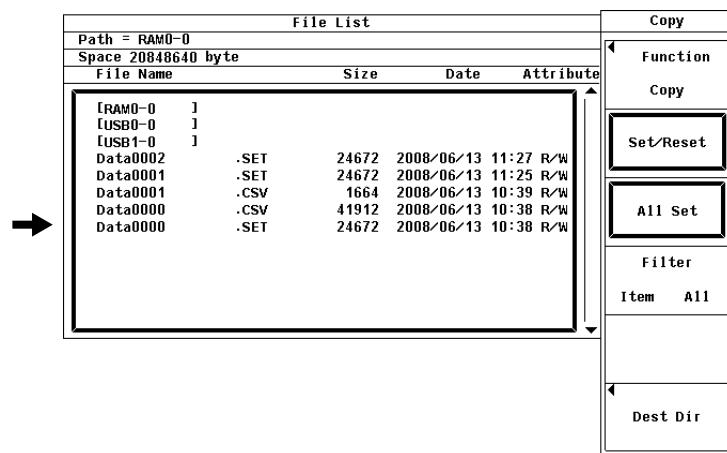
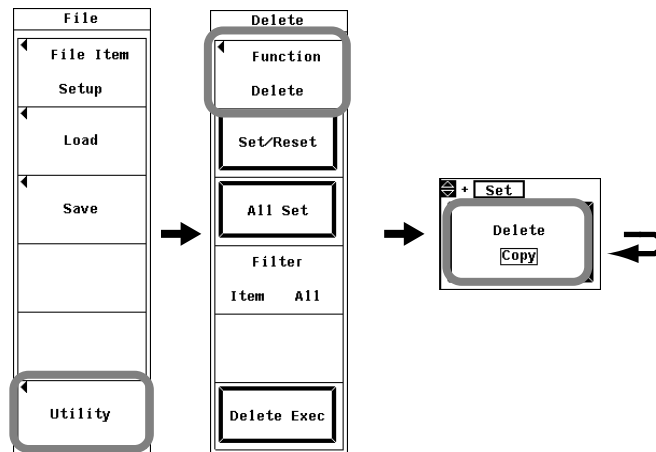
10.7 Copying Files

CAUTION

Do not remove USB memory or turn off the power when  that indicates USB access or USB memory access indicators are blinking. If you do, the USB memory may be damaged, and its data may be corrupted.

Procedure

1. Press **FILE** to display the File menu.
2. Use the **cursor keys** to select Utility.
3. Press **SET** to display the Utility menu and the File List dialog box.
4. Use the **cursor keys** to select Function.
5. Press **SET** to display the function selection box.
6. Use the **cursor keys** to select Copy.
7. Press **SET** to display the Copy menu.



Selecting the Source Storage Medium and Directory to Copy From

- See “Selecting the Storage Medium to Load From” and “Selecting the Directory to Load From” under “Procedure” in section 10.5.

Selecting Which Files to Display in the File List Dialog Box

- See “Selecting Which Files to Display in the File List Dialog Box” under “Procedure” in section 10.5.

Copying Files One by One

- Use the **cursor keys** to select the file you want to copy.
- Use the **cursor keys** to select Set/Reset. If an asterisk appears next to the file, it will be copied when you execute the copy operation. If the asterisk next to a file disappears, it will not be copied when you execute the copy operation. Proceed to step 16.

Copying All of the Files in a Directory or Storage Medium

- Use the **cursor keys** to select a file, directory, or storage medium.
- Use the **cursor keys** to select All Set.
- Press **SET**. Asterisks will appear next to all of the files in the displayed directory, and these files will be copied when you execute the copy operation. The All Set menu item changes to All Reset.
- Use the **cursor keys** to select All Reset.
- Press **SET**. The asterisks next to the files in the displayed directory will disappear, and these files will not be copied when you execute the copy operation. The All Reset menu item changes to All Set.

Selecting the Directory to Copy To

- Use the **cursor keys** to select Dest Dir.
- Press **SET** to display the Copy Execution menu and the File List dialog box.

File List			
Path = RAM0-0			
Space 20848640 byte			
File Name	Size	Date	Attribute
[RAM0-0]			
[USB0-0]			
[USB1-0]			
Data0002	.SET	24672	2008/06/13 11:27 R/W
*Data0001	.SET	24672	2008/06/13 11:25 R/W
P_Data0000	.CSV	1664	2008/06/13 10:39 R/W
TEST0000	.CSV	41912	2008/06/13 10:38 R/W
Data0000	.SET	24672	2008/06/13 10:38 R/W

Copy	
Function	
Copy	
Set/Reset	Selects a single file to copy
All Set	Selects a group of files to copy
Filter	
Item	All
Dest Dir	
Use to select the directory to copy to	

File that will be copied

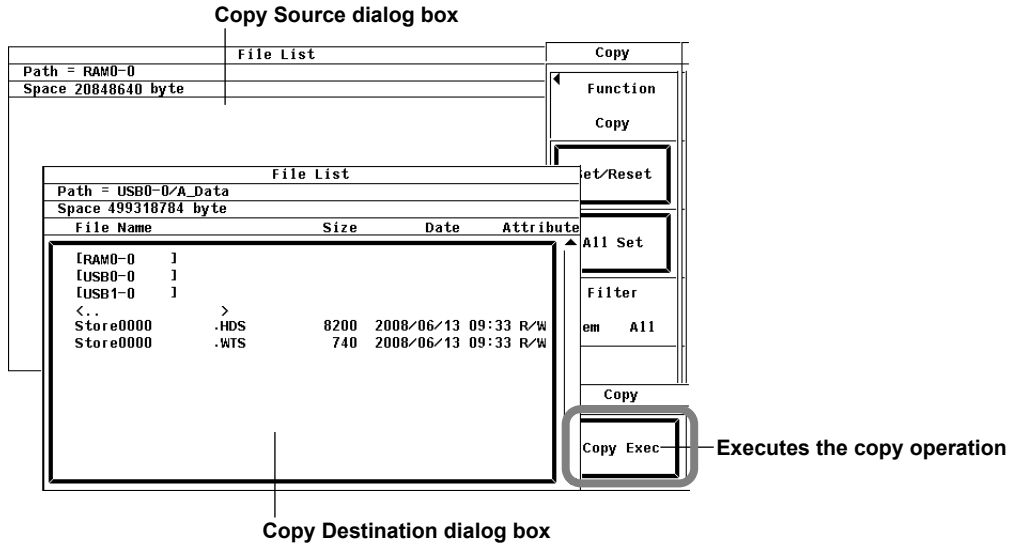
Selecting the Storage Medium and Directory to Copy To

17. See “Selecting a Storage Medium” and “Selecting a Directory” under “Procedure” in section 10.3.

Executing the Copy Operation

18. Use the **cursor keys** to select Copy Exec.

19. Press **SET** to copy every file that has an asterisk next to it.



Explanation**Selecting a Source and Destination Storage Medium and Directory**

See “Selecting the Storage Medium and Directory” under “Explanation” in section 10.3.

Selecting Which Files to Display in the File List Dialog Box

See “Selecting Which Files to Display in the File List Dialog Box” under “Explanation” in section 10.5.

Selecting Which Files to Copy

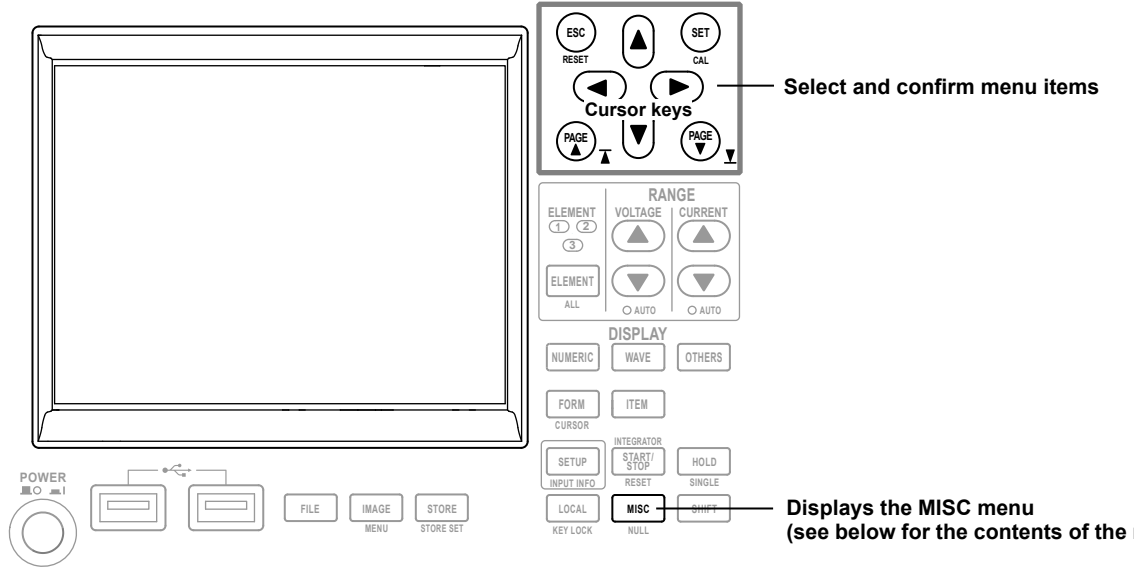
- A file with an asterisk next to it will be copied when you execute the copy operation.
- There are two ways to select the files that will be copied:
 - One at a time
You can put a single asterisk next to a file by pressing Set/Reset.
 - As a group
You can use All Set to select all of the files in the current directory. Asterisks will appear next to the file names.

Note

- You cannot copy a file to a destination if there is already a file with the same name in that destination.
- After executing the copy operation, you cannot simply change the destination directory and then recopy the same files that you copied before. You have to reselect the files that you want to copy.
- Copying will stop if an error occurs while the WT500 is copying files.
- Up to 1000 files and directories can be displayed in the file list. If there are more than a total of 1000 files and directories in a given directory, the file list for that directory will only display 1000 files and directories. There is no way to set which files and directories are displayed.
- Files without archive attributes are not displayed in the File List window. Do not clear the archive attributes of files on your PC that were saved using the WT500.
- File paths can be displayed using up to 41 characters. If a path exceeds 41 characters, an ellipsis appears at the end of the character string.

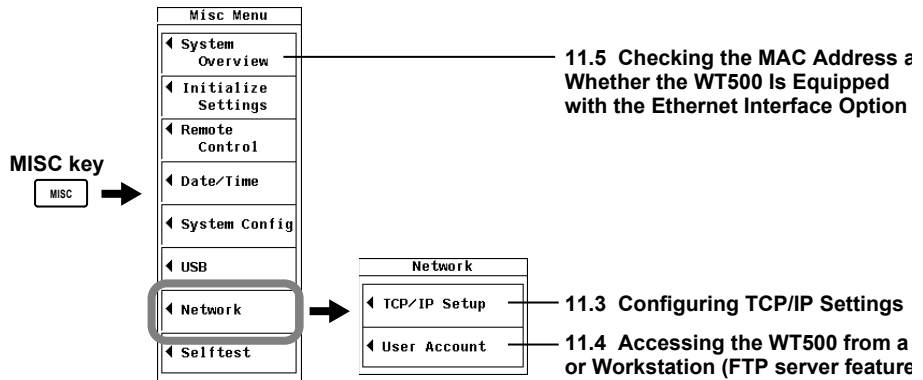
11.1 Panel Keys and Setup Menus Used in This Chapter

Panel Keys Used in This Chapter



Setup Menus Used in This Chapter

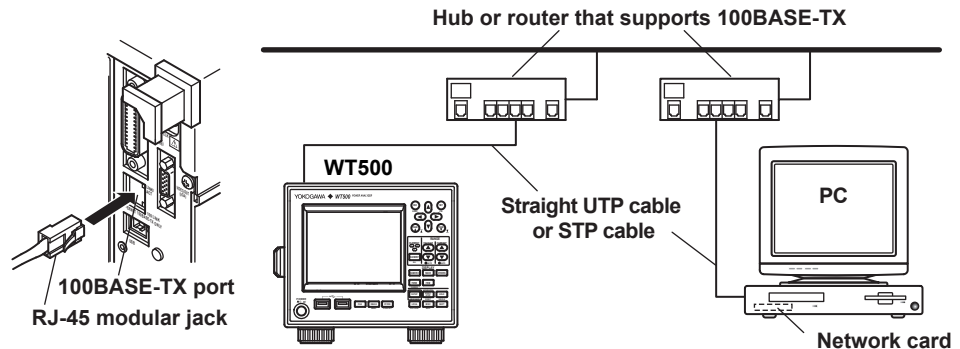
To set a parameter, access its menu by pressing the appropriate panel key. The setup menus and menu items used in this chapter are shown below, along with the sections that correspond to their operating instructions.



11.2 Connecting to a Network

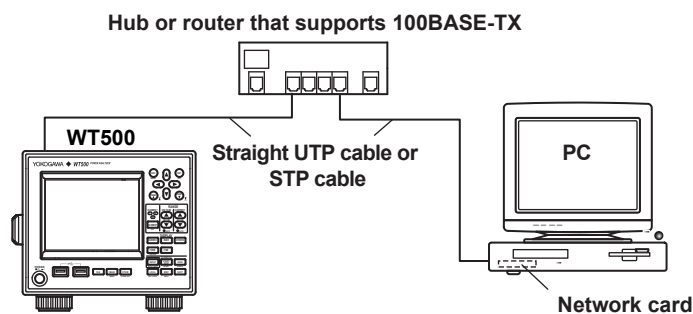
To Connect to a PC over a Network

1. Check that the WT500 power switch is off (see section 3.4 for details).
2. Connect one end of a UTP (or STP) cable to the ETHERNET 100BASE-TX port on the rear panel.
3. Connect the other end of the UTP (or STP) cable to a hub or router.
4. Turn the WT500 power switch on.



To Connect to a PC Through a Hub or Router

1. Check that the WT500 power switch is off (see section 3.4 for details).
2. Connect one end of a UTP (or STP) cable to the ETHERNET 100BASE-TX port on the rear panel.
3. Connect the other end of the UTP (or STP) cable to a hub or router.
4. Connect the PC to the hub or router in the same way.
5. Turn the power switch on (see section 3.4 for details).



Note

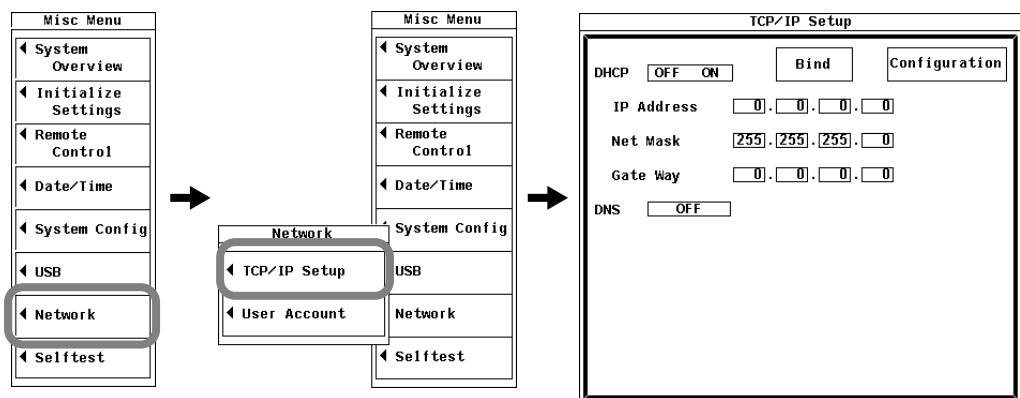
- If you connect the WT500 to a PC through a hub or router, the PC should have a 10BASE-T/100BASE-TX auto switching NIC or a 100BASE-TX NIC.
- Use straight UTP (unshielded twisted pair) or STP (shielded twisted pair) cables that are category 5 or better.
- Do not connect the WT500 to a PC directly. Direct communication without a hub or router is not guaranteed to work.

11.3 Configuring TCP/IP Settings

Procedure

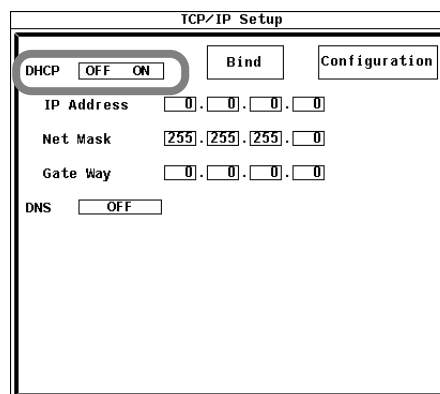
You must restart the WT500 or execute Bind (see page 11-6 for details) to apply new TCP/IP settings and changes.

1. Press **MISC** to display the Misc Menu.
2. Use the **cursor keys** to select Network.
3. Press **SET** to display the Network menu.
4. Use the **cursor keys** to select TCP/IP Setup.
5. Press **SET** to display the TCP/IP Setup dialog box.



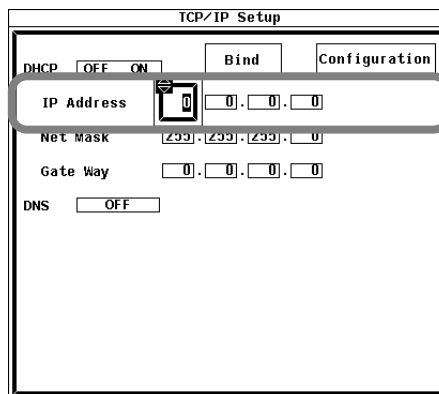
To Only Use DHCP

6. Use the **cursor keys** to select DHCP.
7. Press **SET** to select ON.
8. Use the **cursor keys** to select DNS.
9. Press **SET** to display the DNS selection box.
10. Use the **cursor keys** to select OFF.



To Only Use DNS

6. Use the **cursor keys** to select DHCP.
 7. Press **SET** to select OFF.
- **Entering the IP Address**
 8. Use the **cursor keys** to select IP Address.
 9. Press **SET** to display the IP address entry box.
 10. Use the **cursor keys** to enter the IP address of the WT500.
 11. Press **SET** or **ESC** to close the entry box.
 12. Enter all four octets of the **IP Address**.



The screenshot shows the 'TCP/IP Setup' menu. At the top, there are three tabs: 'DHCP', 'Bind', and 'Configuration'. The 'DHCP' tab is selected, and it has two sub-options: 'OFF' and 'ON'. Below the tabs, there are four input fields: 'IP Address', 'Net Mask', 'Gate Way', and 'DNS'. The 'IP Address' field is highlighted with a grey border and contains a cursor. The 'Net Mask' field has a default value of '255.255.255.0'. The 'Gate Way' field has a default value of '0.0.0.0'. The 'DNS' field has a default value of 'OFF'.

- **Entering the Subnet Mask**

Enter the subnet mask according to the system or network that the WT500 belongs to. If the system or network does not require a subnet mask, proceed to “Entering the Default Gateway.”

 13. Use the **cursor keys** to select Net Mask.
 14. Enter all four octets of the subnet mask of the network that the WT500 belongs to just as you did for the IP address.
- **Entering the Default Gateway**

Enter the default gateway according to the system or network that the WT500 belongs to. If the system or network does not require a default gateway, proceed to “Turning On the DNS.”

 15. Use the **cursor keys** to select Gate Way.
 16. Enter all four octets of the default gateway of the network that the WT500 belongs to just as you did for the IP address.
- **Turning DNS On**
 17. Use the **cursor keys** to select DNS.
 18. Press **SET** to display the DNS selection box.
 19. Use the **cursor keys** to select ON.
 20. Press **SET** to confirm the selection.

The DNS settings appear.

- **Entering the Domain Name**

Enter the domain name of the system or network that the WT500 belongs to.

21. Use the **cursor keys** to select Domain Name.

22. Press **SET**. A keyboard appears on the screen.

23. Use the keyboard to enter the domain name of the network that the WT500 belongs to.

For instructions on how to use the keyboard, see section 3.14, “Entering Values and Character Strings.”

- **Entering the Address of the Primary DNS Server**

24. Use the **cursor keys** to select DNS Server1.

25. Enter all four octets of the primary DNS server address just as you did for the IP address.

- **Entering the Address of the Secondary DNS Server**

Enter a secondary DNS server address if the system or network that the WT500 belongs to uses a secondary DNS server. If a secondary server is not necessary, proceed to “Entering the Primary Domain Suffix.”

26. Use the **cursor keys** to select DNS Server2.

27. Enter all four octets of the secondary DNS server address just as you did for the domain name.

- **Entering the Primary Domain Suffix**

If a domain suffix is required:

28. Use the **cursor keys** to select Domain Suffix1.

29. Enter the primary domain suffix just as you did the domain name.

- **Entering the Secondary Domain Suffix**

If there is a secondary domain suffix:

30. Use the **cursor keys** to select Domain Suffix2.

31. Enter the secondary domain suffix just as you did the domain name.

The screenshot shows a 'TCP/IP Setup' window with the following fields and values:

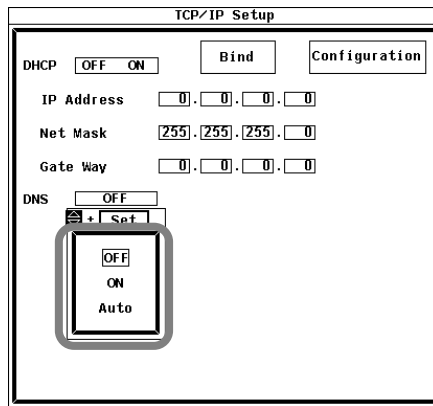
- DHCP:** OFF ON (radio buttons)
- Bind:** [Button]
- Configuration:** [Tab]
- IP Address:** [0].[0].[0].[0]
- Net Mask:** [255].[255].[255].[0]
- Gate Way:** [0].[0].[0].[0]
- DNS:** ON (radio button)
- Domain Name:** [Text Input Field]
- DNS Server1:** [0].[0].[0].[0]
- DNS Server2:** [0].[0].[0].[0]
- Domain Suffix1:** [Text Input Field]
- Domain Suffix2:** [Text Input Field]

To Use Both DHCP and DNS

- 6. Use the **cursor keys** to select DHCP.
- 7. Press **SET** to select ON.
- 8. Use the **cursor keys** to select DNS.
- 9. Press **SET** to display the DNS selection box.
- 10. Use the **cursor keys** to select ON or Auto.

If you select ON, you must enter the necessary information by following the procedures from “Entering the Domain Name” through “Entering the Secondary Domain Suffix” on the previous page.

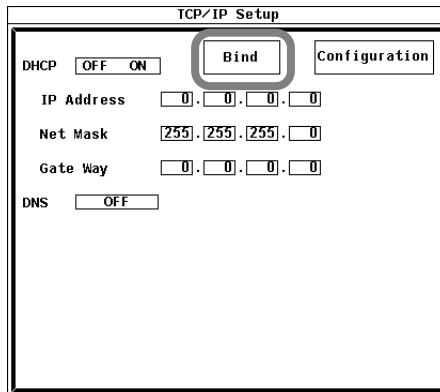
If you select Auto, you do not have to enter the information that you would normally enter by following the procedures from “Entering the Domain Name” to “Entering the Secondary Domain Suffix” because the WT500 uses the DHCP server to automatically enter the information for you.



Executing Bind

Execute Bind to apply new TCP/IP settings and changes.

- 1. Use the **cursor keys** to select Bind.
- 2. Press **SET** to execute Bind.



Viewing the Settings

1. Use the **cursor keys** to select Configuration.
2. Press **SET**. The settings appear.
Press **ESC** to close the setting information.

```

Network Information
-----
DHCP      : OFF
IP Address : 0. 0. 0. 0
Net Mask  : 255.255.255. 0
Gate Way  : 0. 0. 0. 0
DNS1      : 0. 0. 0. 0
DNS2      : 0. 0. 0. 0
Domain Name :
MAC Address : xxxxxx_xxx_xxx

```

Explanation

To use the WT500 Ethernet interface features, you must configure the DHCP, IP address, subnet mask, default gateway, and DNS settings. Consult your system or network administrator about these settings.

DHCP (Dynamic Host Configuration Protocol)

DHCP is a protocol that temporarily allocates necessary information to a computer so that it can connect to the Internet. When a DHCP server exists on a network, the server automatically assigns the information below to PCs and other devices connected to the network that have DHCP enabled.

IP address
Subnet mask
Default gateway
Broadcast
DNS

- The WT500 can only use DHCP if there is a DHCP server on the network. Ask your network administrator whether DHCP is available.
- When the WT500 DHCP setting is switched from OFF to ON, it may take tens of seconds before the IP address can be retrieved.
- Different information may be assigned to the WT500 each time it is turned on. When accessing the WT500 from a PC using the FTP server feature (see section 11.4), you must check the WT500 network settings, such as the IP address, each time you turn the WT500 on.

IP (Internet Protocol) Address

You can set the IP address assigned to the WT500. The default address is 0.0.0.0.

- The IP address is an ID that is assigned to each device on an IP network (Internet or intranet).
- An IP address is a 32-bit value that is expressed using four octets. Each octet is separated by a period and has a value from 0 to 255, as in “192.168.111.24.”
- Obtain an IP address from your network administrator.
- The IP address is automatically set in networks that use DHCP.

Subnet Mask

You can set the mask value used to determine the subnet network address from the IP address. The default value is 255.255.255.0.

- Huge TCP/IP networks such as the Internet are often divided up into smaller networks called subnetworks. The subnet mask is a 32-bit value that specifies the number of bits of the IP address that are used to identify the network address. The remaining portion of the network address is the host address that identifies individual computers on the network.
- Consult your network administrator for the subnet mask value. You may not need to set a subnet mask.
- The subnet mask is automatically set in networks that use DHCP.

Default Gateway

You can set the IP address of the gateway used to communicate with other networks (which is referred to as the default gateway). The default address is 0.0.0.0.

- The default gateway handles data exchange between multiple networks and protocols so that data transmission proceeds smoothly.
- Consult your network administrator for the default gateway value. You may not need to set a default gateway.
- The default gateway is automatically set in networks that use DHCP.

DNS (Domain Name System)

DNS is a system that correlates combinations of host names and domain names to IP addresses. In an address such as AAA.BBBBB.com, AAA is the host name, and BBBBB.com is the domain name. You can use a host name and domain name to access the network instead of a numeric IP address.

- Set the domain name, the DNS server address, and the domain suffix. In a network that supports DHCP, these values can be set automatically.
- You can use a name to access a network drive or printer from the WT500 instead of an IP address.
- For details, consult your network administrator.
- **Domain Name**
 - Set the domain name of the network that the WT500 belongs to.
 - You can enter up to 30 characters.
 - The characters that you can use are: 0-9, A-Z, %, _, parentheses, and minus signs.
- **DNS Server Address**
 - Set the IP address of the DNS server. The default setting is 0.0.0.0.
 - You can specify up to two DNS server addresses, one primary and one secondary. If the primary DNS server is down, the WT500 automatically requests the host name, the domain name, and the IP address from the secondary DNS server.
- **Domain Suffix**
 - When the IP address corresponding to the server name with the specified domain name (see “Domain Name”) is not found on the DNS server, the system may be configured to search using a different domain name. Specify this alternate domain name as the domain suffix.
 - You can specify up to two domain suffixes, one primary and one secondary.

TCP/IP Settings for Connecting over a Network

When connecting the WT500 to a network, set the TCP/IP settings as shown below depending on whether the DHCP server and DNS server are available.

	DHCP Server Is Available	DHCP Server Is Not Available
DHCP	ON	OFF
IP address	Does not need to be set (Automatically set by the DHCP server)	Set manually (supplied by your network administrator)
Subnet mask		Set manually (check with your network administrator)
Default gateway		Set manually (check with your network administrator)

	DNS Server Is Available	DNS Server Is Not Available
DNS	ON	OFF
Domain name	Set manually*	Does not need to be set
DNS server address	Set manually*	Does not need to be set
Domain suffix	Set manually*	Does not need to be set

* In a network that supports DHCP, these values can be assigned automatically. For details, consult your network administrator.

TCP/IP Configuration Example for Connecting the WT500 to a PC through an Independent Ethernet Network

The table below shows an example of WT500 TCP/IP settings. Follow this example when setting the PC's TCP/IP settings according to the procedure described later.

DHCP	OFF
IP address	192.168.21.127
Subnet mask	255.255.255.0
Default gateway	0.0.0.0
DNS	OFF

11.3 Configuring TCP/IP Settings

Note

- You must restart the WT500 or execute Bind (see page 11-6 for details) to apply new TCP/IP settings and changes.
- If the DHCP feature is enabled and you turn the WT500 on without connecting an Ethernet cable to it, communication and file operations may not function properly. If this happens, turn DHCP off and then restart the WT500.

Configuring the TCP/IP Settings on a PC

To connect a PC to the WT500, you must configure PC communication settings, such as the IP address. Configure communication settings for each NIC that is installed in the PC. This section explains the NIC settings that must be made to connect the WT500 to a PC.

You do not need to make the IP address and other settings described below if a DHCP server automatically assigns them.

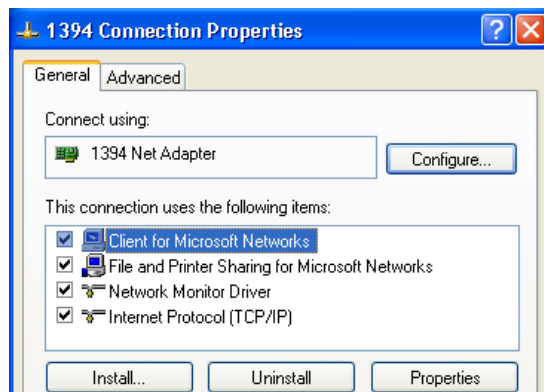
Select **Obtain an IP address automatically** under the **IP Address** tab of the **TCP/IP Properties** dialog box.

For example, if you are connecting a PC and the WT500 through an independent Ethernet network, enter the settings as indicated in the table below. For details about the settings, consult your system or network administrator.

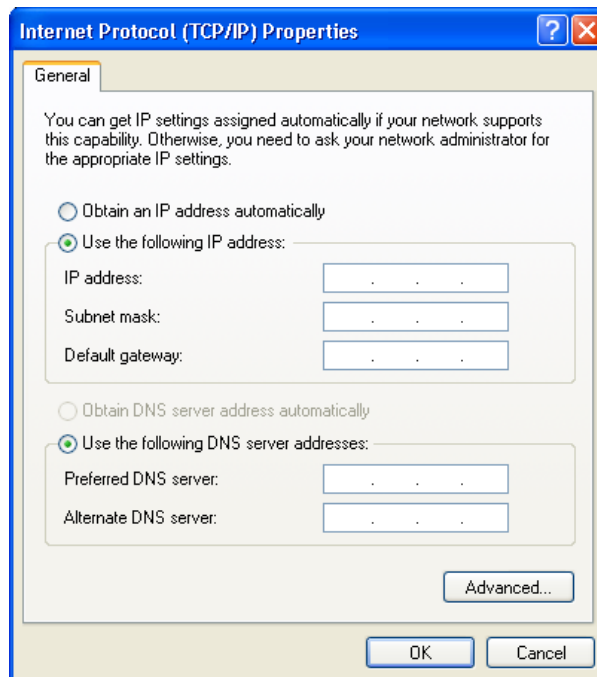
Parameter	Setting	Note
DHCP	Specify an IP address	Do not obtain an IP address automatically (do not use DHCP)
IP address	Example: 192.168.211.255	IP address of the PC
Subnet mask	Example: 255.255.255.0	Set to the same value as the WT500 subnet mask
Gateway	None	
DNS	Disable	
WINS	Disable	

The following procedure shows how to configure the network settings on Windows XP. On Windows NT and 2000 Pro, carry out equivalent steps accordingly.

1. On the taskbar, click **Start**, and then click **Control Panel**. The Control Panel opens.
2. Click **Network and Internet Connections**, and then click **Network Connections**.
3. Double-click **Local Area Connection**. The **Local Area Connection Status** dialog box appears.
4. Click **Properties**. The **Local Area Connection Properties** dialog box appears.
5. Select the TCP/IP corresponding to the Ethernet NIC that is connected to your PC, and then click **Properties**. The **Internet Protocol (TCP/IP) Properties** dialog box appears.



6. Configure the settings, such as the IP address, according to the previous table, and then click **OK**.

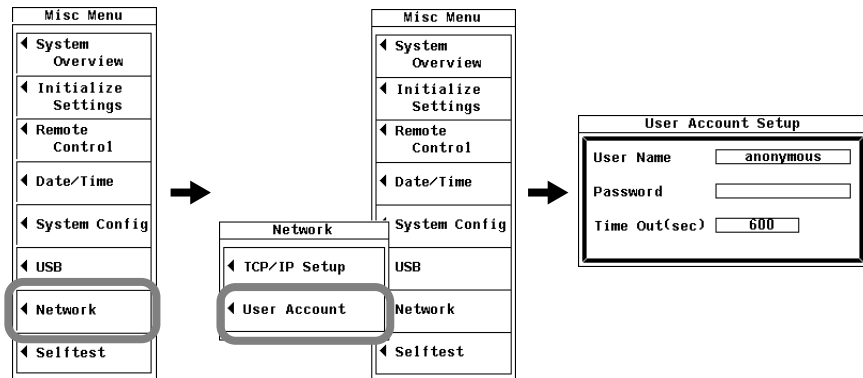


7. Restart the PC.

11.4 Accessing the WT500 from a PC or Workstation (FTP server feature)

Procedure

1. Press **MISC** to display the Misc Menu.
2. Use the **cursor keys** to select Network.
3. Press **SET** to display the Network menu.
4. Use the **cursor keys** to select User Account.
5. Press **SET** to display the User Account setup dialog box.



Setting the User Name

6. Use the **cursor keys** to select User Name.
7. Press **SET**. A keyboard appears on the screen.
8. Use the **keyboard** to set the user name.
 - For instructions on how to use the keyboard, see section 3.14, "Entering Values and Character Strings."
 - Enter "anonymous" as the user name if you do not want to require a password.

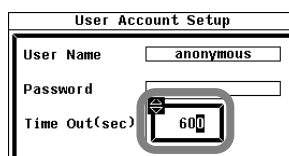
Setting the Password

(The password setting is not necessary if you set the user name to anonymous in step 8.)

9. Use the **cursor keys** to select Password.
10. Press **SET**. A keyboard appears on the screen.
11. Use the **keyboard** to set the password.
For instructions on how to use the keyboard, see section 3.14, "Entering Values and Character Strings."

Setting the Timeout Value

12. Use the **cursor keys** to select Time Out.
13. Press **SET** to display the timeout value entry box.
14. Use the **cursor keys** to set the timeout value.
15. Press **SET** or **ESC** to close the entry box.



Connecting to the WT500

16. Run FTP client software from a PC or workstation.
17. To access the WT500, use the user name and password that you set in steps 6 to 11.

Explanation

You can use a PC or workstation to connect to the WT500 over a network and access its internal RAM disk and the USB memory connected to its USB ports.

The PC or workstation must have FTP client software to access the WT500.

Setting the User Name

- Set the user name that a user can enter to gain access to the WT500.
- You can enter up to 15 characters.
- The characters that you can use are: 0-9, A-Z, %, _, parentheses, and minus signs.
- If you set the user name to “anonymous,” a PC or workstation can access the WT500 without a password.

Setting the Password

- Set the password that that a user can enter to gain access to the WT500.
- You can enter up to 15 characters.
- The characters that you can use are: 0-9, A-Z, %, _, parentheses, and minus signs.
- If you set the user name to “anonymous,” a PC or workstation can access the WT500 without a password.

Setting the Timeout Value

If the WT500 is not accessed within a given period of time (specified by the timeout value), it will disconnect from the network.

The timeout value can be set from 0 to 3600 s. The default value is 600 s.

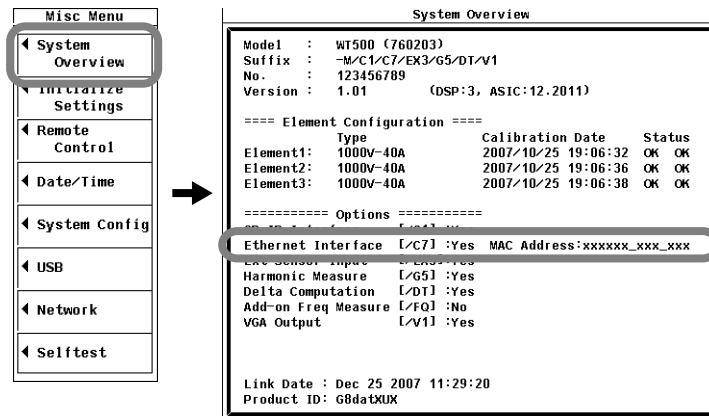
Note

- The WT500 can only connect to one client at a time.
 - The FTP server feature does not function when the WT500 is manipulating files (see chapter 10 for details).
 - In the root directory of a PC or workstation that accesses the WT500, the internal RAM disk appears as “[RAM0-0]”, and the USB memory appears as “[USB0-0]” or “[USB1-0].”
 - Before using the FTP server feature, follow the procedures in section 11.3, “Configuring TCP/IP Settings” to configure TCP/IP settings.
-

11.5 Checking the MAC Address and Whether the WT500 Is Equipped with the Ethernet Interface Option

Procedure

1. Press **MISC** to display the Misc Menu.
2. Use the **cursor keys** to select System Overview.
3. Press **SET** to display the System Overview window.
The System Overview window shows the MAC address and whether or not the WT500 is equipped with the Ethernet interface option.



Explanation

Ethernet Interface Option Availability

Whether or not the WT500 is equipped with the Ethernet interface option is indicated next to "Ethernet Interface" in the System Overview window.

- If "Yes" is displayed, the Ethernet interface option is installed.
- If "No" is displayed, Ethernet interface option is not installed.

MAC Address

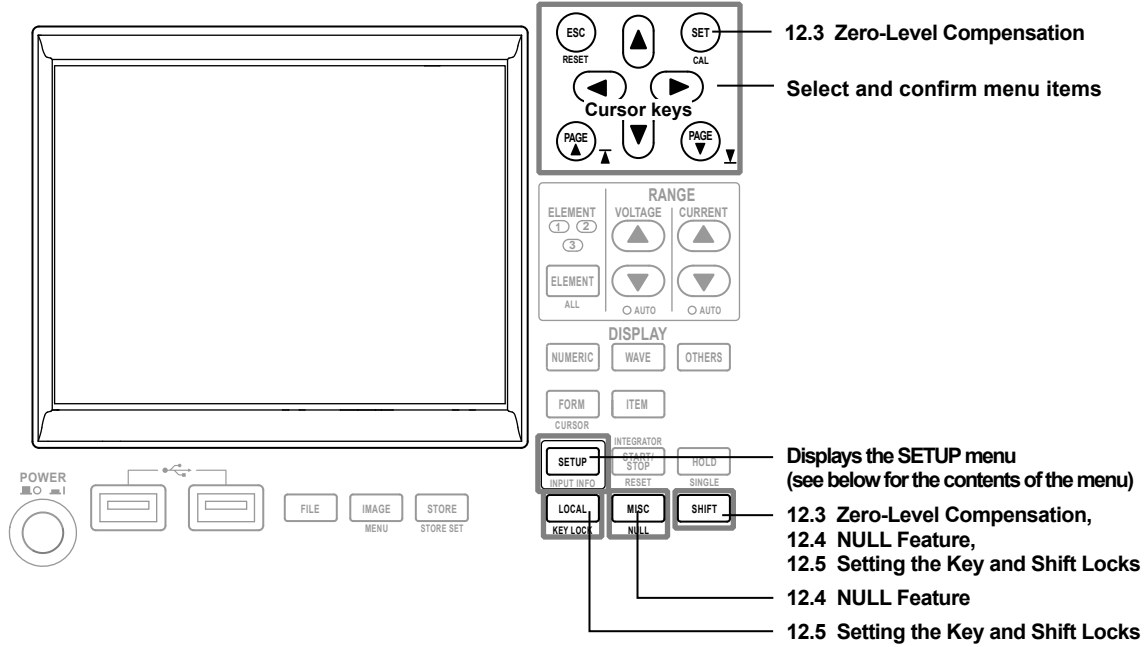
The WT500 MAC address is a fixed preset address. It is indicated next to "Mac Address" in the System Overview window.

Note

The MAC address only appears on models with the Ethernet interface option. If your WT500 is equipped with the Ethernet interface option but the MAC address is displayed as "xxxxxx_xxx_xx," contact your nearest YOKOGAWA dealer.

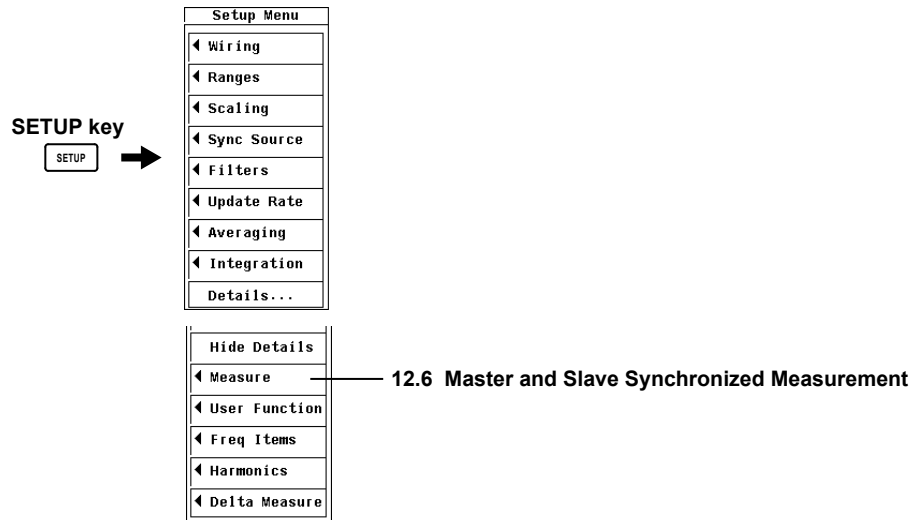
12.1 Panel Keys and Setup Menu Used in This Chapter

Panel Keys Used in This Chapter

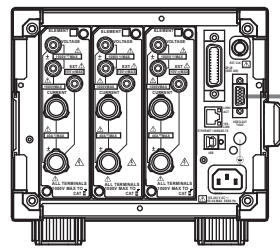


Setup Menu Used in This Chapter

To set a parameter, access its menu by pressing the appropriate panel key. The setup menu and menu items used in this chapter are shown below, along with the sections that correspond to their operating instructions.



12.2 RGB Video Signal (VGA) Output (Optional)



RGB video signal (VGA) output connector Transmits image signals.

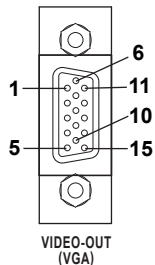
With the RGB video signal (VGA) output feature, you can use a monitor as the WT500 display. You can use a VGA monitor or a multi-sync monitor that is capable of displaying VGA.

CAUTION

- Only connect the WT500 to a monitor after turning both the WT500 and the monitor off.
- Do not short the RGB VIDEO OUT terminal or apply external voltage to it. Doing so may damage the WT500.

Video Signal Output Connector Pin Arrangement and Signal Assignments

The connector's pin arrangement and signal assignments are explained in the table below.



Pin No.	Signal Name	Specification
1	Red	0.7 Vp-p
2	Green	0.7 Vp-p
3	Blue	0.7 Vp-p
4	—	
5	—	
6	GND	
7	GND	
8	GND	
9	—	
10	GND	
11	—	
12	—	
13	Horizontal sync signal	Approximately 31.5 kHz, TTL $\overline{\square}$ (negative logic)
14	Vertical sync signal	Approximately 60 Hz, TTL $\overline{\square}$ (negative logic)
15	—	

Connecting to a Monitor

1. Turn off the WT500 and the monitor.
2. Connect the WT500 and the monitor using an RGB cable.
3. Turn both the WT500 and the monitor on. The WT500 display will appear on the monitor.

Note

- An RGB video signal is always running through the video signal output connector.
- The monitor display may flicker if you place the WT500 or some other device close to it.
- Parts of the WT500 display may be cut off, depending on the type of monitor.

12.3 Zero-Level Compensation

Procedure

Press **SHIFT+SET (CAL)** to execute zero-level compensation.

Explanation

Zero-Level Compensation

Zero-level compensation is the process of creating a zero-input condition using the WT500 internal circuit and setting the level at that point to the zero level. It must be performed to meet the specifications of this instrument (see chapter 14 for details).

- Pressing **SHIFT+SET (CAL)** executes zero level compensation.
- The WT500 automatically performs zero-level compensation after you change the measurement range or input filter.

Note

- 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 14 for details).
 - 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 the WT500. If this happens, we recommend that you execute zero-level compensation.
 - There is a feature that automatically performs zero-level compensation during integration. For details, see section 5.10.
-

12.4 NULL Feature

Procedure

Enabling the NULL Feature

1. Press **SHIFT+MISC (NULL)**. The NULL feature is enabled and the NULL indicator at the top of the screen lights.

Disabling the NULL Feature

2. When the NULL feature is enabled, press **SHIFT+MISC (NULL)**. The NULL indicator turns off, and the NULL feature is disabled.

Explanation

You can use the NULL feature to subtract the DC offset while an external sensor or measurement cable is connected.

NULL Values

When the NULL feature is enabled, the NULL values are set to the most recently measured Udc and Idc values (the voltage and current simple averages). If cases when there are no previously measured Udc and Idc values, such as when the NULL feature is turned on before any measurements have been made, Udc and Idc are set to zero.

Note

- The NULL feature is disabled when:
 - The WT500 is turned on.
 - A setup parameter file is loaded.
 - The settings are initialized.
 - You switch from direct input to external current sensor input during current measurement.
 - 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.
 - DC values are held when the NULL feature is ON, but the actual NULL value is set with $\pm 10\%$ of the range as the upper limit when the crest factor is set to 3.
The actual NULL value is set with $\pm 20\%$ of the range as the upper limit when the crest factor is set to 6.
 - 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.
-

Measurement Functions Affected by the NULL Feature

Because the NULL values are subtracted from sampled data, all measurement functions are affected by them.

12.5 Setting the Key and Shift Locks

Procedure

Activating the Key Lock

Press **SHIFT+LOCAL (KEY LOCK)**.

Releasing the Key Lock

When the key lock has been set, press **SHIFT+LOCAL (KEY LOCK)**.

Activating the Shift Lock

1. Hold down **SHIFT** for two seconds or more. The SHIFT key lights.

Releasing the Shift Lock

2. When the shift lock has been set, press **SHIFT** once. The SHIFT key light turns off.

Explanation

Key Lock

When the key lock is activated, all key operations are disabled except for those of the power switch and **SHIFT+LOCAL (KEY LOCK)**.

When the key lock is activated, "LOCK" appears in the upper right of the screen.

Note

The key lock remains on or off even after the power is turned off.

Shift Lock

Activating the shift lock is like always pressing the shift key (the WT500 remains in the shifted state). You can use the shift lock when you want to repeatedly use the setup menus indicated by the purple letters below the panel keys.

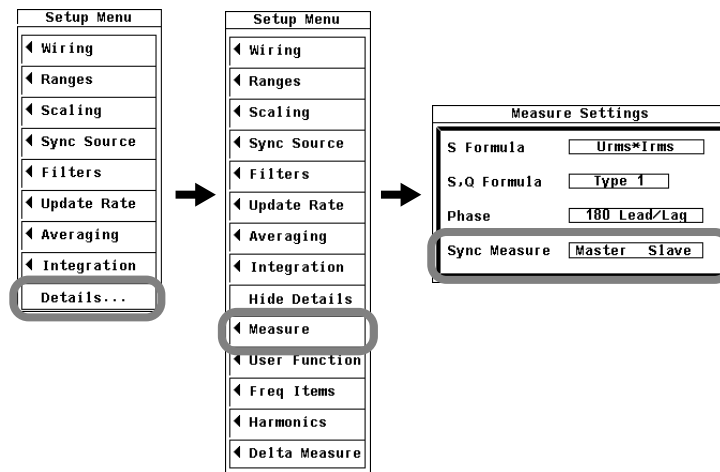
To release the shift lock, press the shift key once.

12.6 Master and Slave Synchronized Measurement

Procedure

Making the WT500 the Master or the Slave

1. Press **SETUP** to display the Setup menu.
If the full Setup menu does not appear, proceed to step 2. If the full Setup menu appears, proceed to step 4.
 2. Use the **cursor keys** to select Details.
 3. Press **SET** to display the full Setup menu.
 4. Use the **cursor keys** to select Measure.
 5. Press **SET** to display the Measure Settings dialog box.
 6. Use the **cursor keys** to select Sync Measure.
 7. Press **SET** to select Master or Slave.
- You can only set one instrument as the master and one instrument as the slave.



Performing Synchronized Measurement

Connect the external start signal input/output connectors (EXT CLK) of the master and slave instruments using a BNC cable (sold separately).

- The slave instrument starts measuring at approximately the same time as the master instrument.
- The slave instrument stops measuring at approximately the same time as the master instrument.

Explanation

The measurement of two WT500s can be synchronized by making one WT500 the master and the other WT500 the slave. The master outputs a measurement start signal, and the slave receives the signal.

External Start Signal Input/Output Connector

Connect the rear panel EXT CLK connectors between the master and slave instruments using a BNC cable (sold separately).



Item	Specification	Note
Connector	BNC connector	Same for both master and slave
I/O level	TTL	Same for both master and slave
Output logic	⌋ (negative logic), falling edge	Applies to the master
Measurement start delay time	within (1 μ s + sample interval)	Applies to the master
Output hold time	Low level, 500 ns or more	Applies to the master
Input logic	⌋ (negative logic), falling edge	Applies to the slave
Minimum pulse width	Low level, 500 ns or more	Applies to the slave
Input delay time	When the display is held within (1 μ s + sample interval)	Applies to the slave
	When the display is not held within (63 ns + sample interval)	Applies to the slave

Note

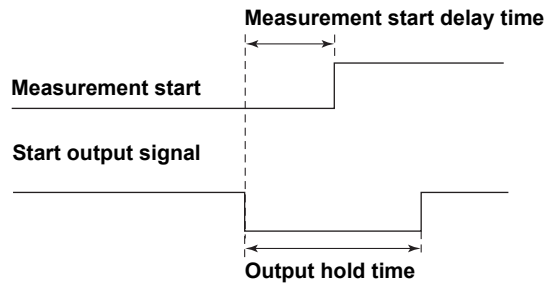
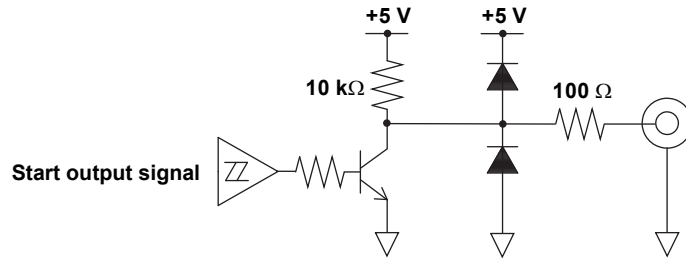
The measurement of the master and slave cannot be synchronized under the following conditions:

- When the data update rate differs between the master and slave.
- During real-time integration mode or real-time store mode.

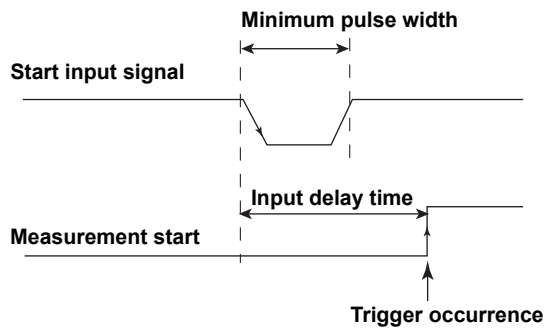
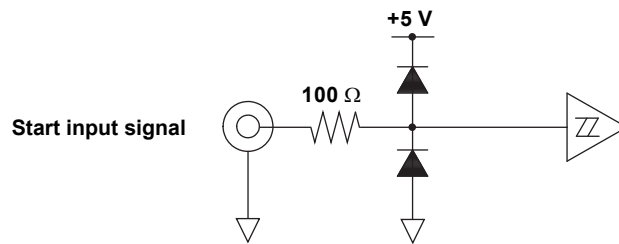
Follow the procedure below to hold the display during synchronized measurement.

- To hold the display: Hold the display of the master first.
- To un-hold the display: Un-hold the display of the slave first.
- When the synchronized measurement setting is set to slave, you cannot set the synchronization source (see section 4.7 for details), PLL source (see section 6.3 for details), or trigger source (see section 7.5 for details) Ext Clk setting, because all of these settings use the same connectors.
- To connect a BNC cable to the external clock input/external start signal output connector (EXT CLK) when a GP-IB cable is connected to the GP-IB connector, first remove the GP-IB cable. Then connect the BNC cable. Finally, reconnect the GP-IB cable.

External Start Signal Output Circuit and Time Chart



External Start Signal Input Circuit and Time Chart



CAUTION

Applying a voltage outside of the range of 0 to 5 V to the EXT CLK connector can damage the WT500.

13.1 Troubleshooting

Dealing with Unusual Circumstances

- If a message appears on the screen, see the following pages for reference.
- If servicing is necessary, or if the instrument does not operate properly even after you have attempted to deal with the problem according to the instructions in this section, contact your nearest YOKOGAWA dealer.

Problems and Solutions	Refer to section
Nothing appears on the screen when you turn on the power switch.	
Securely connect the power cord to the instrument and to the power outlet.	3.3
Set the supply voltage to within the permitted range.	3.3
The displayed data is not correct.	
Check that the ambient temperature and humidity are within their specified ranges.	3.2
Check to make sure that noise is not affecting the measurement.	3.1, 3.5
Check the measurement cable wiring.	3.8 to 3.11
Check the wiring system.	3.8 to 3.11, 4.2
Check that the line filter is off.	4.8
Check the measurement period settings.	4.7
Check the FAQ at the following URL. http://www.yokogawa.com/tm/	—
Turn the power off and then on again.	3.4
Keys are not functioning.	
Check the REMOTE indicator. If the REMOTE indicator is lighted, press LOCAL to turn it off.	—
Check that the key lock is off.	12.5
Perform a key test. If the test fails, servicing is necessary.	13.3
Triggering does not work.	
Check the trigger conditions.	7.5
Check that the trigger source is being applied.	7.5
Unable to make harmonic measurements.	
Check the PLL source settings.	6.3
Check that the PLL source input signal is within the specifications.	6.3
Unable to recognize storage medium. The storage medium may be damaged.	—
Unable to save data to the selected medium.	
Check the free space on the medium. Remove files or use a different medium as necessary.	10.2
Unable to configure or control the instrument through the communication interface.	
Check that the communication interface parameters, such as the serial number (for USB), GP-IB address, and IP address (for Ethernet), meet the specifications.	—*
Check that the interface meets the electrical and mechanical specifications.	—*

* See the *Communication Interface User's Manual (IM760201-17E)*.

13.2 Error Messages and Troubleshooting Methods

Error Messages

Error messages may appear on the screen while you are using the WT500. This section explains the meanings of the error messages and how to respond to them. You can display the error messages in English or Japanese (see section 3.17 for details). If servicing is necessary to solve the problem indicated by a message, contact your nearest YOKOGAWA dealer.

Other communication-related error messages may also appear. These messages are explained in the *Communication Interface User's Manual (IM760201-17E)*.

Error in Execution

Code	Message	Solution	Refer to section
601	Invalid file name.	Check the file name.	10.4, 10.5
602, 603	No USB device or no storage media inserted.	Check the USB device connection, and the existence of a storage medium in the device.	10.2
604	Media failure.	Check the storage medium.	—
605	File not found.	Check the file name and the storage medium.	—
606	Media is protected.	Set the disk's (medium's) write protect switch to OFF.	—
607	Media was removed while accessing.	Check the storage medium.	—
608, 609	File already exists.	—	10.4
610	Contains invalid characters.	—	10.4
611, 612	Media full.	Delete unnecessary file(s) or use another disk.	10.3 to 10.9
613	Cannot delete a directory if there are files in the directory.	Delete all the files in the directory to be deleted.	10.9
614	File is protected.	—	10.8
615	Physical format error.	Reformat the medium. If the same error occurs, the instrument is probably unable to execute a format on this medium.	9.3
616 to 620	File system failure.	Check using another disk. If the same message still appears, maintenance service is required.	—
621	File is damaged.	Check the file.	—
622 to 641	File system failure.	Check using another disk. If the same message still appears, maintenance service is required.	—
643 to 653	Media failure.	Check the medium.	—
655 to 664	File system failure.	Check using another disk. If the same message still appears, maintenance service is required.	—
665	Cannot load this file format. File was stored on other models or other versions.	—	—
666	File is now being accessed.	Execute after access is made.	—
671	Save data not found.	Check for presence of data.	10.4, 10.5
674	Initializing file system.	Please wait.	10.3
675	Cannot load this file. Model/options do not conform.	—	—
705	Can not operate while accessing medium.	Wait until access has completed.	—
750	Cannot connect to the ftp server.	Confirm the network settings and connection.	—
751	Has not connect with ftp server yet.	Confirm the network settings and connection.	—
752	This ftp function in not supported.	—	—
753	FTP Error: Pwd	Confirm the network settings and connection.	—
754	FTP Error: Cwd	Confirm the network settings and connection.	—
755	FTP Error: Rm	Confirm the network settings and connection.	—
756	FTP Error: List	Confirm the network settings and connection.	—
757	FTP Error: Mkdir	Confirm the network settings and connection.	—
758	FTP Error: Rmdir	Confirm the network settings and connection.	—
759	FTP Error: Get	Confirm the network settings and connection.	—
760	FTP Error: Put	Confirm the network settings and connection.	—
761	FTP Error: GetData	Confirm the network settings and connection.	—

13.2 Error Messages and Troubleshooting Methods

Code	Message	Solution	Refer to section
762	FTP Error: PutData	Confirm the network settings, connection, and disk capacity.	—
763	FTP Error: AppendData	Confirm the network settings, connection, and disk capacity.	—
764	FTP Error: Client Handle	Confirm the network settings and connection.	—
765	FTP Error: Others	Confirm the network settings and connection.	—
798	Failed to initialize network.	Confirm the network settings.	11.3

13.2 Error Messages and Troubleshooting Methods

Error in Setting

Code	Message	Solution	Refer to section
800	Illegal date-time.	Set the correct date and time.	3.12
801	Illegal file name.	The file name contains characters which are not allowed or the file name is not a valid MS-DOS file name. Enter another file name.	10
808	Cannot change this parameter during numerical display.	—	—
809	Cannot change this parameter during vector display.	—	—
810	Cannot change this parameter during bar graph display.	—	—
812	Cannot be set while storing data.	—	—
813	Cannot be set while integration is running.	Reset Integration.	5.9
823	Cannot change during CAL.	Wait until CAL is completed.	12.3
827	Illegal math expression.	Input a correct computing equation.	5.4
831	Processing now.	Retry setting or execution again.	—
841	Attempted to start integration after integration time has reached its preset value.	Reset Integration.	5.9
842	Attempted to start integration while integration is in progress.	—	5.9
843	Measurement stopped due to overflow during integration or due to a power failure.	Reset Integration.	5.9
844	Attempted to stop integration even though integration was not in progress.	—	5.9
845	Attempted to reset integration even though integration was in progress or integration mode was not selected.	—	5.9
846	Attempted to start integration while measurement of peak overflow was in progress.	—	5.9
847	Attempted to start integration in continuous integration mode when integration preset time was set to "0".	—	5.8
848	Attempted made to start integration in real time counting integration mode when the end time had already passed.	—	5.9
849	Attempted made to start storing in real time counting storing mode when the end time had already passed.	—	9.3
850	Cannot be set or executed at current store state. To set or execute, reset store.	—	9.4
852	Stored file is illegal. Initialize memory before storing.	—	9.4
854	Waveform display data not found.	—	—
855	Store data destination memory is full. Storing has been stopped.	—	9.4
856	An error has occurred while storing. Storing has been stopped.	—	—
857	Cannot be set while Master/Slave Synchronized Measurement is set to Slave.	—	12.6
858	Store process is in progress now.	Execute or set setting again.	9.4, 9.6
859	Cannot convert selected file.	Select a file with an extension of WTS or HDS.	9.7
862	Numeric data not found.	—	—
864	This wiring cannot be set as the first selected element.	—	4.2
865	Cannot be set while integration is running.	Stop or reset Integration.	5.7
873	When 500 Hz is selected as the line filter, the freq filter is set ON and can not be changed. PLL source or trigger source cannot be set to Ext Clk, while Master/Slave	To change the freq filter, choose a line filter other than 500 Hz.	4.8
874	Sync source, PLL source or trigger source cannot be set to Ext Clk, while Master/Slave Synchronization Measurement is set to Slave.	—	4.7, 6.3, 7.5, 12.6

13.2 Error Messages and Troubleshooting Methods

Code	Message	Solution	Refer to section
875	Master/Slave Synchronization Measurement cannot be set to Slave, while sync source, PLL source or trigger source is set to Ext Clk.	—	4.7, 6.3, 7.5, 12.6

Error in System Operation

Code	Message	Solution	Refer to section
901	Failed to backup setup data. Maintenance service is required.	The system has been initialized.	3.4
902	System RAM failure.	Maintenance service is required.	—
903	System ROM failure.	Maintenance service is required.	—
904	System RAM failure.	Maintenance service is required.	—
915	EEPROM SUM error.	EEPROM may be damaged. Maintenance service is required.	—
919	Module installation condition and setup parameters do not match.	The system has been initialized. Maintenance service is required.	—
921	System Failed to Draw Display.	Maintenance service is required.	—
922	Failed in communication with DSP.	Maintenance service is required.	—
923	Transmit data abnormality from DSP.	Maintenance service is required.	—
926	The USB device's power consumption exceeded the capacity of the USB hub.	—	14.10
927	Disconnected USB device port 1, because overcurrent was detected.	—	10.2
928	Disconnected USB device port 2, because overcurrent was detected.	—	10.2
929	A USB mass storage device that is greater than 137 GB in capacity has been connected.	Be careful in using this device. If an area exceeding 137 GB is accessed,	—
930	Disconnected the connection, because a 10BASE-T Ethernet device was detected.	This Instrument supports 100BASE-TX only.	14.2

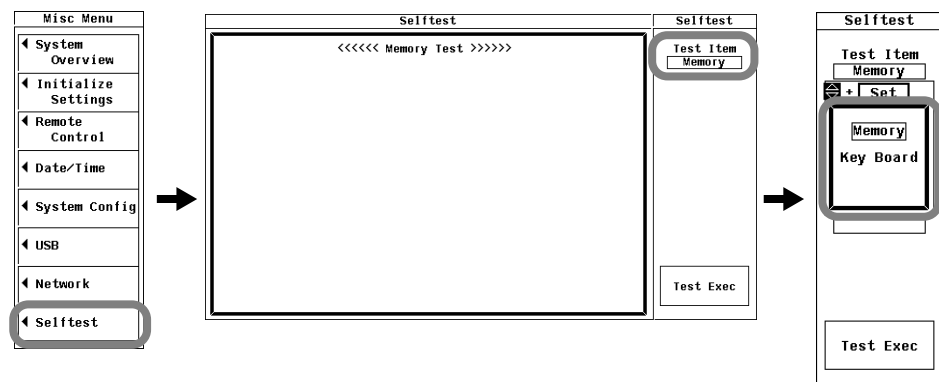
Note

If the system is not operating correctly and servicing is necessary, try initializing the WT500. It may recover.

13.3 Self-Test

Procedure

1. Press **MISC** to display the Misc Menu.
2. Use the **cursor keys** to select Selftest.
3. Press **SET** to display the Selftest menu.
4. Use the **cursor keys** to select Test Item.
5. Press **SET** to display the Test Item menu.
6. Use the **cursor keys** to select Memory or Key Board.
If you select Memory, proceed to “Performing a Memory Test.”
If you select Key Board, proceed to “Performing a Panel Key and Keyboard Test.”

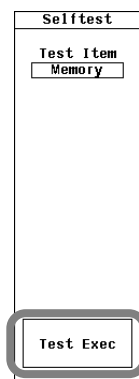


Note

The time display in the lower right of the screen may freeze during the self-test.

Performing a Memory Test

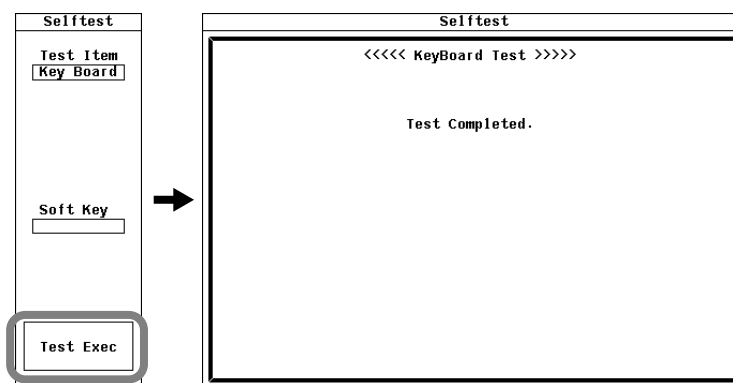
7. Use the **cursor keys** to select Test Exec.
8. Press **SET**. The WT500 executes a memory test. The results appear after the test finishes.



Testing the Keyboard and Panel Keys

• Testing the Panel Keys

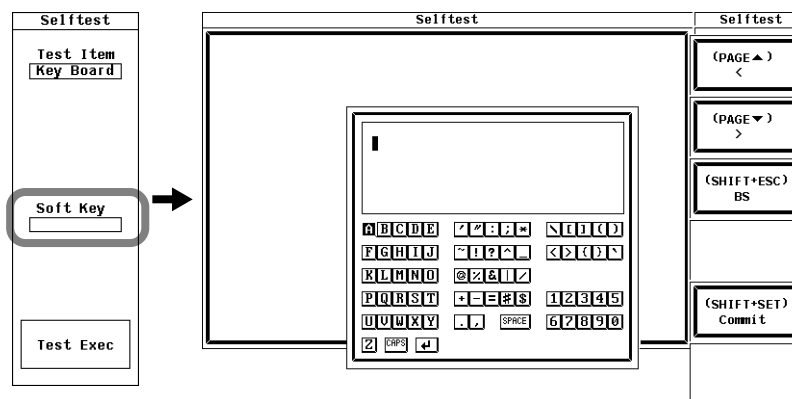
7. Use the **cursor keys** to select Test Exec.
8. Press **SET** to enter into the panel key test mode.
9. Press a **panel key** on the front panel. The key you pressed is tested.
10. Press one of the **cursor keys** (◀ or ▶). Each time you press a cursor key, an front-panel indicator lights.
11. You can exit the panel key test by pressing **ESC** twice.



• Testing the Keyboard

12. Use the **cursor keys** to select Soft Key.
13. Press **SET**. A keyboard appears on the screen.
14. Use the **keyboard**, and check whether or not the characters that you enter appear correctly in the entry box.

For instructions on how to use the keyboard, see section 3.14, "Entering Values and Character Strings."



Explanation

Memory Test

The memory test determines whether or not the internal RAM disk is operating properly. If "Pass" is displayed, they are operating properly. If "Failed" is displayed, contact your nearest YOKOGAWA dealer.

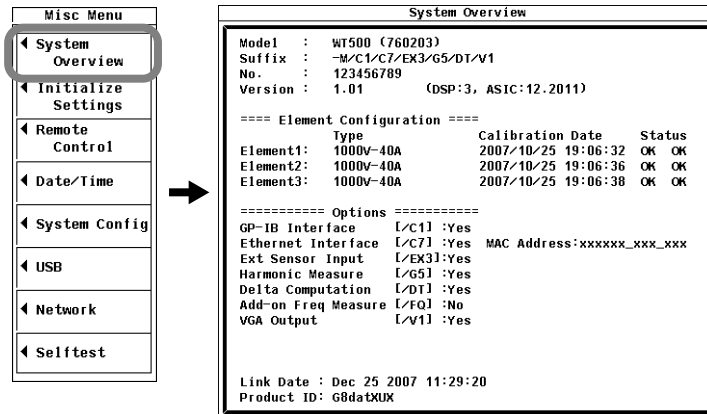
Panel Key and Keyboard Tests

- To test whether the front panel keys are operating properly, press a key and check whether or not the name of the key appears on the screen.
- If the front-panel indicator turns on or off when the cursor keys (◀ and ▶) are pressed, the keys are operating properly.
- To exit the panel key test, press ESC twice.
- If the correct panel key names do not appear, contact your nearest YOKOGAWA dealer.

13.4 Displaying the System Overview

Procedure

1. Press **MISC** to display the Misc Menu.
2. Use the **cursor keys** to select System Overview.
3. Press **SET** to display the System Overview window.



Explanation

Displaying the System Overview

You can view the model, suffix code, serial number, firmware version, element configuration, and option configuration of the WT500.

13.5 Recommended Part Replacement

The three-year warranty applies only to the main unit of the instrument (starting from the day of delivery) and does not cover any other items or expendable items (items which wear out). The replacement period for expendable items varies depending on the conditions of use. Refer to the table below as a general guideline. Contact your nearest YOKOGAWA dealer to have parts replaced.

Part name	Recommended Replacement Period
LCD backlight	3 years
Backup battery (lithium)	3 years

14.1 Input

Item	Specifications
Input terminal type	Voltage Plug-in terminal (safety terminal) Current <ul style="list-style-type: none"> • Direct input: Large binding post • Current sensor input: Isolated BNC connector
Input format	Voltage Floating input through resistive voltage divider Current Floating input through shunt
Measurement range (rated value)	Voltage <ul style="list-style-type: none"> • When the crest factor is set to 3: 15 V, 30 V, 60 V, 100 V, 150 V, 300 V, 600 V, and 1000 V • When the crest factor is set to 6: 7.5 V, 15 V, 30 V, 50 V, 75 V, 150 V, 300 V, and 500 V Current <ul style="list-style-type: none"> • Direct input <ul style="list-style-type: none"> • When the crest factor is set to 3: 500 mA, 1 A, 2 A, 5 A, 10 A, 20 A, and 40 A • When the crest factor is set to 6: 250 mA, 500 mA, 1 A, 2.5 A, 5 A, 10 A, 20 A • External sensor input <ul style="list-style-type: none"> • When the crest factor is set to 3: 50 mV, 100 mV, 200 mV, 500 mV, 1 V, 2 V, 5 V, and 10 V • When the crest factor is set to 6: 25 mV, 50 mV, 100 mV, 250 mV, 500 mV, 1 V, 2.5 V, and 5 V
Input impedance	Voltage Input resistance: Approx. 2 M Ω ; input capacitance: Approx. 13 pF Current <ul style="list-style-type: none"> • Direct input: Approx. 5 mΩ + approx. 0.1 μH • External sensor input: Approx. 100 KΩ
Instantaneous maximum allowable input (within 20 ms)	Voltage Peak value of 2.8 kV or rms value of 2 kV, whichever is less. Current <ul style="list-style-type: none"> • Direct input: Peak value of 450 A or rms value of 300 A, whichever is less. • External sensor input: Peak value less than or equal to 10 times the measurement range.
Instantaneous maximum allowable input (within 1 s)	Voltage Peak value of 2 kV or rms value of 1.5 kV, whichever is less. Current <ul style="list-style-type: none"> • Direct input: Peak value of 150 A or rms value of 45 A, whichever is less. • External sensor input: Peak value less than or equal to 10 times the measurement range.
Continuous maximum allowable input	Voltage Peak value of 1.5 kV or rms value of 1 kV, whichever is less. Current <ul style="list-style-type: none"> • Direct input: Peak value of 100 A or rms value of 45 A, whichever is less. • External sensor input: Peak value less than or equal to 5 times the measurement range.
Continuous maximum allowable input (50/60 Hz)	1000 Vrms
Influence of common-mode voltage	When 1000 Vrms is applied with the voltage input terminals shorted and the current input terminals open. <ul style="list-style-type: none"> • 50/60 Hz: $\pm 0.01\%$ of range or less. • Reference value for up to 100 kHz: $\pm \{(\text{Rated maximum range})/(\text{rated range}) \times 0.001 \times f\%$ of range} or less However, 0.01% or greater. The unit of f is kHz. The external sensor input range is the value of the above equation $\times 20$. The maximum rated range in the equation is 1000 V, 45 A, or 10 V.
Line filter	The choices are OFF, 500 Hz, and 5.5 kHz.
Frequency filter	The choices are OFF and ON.
A/D converter	Converts voltage and current inputs simultaneously. Resolution: 16 bits. Conversion rate (sampling interval): Approx. 10 μ s. For the values when displaying harmonics, see the sections on harmonic measurement.

14.1 Input/14.2 Display

Item	Specifications
Range switching	The range can be set for each input element.
Auto range feature	Range Increase <ul style="list-style-type: none">When Urms or Irms exceeds 110% of the rated rangeWhen the peak value of the input signal exceeds approximately 330% of the rated range (approximately 660% when the crest factor is set to 6). Range decrease <p>When Urms or Irms is less than or equal to 30% of the rated range and Upk or Ipk is less than or equal to 300% of the lower range (approximately 600% when the crest factor is set to 6).</p>

14.2 Display

Item	Specifications
Display	5.7-inch color TFT LCD
Resolution of the entire screen*	640 × 480 dots (H × V)
Resolution of the waveform display	501 × 432 dots (H × V)
Display update interval	Same as the data update interval (see section 14.6). However, <ul style="list-style-type: none">Numeric display When the data update interval is 100 ms and the numeric value display is set to 4, 8, or 16 items, the numeric display update interval is 200 ms. When the data update interval is 100 ms and the numeric value display is set to Matrix, ALL Items, Single List, or Dual List, the numeric display update interval is 500 ms. When the data update interval is 200 ms and the numeric value display is set to Matrix, ALL Items, Single List, or Dual List, the numeric display update interval is 400 ms.Waveform display When the data update interval is within the range of 100 ms to 1 s, the waveform display and data update intervals are approximately 1 s. When the data update interval is 1 s or longer, the waveform display and data update intervals are the same as the data update interval. However, the waveform display and data update intervals may be longer depending on the trigger setting.Other displays When the data update interval is set to a value from 100 ms to 500 ms, the data and display update intervals of the trend display, bar graph display, and vector display are 1 s. When the data update interval is set to 1 s or longer, the various display and data update intervals are the same as the data update interval.The various display and data update intervals are determined by the external clock when the WT500 is set to the slave in synchronized measurement. However, the limitations listed above apply if the period of the external clock is greater than that of the data update rate.

* Relative to the total number of pixels, 0.02% of the LCD screen may be defective.

14.3 Normal Measurement Functions (Measured Items)

Measurement Functions Determined for Each Input Element

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

Item	Symbols and Meanings
Voltage (V)	Urms: true rms value, Umn: rectified mean value calibrated to the rms value, Udc: simple average, Urmn: rectified mean value, Uac: AC component
Current (A)	Irms: true rms value, Imn: rectified mean value calibrated to the rms value, Idc: simple average, Irmn: rectified mean value, Iac: AC component
Active power (W)	P
Apparent power (VA)	S
Reactive power (var)	Q
Power factor	λ
Phase difference (°)	ϕ
Frequency (Hz)	fU (FreqU): voltage frequency, fI (FreqI): current frequency The two frequencies fU and fI can be measured simultaneously from any installed element. For signals that are not selected, [-----] (no data) is displayed. On models with the frequency measurement add-on option, the fU and fI of all elements can be measured simultaneously.
Voltage max. and min. (V)	U+pk: Maximum voltage, U-pk : Minimum voltage
Current max. and min. (A)	I+pk: Maximum current, I-pk : Minimum current
Crest factor (peak-to-rms ratio)	CfU: Voltage crest factor, CfI : Current crest factor
Integration	Time: Integration time WP: Sum of positive and negative watt hours WP+: Sum of positive P (consumed watt hours) WP-: Sum of negative P (watt hours returned to the power supply) q: Sum of positive and negative ampere hours q+: Sum of positive I (ampere hours) q-: Sum of negative I (ampere hours) WS: Volt-ampere hours WQ: Var hours

You can select to integrate the ampere hours using Irms, Imn, Idc, Irmn, or Iac.

14.3 Normal Measurement Functions (Measured Items)

Measurement Functions Determined for Each Wiring Unit (Σ Functions)

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

Item	Symbols and Meanings
Voltage (V)	Urms Σ : true rms value, Umn Σ : rectified mean value calibrated to the rms value, Udc Σ : simple average, Urmn Σ : rectified mean value, Uac Σ : AC component
Current (A)	Irms Σ : true rms value, Imn Σ : rectified mean value calibrated to the rms value, Idc Σ : simple average, Irmn Σ : rectified mean value, Iac Σ : AC component
Active power (W)	P Σ
Apparent power (VA)	S Σ
Reactive power (var)	Q Σ
Power factor	$\lambda\Sigma$
Phase difference (°)	$\phi\Sigma$
Integration	Time: Integration time WP Σ : Sum of positive and negative watt hours WP+ Σ : Sum of positive P (consumed watt hours) WP- Σ : Sum of negative P (watt hours returned to the power supply) q Σ : Sum of positive and negative ampere hours q+ Σ : Sum of positive I (ampere hours) q- Σ : Sum of negative I (ampere hours) WS Σ : Integrated value of S Σ WQ Σ : Integrated value of Q Σ

You can select to integrate the ampere hours using Irms, Imn, Idc, Irmn, or Iac.

14.4 Harmonic Measurement Functions (Measured Items)

Measurement Functions Determined for Each Input Element

Item	Symbols and Meanings
Voltage (V)	U(k): Rms voltage value of harmonic order k. ¹ U(Total): Rms voltage. ²
Current (A)	I(k): Rms current value of harmonic order k. I(Total): Rms current. ²
Active power (W)	P(k): Active power of harmonic order k. P(Total): Active power. ²
Apparent power (VA)	S(k): Apparent power of harmonic order k. S(Total): Total apparent power. ²
Reactive power (var)	Q(k): Reactive power of harmonic order k. Q(Total): Total reactive power. ²
Power factor	$\lambda(k)$: Power factor of harmonic order k. $\lambda(\text{Total})$: Total power factor. ²
Phase difference (°)	$\phi(k)$: Phase difference between the voltage and current of harmonic order k. ϕ : Total phase difference. $\phi U(k)$: Phase difference between harmonic voltage U(k) and the fundamental signal U(1). $\phi I(k)$: Phase difference between harmonic current I(k) and the fundamental signal I(1).
Harmonic distortion factor (%)	Uhd(k): Ratio of harmonic voltage U(k) to U(1) or U(Total). Ihd(k): Ratio of harmonic current I(k) to I(1) or I(Total). Phd(k): Ratio of harmonic active power P(k) to P(1) or P(Total).
Total harmonic distortion (%)	Uthd: Ratio of the total harmonic voltage to U(1) or U(Total). ³ Ithd: Ratio of the total harmonic current to I(1) or I(Total). Pthd: Ratio of the total harmonic active power to P(1) or P(Total).

- 1 Harmonic order k is an integer from 0 to the upper limit of harmonic analysis. The 0th order is the DC component. The upper limit of harmonic analysis is either set to an automatically determined value or to the value that you set, whichever is smaller. It can go up to the 50th harmonic order.
- 2 The total value is determined according to the equation in appendix 1 from the fundamental signal (1st order) and all harmonic components (2nd order to the upper limit of harmonic analysis). The DC component can also be included.
- 3 Total harmonic values are determined from all harmonic components (the 2nd order to the upper limit of harmonic analysis) according to the equations in appendix 1.

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

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

Item	Symbols and Meanings
Phase difference U1-U2 (°)	$\phi U1-U2$: Phase difference between the fundamental voltage of element 1, which is expressed as U1(1), and the fundamental voltage of element 2, which is expressed as U2(1).
Phase difference U1-U3 (°)	$\phi U1-U3$: Phase difference between U1(1) and the fundamental voltage of element 3, U3(1).
Phase difference U1-I1 (°)	$\phi U1-I1$: The phase difference between U1(1) and the fundamental current of element 1, I1(1).
Phase difference U1-I2 (°)	$\phi U1-I2$: The phase difference between U1(1) and the fundamental current of element 2, I2(1).
Phase difference U1-I3 (°)	$\phi U1-I3$: The phase difference between U1(1) and the fundamental current of element 3, I3(1).

Measurement Functions Determined for Each Wiring Unit (Σ Functions)

Item	Symbols and Meanings
Voltage (V)	U Σ (1): Rms voltage of harmonic order 1. U Σ (total value): Rms voltage. ¹
Current (A)	I Σ (1): Rms current of harmonic order 1. I Σ (total value): Rms current. ¹
Active power (W)	P Σ (1): Active power of harmonic order 1. P Σ (total value): Active power. ¹
Apparent power (VA)	S Σ (1): Apparent power of harmonic order 1. S Σ (total value): Total apparent power. ¹
Reactive power (var)	Q Σ (1): Reactive power of harmonic order 1. Q Σ (total value): Total reactive power. ¹
Power factor	$\lambda\Sigma(1)$: Power factor of harmonic order 1. $\lambda\Sigma(\text{total value})$: Total power factor. ¹

- 1 The total value is determined according to the equation in appendix 1 from the fundamental signal (1st order) and all harmonic components (2nd order to the upper limit of harmonic analysis). The DC component can also be included.

14.5 Accuracy

Voltage and Current Accuracy

tem	Specifications																												
Accuracy (at 6 months)	<p>Conditions</p> <p>Temperature: $23 \pm 5^\circ\text{C}$ Humidity: 30 to 75%RH. Input waveform: Sine wave. Common-mode voltage: 0 V. Frequency filter: Set to 440 Hz. λ (power factor): 1. Crest factor: 3. After the warm-up time has passed. Wired condition after zero-level compensation or measurement range change. f is the frequency.</p> <ul style="list-style-type: none"> Voltage <table border="1"> <thead> <tr> <th>Frequency</th> <th>Accuracy</th> </tr> </thead> <tbody> <tr> <td>DC</td> <td>$\pm(\text{reading error} + \text{measurement range error})$ 0.1% of reading + 0.1% of range</td> </tr> <tr> <td>$0.5 \text{ Hz} \leq f < 45 \text{ Hz}$</td> <td>0.1% of reading + 0.2% of range</td> </tr> <tr> <td>$45 \text{ Hz} \leq f \leq 66 \text{ Hz}$</td> <td>0.1% of reading + 0.1% of range</td> </tr> <tr> <td>$66 \text{ Hz} < f \leq 1 \text{ kHz}$</td> <td>0.1% of reading + 0.2% of range</td> </tr> <tr> <td>$1 \text{ kHz} < f \leq 10 \text{ kHz}$</td> <td>$\{0.1 + 0.05 \times (f - 1)\}$% of reading + 0.2% of range</td> </tr> <tr> <td>$10 \text{ kHz} < f \leq 100 \text{ kHz}$</td> <td>$\{0.5 + 0.04 \times (f - 10)\}$% of reading + 0.3% of range</td> </tr> </tbody> </table> <p>* The unit of f in reading-error equations is kHz.</p> Current <table border="1"> <thead> <tr> <th>Frequency</th> <th>Accuracy</th> </tr> </thead> <tbody> <tr> <td>DC</td> <td>$\pm(\text{reading error} + \text{measurement range error})$ 0.1% of reading + 0.1% of range</td> </tr> <tr> <td>$0.5 \text{ Hz} \leq f < 45 \text{ Hz}$</td> <td>0.1% of reading + 0.2% of range</td> </tr> <tr> <td>$45 \text{ Hz} \leq f \leq 66 \text{ Hz}$</td> <td>0.1% of reading + 0.1% of range</td> </tr> <tr> <td>$66 \text{ Hz} < f \leq 1 \text{ kHz}$</td> <td>0.1% of reading + 0.2% of range</td> </tr> <tr> <td>$1 \text{ kHz} < f \leq 10 \text{ kHz}$</td> <td>$(0.1 \times f)$% of reading + 0.2% of range</td> </tr> <tr> <td>$10 \text{ kHz} < f \leq 100 \text{ kHz}$</td> <td>$\{1 + 0.08 \times (f - 10)\}$% of reading + 0.3% of range</td> </tr> </tbody> </table> <p>* The unit of f in reading error equations is kHz.</p> <ul style="list-style-type: none"> For the external current sensor range, add $50 \mu\text{V}$ to the DC current accuracy. For the directly applied current input range, add $500 \mu\text{A}$ to the DC current accuracy. For the accuracies of waveform display data functions Upk and Ipk: Add the following values (reference values) to the accuracies listed above. For the voltage input, add $1.5 \times 1.5 \times \sqrt{(15/\text{rated range})\% \text{ of range}}$. For the directly applied current input, add $3 \times 3 \times \sqrt{(0.5/\text{rated range})\% \text{ of range} + 5 \text{ mA}}$. For the external current sensor input, add $3 \times 3 \times \sqrt{(0.05/\text{rated range})\% \text{ of range} + 2 \text{ mV}}$. The effective input range is within $\pm 300\%$ of the range (within $\pm 600\%$ of the range if the crest factor is set to 6). Influence of temperature changes after zero-level compensation or range change DC voltage accuracy: add 0.02% of range/$^\circ\text{C}$. DC current accuracy: add $500 \mu\text{A}/^\circ\text{C}$. External input sensor DC accuracy: add $50 \mu\text{V}/^\circ\text{C}$. Influence of self-generated heat caused by voltage input Add $0.0000001 \times U^2\%$ of reading to the AC voltage accuracies. Add $0.0000001 \times U^2\%$ of reading + $0.0000001 \times U^2\%$ of range to the DC voltage accuracies. U is the voltage reading (V). Even if the voltage input decreases, the influence from self-generated heat continues until the temperature of the input resistor inside the WT500 decreases. Influence of self-generated heat caused by current input Add $0.00013 \times I^2\%$ of reading to the AC current accuracies. Add $0.00013 \times I^2\%$ of reading + $0.004 \times I^2 \text{ mA}$ to the DC current accuracies. I is the current reading (A). Even if the current input decreases, the influence from self-generated heat continues until the temperature of the shunt resistor inside the WT500 decreases. Accuracy changes caused by data update interval When the data update interval is 100 ms, add 0.05% of reading to all accuracy figures. Guaranteed accuracy ranges for frequency, voltage, and current All accuracy figures for 0.1 to 10 Hz are reference values. The voltage accuracy figures for 30 kHz to 100 kHz when the voltage exceeds 750 V are reference values. The current and power accuracy figures for DC, 10 Hz to 45 Hz, and 400 Hz to 200 kHz when the current exceeds 20 A are reference values. 	Frequency	Accuracy	DC	$\pm(\text{reading error} + \text{measurement range error})$ 0.1% of reading + 0.1% of range	$0.5 \text{ Hz} \leq f < 45 \text{ Hz}$	0.1% of reading + 0.2% of range	$45 \text{ Hz} \leq f \leq 66 \text{ Hz}$	0.1% of reading + 0.1% of range	$66 \text{ Hz} < f \leq 1 \text{ kHz}$	0.1% of reading + 0.2% of range	$1 \text{ kHz} < f \leq 10 \text{ kHz}$	$\{0.1 + 0.05 \times (f - 1)\}$ % of reading + 0.2% of range	$10 \text{ kHz} < f \leq 100 \text{ kHz}$	$\{0.5 + 0.04 \times (f - 10)\}$ % of reading + 0.3% of range	Frequency	Accuracy	DC	$\pm(\text{reading error} + \text{measurement range error})$ 0.1% of reading + 0.1% of range	$0.5 \text{ Hz} \leq f < 45 \text{ Hz}$	0.1% of reading + 0.2% of range	$45 \text{ Hz} \leq f \leq 66 \text{ Hz}$	0.1% of reading + 0.1% of range	$66 \text{ Hz} < f \leq 1 \text{ kHz}$	0.1% of reading + 0.2% of range	$1 \text{ kHz} < f \leq 10 \text{ kHz}$	$(0.1 \times f)$ % of reading + 0.2% of range	$10 \text{ kHz} < f \leq 100 \text{ kHz}$	$\{1 + 0.08 \times (f - 10)\}$ % of reading + 0.3% of range
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tem	Specifications														
Effective input range	<p>0 to $\pm 110\%$ of the measurement range for Udc and Idc.*</p> <p>1 to 110% of the measurement range for Urms and Irms (2 to 220% when the crest factor is set to 6).*</p> <p>10 to 110% of the measurement range for Umn and Imn.*</p> <p>10 to 110% of the measurement range for Urmn and Irmn.*</p> <p>10 to 110% of the measurement range for Uac and Iac.*</p> <p>However, the synchronization source signal level must meet the frequency measurement input signal level (see section 14.5 for details).</p> <p>* 100% for the maximum voltage range.</p>														
Maximum display	140% of the rated voltage or current range.														
Minimum display	<p>As low as 0.5% of the measurement range for Urms, Uac, Irms, and Iac (1.0% when the crest factor is set to 6). As low as 2% of the measurement range for Umn, Urmn, Imn, and Irmn (4% when the crest factor is set to 6).</p> <p>Values lower than these figures are fixed at zero. The integrated current q is dependent on the current value.</p>														
Lower limit of measurement frequency	<table border="1"> <thead> <tr> <th>Data update interval</th> <th>100 ms</th> <th>200 ms</th> <th>500 ms</th> <th>1 s</th> <th>2 s</th> <th>5 s</th> </tr> </thead> <tbody> <tr> <td>Lower limit of measurement frequency</td> <td>25 Hz</td> <td>12.5 Hz</td> <td>5 Hz</td> <td>2.5 Hz</td> <td>1.25 Hz</td> <td>0.5 Hz</td> </tr> </tbody> </table>	Data update interval	100 ms	200 ms	500 ms	1 s	2 s	5 s	Lower limit of measurement frequency	25 Hz	12.5 Hz	5 Hz	2.5 Hz	1.25 Hz	0.5 Hz
Data update interval	100 ms	200 ms	500 ms	1 s	2 s	5 s									
Lower limit of measurement frequency	25 Hz	12.5 Hz	5 Hz	2.5 Hz	1.25 Hz	0.5 Hz									
Line filter influence	<p>When the cutoff frequency is 500 Hz</p> <p>45 to 66 Hz: Add 0.2% of reading. Less than 45 Hz: Add 0.5% of reading.</p> <p>When the cutoff frequency is 5.5 kHz</p> <p>66 Hz or less: Add 0.2% of reading. 66 to 500 Hz: Add 0.5% of reading.</p>														
Conditions for detecting lead and lag (D/G, for lead and lag, of phase angle ϕ ; sign s* when computing reactive power $Q\Sigma$)	<p>Lead and lag are detected correctly when the voltage and current signals are both sine waves, the lead and lag amplitude is greater than or equal to 50% (greater than or equal to 100% if the crest factor is set to 6) of the measurement range, the frequency is between 20 Hz and 2 kHz, and the phase difference is between ± 5 and 175°.</p> <p>* s is the sign for the lead and lag of each element. It is negative when the current leads the voltage.</p>														
Temperature coefficient	Add $\pm 0.03\%$ of reading/ $^\circ\text{C}$ within the range of 5 to 18°C or 28 to 40°C .														
One year accuracy	Reading error of accuracy at 6 months $\times 1.5$.														
Accuracy when the crest factor is set to 6	Same as the accuracy when the crest factor is 3 after doubling the measurement range.														

14.5 Accuracy

Power Accuracy

Item	Specifications																
Accuracy (at 6 months)	<p>Conditions</p> <p>Same as the conditions for the voltage and current accuracies.</p> <table border="1"> <thead> <tr> <th>Frequency</th> <th>Accuracy</th> </tr> </thead> <tbody> <tr> <td>DC</td> <td>$\pm(\text{reading error} + \text{measurement range error})$</td> </tr> <tr> <td>DC</td> <td>0.1% of reading + 0.1% of range</td> </tr> <tr> <td>$0.5 \text{ Hz} \leq f < 45 \text{ Hz}$</td> <td>0.3% of reading + 0.2% of range</td> </tr> <tr> <td>$45 \text{ Hz} \leq f \leq 66 \text{ kHz}$</td> <td>0.1% of reading + 0.1% of range</td> </tr> <tr> <td>$66 \text{ Hz} < f \leq 1 \text{ kHz}$</td> <td>0.2% of reading + 0.2% of range</td> </tr> <tr> <td>$1 \text{ kHz} < f \leq 10 \text{ kHz}$</td> <td>$\{0.1 + 0.067 \times (f - 1)\}\%$ of reading + 0.3% of range</td> </tr> <tr> <td>$10 \text{ kHz} < f \leq 100 \text{ kHz}$</td> <td>$\{5.1 + 0.18 \times (f - 50)\}\%$ of reading + 0.3% of range</td> </tr> </tbody> </table> <p>* The unit of f in the reading-error equations is kHz.</p> <ul style="list-style-type: none"> For the external current sensor range, add $(50 \mu\text{V} / \text{external current sensor range rating}) \times 100\%$ to the DC power accuracy. For the directly applied current input range, add $(500 \mu\text{A} / \text{directly applied current input range rating}) \times 100\%$ of range to the DC power accuracy. Influence of temperature changes after zero-level compensation or range change. DC voltage accuracy: add 0.02% of range/$^{\circ}\text{C}$. DC current accuracy for direct input: add 500 $\mu\text{A}/^{\circ}\text{C}$. DC voltage accuracy for external sensor input: add 50 $\mu\text{V}/^{\circ}\text{C}$. DC power accuracy: add the product of the voltage influence and the current influence. Influence of self-generated heat caused by voltage input Add $0.0000001 \times U^2\%$ of reading to the AC power accuracies. Add $0.0000001 \times U^2\%$ of reading + $0.0000001 \times U^2\%$ of range to the DC power accuracies. U is the voltage reading (V). Even if the voltage input decreases, the influence from self-generated heat continues until the temperature of the input resistor inside the WT500 decreases. Influence of self-generated heat caused by current input Add $0.00013 \times I^2\%$ of reading to the AC power accuracies. Add $0.00013 \times I^2\%$ of reading + $0.0004 \times I\%$ of reading to the DC power accuracies. I is the current reading (A). Even if the current input decreases, the influence from self-generated heat continues until the temperature of the shunt resistor inside the WT500 decreases. Accuracy changes caused by data update interval When the data update interval is 100 ms, add 0.05% of reading to all accuracy figures. Guaranteed accuracy ranges for frequency, voltage, and current All accuracy figures for 0.1 to 10 Hz are reference values. The power accuracy figures for 30 kHz to 100 kHz when the voltage exceeds 750 V are reference values. The power accuracy figures for DC, 10 Hz to 45 Hz, and 400 Hz to 200 kHz when the current exceeds 20 A are reference values. 	Frequency	Accuracy	DC	$\pm(\text{reading error} + \text{measurement range error})$	DC	0.1% of reading + 0.1% of range	$0.5 \text{ Hz} \leq f < 45 \text{ Hz}$	0.3% of reading + 0.2% of range	$45 \text{ Hz} \leq f \leq 66 \text{ kHz}$	0.1% of reading + 0.1% of range	$66 \text{ Hz} < f \leq 1 \text{ kHz}$	0.2% of reading + 0.2% of range	$1 \text{ kHz} < f \leq 10 \text{ kHz}$	$\{0.1 + 0.067 \times (f - 1)\}\%$ of reading + 0.3% of range	$10 \text{ kHz} < f \leq 100 \text{ kHz}$	$\{5.1 + 0.18 \times (f - 50)\}\%$ of reading + 0.3% of range
Frequency	Accuracy																
DC	$\pm(\text{reading error} + \text{measurement range error})$																
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$10 \text{ kHz} < f \leq 100 \text{ kHz}$	$\{5.1 + 0.18 \times (f - 50)\}\%$ of reading + 0.3% of range																
Effective input range	<p>0 to $\pm 110\%$ of the measurement range for DC power. For AC, current and voltage are 1 to $\pm 110\%$ of the measurement range and power is up to $\pm 110\%$.*</p> <p>However, the synchronization source signal level must meet the frequency measurement input signal level (see section 14.6 for details).</p> <p>* 100% for the maximum voltage range.</p>																
Lower limit of measurement frequency	Same as the lower limits for the voltage and current measurement frequencies.																
Power factor influence (not including when $\lambda = 1$)	<ul style="list-style-type: none"> When $\lambda = 0$ Apparent power reading $\times 0.2\%$ in the range of 45 to 66 Hz. For other frequency ranges, see below. However, be aware that these figures are reference values. Apparent power reading $\times (0.2 + 0.2 \times f \text{ (kHz)})\%$ When $0 < \lambda < 1$ $(\text{Power reading}) \times \{(\text{power reading error } \%) + (\text{power range error } \%) \times (\text{power range/indicated apparent power value}) + \{\tan \phi \times (\text{influence when } \lambda = 0\%)\}\}$ where ϕ is the phase angle between the voltage and current. 																

Item	Specifications
Line filter influence	When the cutoff frequency is 500 Hz 45 to 66 Hz: Add 0.3% of reading. Less than 45 Hz: Add 1% of reading. When the cutoff frequency is 5.5 kHz 66 Hz or less: Add 0.4% of reading. 66 to 500 Hz: Add 1.2% of reading.
Temperature coefficient	Same as the temperature coefficients for the voltage and current.
One year accuracy	Reading error of accuracy at 6 months \times 1.5.
Accuracy when the crest factor is set to 6	Same as the accuracy when the crest factor is 3 after doubling the measurement range.

Other Computation and Measurement Accuracies

- Accuracy of apparent power S Voltage accuracy + current accuracy
- Accuracy of reactive power Q Accuracy of apparent power + $(\sqrt{(1.0004 - \lambda^2)} - \sqrt{(1 - \lambda^2)}) \times 100\%$ of range
- Accuracy of power factor λ $\pm[(\lambda - \lambda/1.0002) + |\cos\phi - \cos\{\phi + \sin^{-1}(\text{influence from the power factor when } \lambda = 0\%/100)\}|] \pm 1$ digit
when voltage and current are at the measurement range rated input.
- Accuracy of phase difference ϕ $\pm[|\phi - \cos^{-1}(\lambda/1.0002)| + \sin^{-1}\{(influence from the power factor when } \lambda = 0\%/100)\}] \text{ deg} \pm 1$ digit
when voltage and current are at the measurement range rated input.
- For the accuracies of frequencies fU and fI, see "Frequency Measurement" in section 14.6, "Functions."
- For the accuracies of integrated values WP, WP+, WP-, q, q+, and q- and the integration time (Time), see "Integration" in section 14.6, "Functions."
- For the accuracies of voltage, current, and power during harmonic measurement, see "Harmonic Measurement" in section 14.6, "Functions."

14.6 Functions

Measurement Functions and Measurement Conditions

Item	Specifications
Frequency range	DC, or 0.5 Hz to 100 kHz
Crest factor	Can be set to 3 or 6 (when the rated input of a given measurement range is applied). 300 for the minimum effective input.
Measurement period	<p>Period used to determine and compute measurement functions.</p> <ul style="list-style-type: none"> Except for ampere hours (q) during DC mode and watt hours (WP), the measurement period is set using the zero crossing points of the reference signal (synchronization source). In harmonic display (optional): The measurement period is the first 1024 points from the beginning of the data update interval at the harmonic sampling frequency.
Wiring system	<p>Can be set to one of the following five types: (1) 1P2W, single-phase, two-wire; (2) 1P3W, single-phase, three-wire; (3) 3P3W, three-phase, three-wire; (4) 3P4W, three-phase, four-wire; and (5) 3P3W (3V3A), three-phase, three-wire with three-voltage, three-current method.</p> <p>The selectable wiring systems vary depending on the number of input elements that are installed.</p>
Measurement range	See section 14.1.
Scaling	Set the current sensor transformation ratio, VT ratio, CT ratio, and power factor in the range of 0.0001 to 99999.9999 when applying the external current sensor, VT, or CT output to the instrument.
Input filter	A line or frequency filter can be set. See section 14.1 for details.
Averaging	<ul style="list-style-type: none"> For measurement functions used in normal measurement The following kinds of averaging can be performed on voltage U (Urms, Umn, Udc, Urmn, and Uac), current I (Irms, Imn, Idc, Irmn, Iac), power P, apparent power S, and reactive power Q functions. Power factor λ and phase difference angle ϕ are determined from the averaged P and S values. Exponential averages or moving averages can be determined. <ul style="list-style-type: none"> Exponential average The attenuation constant can be set to 2, 4, 8, 16, 32, or 64. Moving Average The average count can be set to 8, 16, 32, or 64. For measurement functions used in harmonic measurement <ul style="list-style-type: none"> Exponential average The attenuation constant can be set to 2, 4, 8, 16, 32, and 64.
Data update interval	The update interval can be set to 100 ms, 200 ms, 500 ms, 1 s, 2 s, or 5 s.
Response time	The maximum response time is the data update interval \times 2. However, this is only when displaying numeric values.
Hold	The hold feature holds the display.
Single measurement	The single measurement feature executes a single measurement while the display is held. During integration, the display is updated with the most recent data.
Zero-level compensation (NULL)	Compensation range: \pm 10% of range (when the crest factor is set to 3), \pm 20% of range (when the crest factor is set to 6)

Frequency Measurement

Item	Specifications														
What is measured	Up to two of the voltage or current frequencies applied to an element can be selected and measured. On models with the frequency measurement add-on option, the voltage and current frequencies of all elements can be measured.														
Measurement method	Reciprocal method														
Measurement range	<table border="1"> <thead> <tr> <th>Data Update Interval</th> <th>Measurement Range</th> </tr> </thead> <tbody> <tr> <td>100 ms</td> <td>25 Hz ≤ f ≤ 100 kHz</td> </tr> <tr> <td>200 ms</td> <td>12.5 Hz ≤ f ≤ 100 kHz</td> </tr> <tr> <td>500 ms</td> <td>5 Hz ≤ f ≤ 100 kHz</td> </tr> <tr> <td>1 s</td> <td>2.5 Hz ≤ f ≤ 100 kHz</td> </tr> <tr> <td>2 s</td> <td>1.5 Hz ≤ f ≤ 50 kHz</td> </tr> <tr> <td>5 s</td> <td>0.5 Hz ≤ f ≤ 20 kHz</td> </tr> </tbody> </table>	Data Update Interval	Measurement Range	100 ms	25 Hz ≤ f ≤ 100 kHz	200 ms	12.5 Hz ≤ f ≤ 100 kHz	500 ms	5 Hz ≤ f ≤ 100 kHz	1 s	2.5 Hz ≤ f ≤ 100 kHz	2 s	1.5 Hz ≤ f ≤ 50 kHz	5 s	0.5 Hz ≤ f ≤ 20 kHz
Data Update Interval	Measurement Range														
100 ms	25 Hz ≤ f ≤ 100 kHz														
200 ms	12.5 Hz ≤ f ≤ 100 kHz														
500 ms	5 Hz ≤ f ≤ 100 kHz														
1 s	2.5 Hz ≤ f ≤ 100 kHz														
2 s	1.5 Hz ≤ f ≤ 50 kHz														
5 s	0.5 Hz ≤ f ≤ 20 kHz														
Accuracy	±0.06% of reading When the input signal level is 30% or more of the measurement range (0.5 to 440 Hz; frequency filter on), or for external current sensor input, when it is 25 mV or more. When the input signal is less than or equal to two times the frequency lower limit written above, and when it is greater than or equal to 50% of the measurement range. Add 0.05% of reading when the external current sensor input is 50 mV or less. Double the input signal level values when the crest factor is 6.														
Display resolution	99999														
Minimum frequency resolution	0.0001 Hz														
Frequency measurement filter	Frequency filter (see section 14.1)														

Integration

Item	Specifications
Modes	Manual, normal, continuous, real-time normal, and real-time continuous
Measurement functions	See section 14.3 for details.
Integration timer	Integration can be stopped automatically by a timer that can be set to: 0000h00m00s to 10000h00m00s
Count overflow	When the maximum integration time (10000 hours) is reached or when an integrated value reaches the maximum or minimum displayable integrated value,* the integration time and value at that point are held and integration is stopped. * WP: ±99999 MWh q: ±99999 MAh WS: ±99999 MVAh WQ: ±99999 Mvarh
Accuracy	Power: ±(power accuracy + 0.02% × WS) Current: ±(current accuracy + 0.02% of reading) if a value other than dc is selected ±(current accuracy + 0.02 × integration time (h)% of range) if dc is selected However, there is approximately 70μs of unsampled space in each data update interval.
Timer accuracy	±0.02% of reading

14.6 Functions

Computation

Item	Specifications
User-defined functions	Used to compute equations that are created by combining measurement function symbols and operators (up to eight equations can be created).
Average active power setting	Is set with a user-defined function.
Efficiency equation setting	Computes equations that are created by combining measurement function symbols (up to two equations can be created).
Equation for apparent power and reactive power	Can be set to Type 1, Type 2, or Type 3. Type 3 can only be selected on models with the harmonic measurement option.
Phase difference display	Can be set to display the phase difference using a 180° lead and lag format or a 360° format.
Delta computation	Computes measured circuit values using the computed results of the differences of instantaneous values. This feature can only be used on models with the delta computation option.
Distortion factor equation	The denominator of the equation can be set to the total waveform or to the fundamental signal. This feature can only be used on models with the harmonic measurement option.

Numeric Display

Item	Specifications
Displayed Items	Displays the numeric data of the measurement functions described in section 14.3 and the delta computation and harmonic measurement functions.
Display resolution	60000
Number of displayed items	The options are 4, 8, 16, matrix, all, single list, and dual list.* * Single and dual list can only be selected on models with the harmonic measurement option.
Scrolling of displayed items	Up to nine pages of measurement function numeric data can be scrolled through.
Display reset	Resets the display order of the numeric data to the default order.

Waveform Display

Item	Specifications
Number of display rasters	501
Display format	Peak-to-peak compressed data
Sample rate	Approx. 100 kS/s Waveforms can be reproduced accurately up to approximately 5 kHz.
Time axis	In the range of 1 to 500 ms/div. Must be less than or equal to 1/10 of the data update rate.
Trigger	<ul style="list-style-type: none">• Trigger type: Edge• Trigger modes: Auto and normal. Triggering is automatically switched off during integration.• Trigger source: Can be set to an external clock signal or to a voltage or current applied to an input element.• Trigger slope: ↗ (rising), ↘ (falling), or ↗↘ (rising and falling).• Trigger level<ul style="list-style-type: none">• When the trigger source is a voltage or current applied to the input element The trigger level can be set in the range of ±100% from the screen center (to the top or bottom edge of the screen) in 0.1% steps.• When the trigger source is Ext Clk (external clock) The trigger level is the TTL level. For the external clock specifications, see section 14.7.
Vertical waveform zoom	Each voltage or current waveform can be vertically scaled within the range of 0.1 to 100 times magnification.
Turning waveform displays on and off	The displays of each voltage or current waveform can be turned on or off.
Waveform display format	The split-screen options are: 1, 2, 3, and 4.
Waveform display interpolation	The interpolation options are dot and linear.
Graticule	The graticule options are grid and cross-hair.
Turning auxiliary displays on and off	The displays of the upper and lower limits (scale values) and of waveform labels can be turned on and off.
Cursor measurement	A cursor can be placed on a waveform, and the values at the cursor location can be measured.

Vector and Bar Graph Displays

Item	Specifications
Vector display	Displays the phase differences of the fundamental signals using vectors. This feature can only be used on models with the harmonic measurement option.
Bar graph display	Displays a bar graph of the amplitudes of each harmonic. This feature can only be used on models with the harmonic measurement option.

Trend Display

Displays a graph of measurement function numeric data trends.
The trends of up to eight functions can be displayed.

Data Storage

Item	Specifications		
Binary save	Saves data directly to the medium* at the data update interval. The maximum file size is 1 GB.		
ASCII save	Automatically or manually converts data saved in binary format to ASCII data (.csv extension) after measurement finishes. The maximum file size is 4 GB.		
Internal memory	Approximately 20 MB		
Store interval (Waveform display off)	100 ms to 99 hours 59 minutes 59 seconds		
Internal memory maximum storage time estimates (With waveform display and the integration feature off)			
Measurement Channel	Number of Measured Items (On each channel)	Store Interval	Max. Storage Time
Channel 1	3	100 ms	Approx. 40 hours
Channel 1	10	1 s	Approx. 120 hours
Channel 3	10	100 ms	Approx. 4 hours
Channel 3	20	1 s	Approx. 20 hours

The maximum storage time may be lower than the values given above depending on factors such as user-defined function and integration settings.

The USB direct save interval varies depending on the number of saves and the specifications of the memory. The maximum file size is 1 GB.

* The available storage media are USB storage and the internal RAM disk.

Saving and Loading of Data

Setup parameters, numeric data, waveform display data, and screen image data can be saved to a storage medium.*

Saved setup parameters can be loaded from the storage medium.*

* The available storage media are USB storage and the internal RAM disk.

Harmonic Measurement

Item	Specifications
What is measured	All installed elements.
Method	PLL synchronization
Frequency range	The range for the fundamental frequency of the PLL source is 10 Hz to 1.2 kHz.
PLL source	<ul style="list-style-type: none"> Can be set to an input element voltage or current or to an external clock signal. Input level <ul style="list-style-type: none"> 50% or more of the rated measurement range when the crest factor is 3. 100% or more of the rated measurement range when the crest factor is 6. The frequency filter must be turned on when the fundamental frequency is less than or equal to 440 Hz.
FFT data length	1024
FFT processing word length	32 bits
Window function	Rectangular
Anti-aliasing filter	Set using the line filter. (Set to OFF or 5.5 kHz.)

14.6 Functions

Item	Specifications			
Sample rates, window widths, and upper limits of harmonic analysis				
	Fundamental frequency	Sample rate	Window width	Upper limit of harmonic analysis
	10 Hz to 75 Hz	$f \times 1024$	1	50
	75 Hz to 150 Hz	$f \times 512$	2	32
	150 Hz to 300 Hz	$f \times 256$	4	16
	300 Hz to 600 Hz	$f \times 128$	8	8
	600 Hz to 1200 Hz	$f \times 64$	16	4

Accuracy, \pm (reading error + measurement range error)

- When the line filter is off

Frequency	Voltage and current	Power
10 Hz \leq f < 45 Hz	0.15% of reading + 0.35% of range	0.35% of reading + 0.5% of range
45 Hz \leq f \leq 440 Hz	0.15% of reading + 0.35% of range	0.25% of reading + 0.5% of range
440 Hz < f \leq 1 kHz	0.2% of reading + 0.35% of range	0.4% of reading + 0.5% of range
1 kHz < f \leq 2.5 kHz	0.8% of reading + 0.45% of range	1.4% of reading + 0.6% of range
2.5 kHz < f \leq 5 kHz	3% of reading + 0.45% of range	5% of reading + 0.6% of range

- When the line filter is on (5.5 kHz)

Frequency	Voltage and current	Power
10 Hz \leq f < 45 Hz	0.4% of reading + 0.35% of range	0.85% of reading + 0.5% of range
45 Hz \leq f \leq 440 Hz	0.75% of reading + 0.35% of range	1.5% of reading + 0.5% of range
440 Hz < f \leq 1 kHz	1.2% of reading + 0.35% of range	2.4% of reading + 0.5% of range
1 kHz < f \leq 2.5 kHz	5% of reading + 0.45% of range	10% of reading + 0.5% of range

The items listed below apply to all of the tables.

- When the crest factor is set to 3.
- When λ (the power factor) is 1.
- Power figures that exceed 440 Hz are reference values.
- For the external current sensor range, add 100 μ V to the current accuracy and (100 μ V/external current sensor range rating) \times 100% of range to the power accuracy.
- For n^{th} order component input, add $(\{n/(m+1)\}/50)\%$ of (the n^{th} order reading) to the $n+m^{\text{th}}$ order and $n-m^{\text{th}}$ order of the voltage and current, and add $(\{n/(m+1)\}/25)\%$ of (the n^{th} order reading) to the $n+m^{\text{th}}$ order and $n-m^{\text{th}}$ order of the power.
- Add $(n/500)\%$ of reading to the n^{th} component of the voltage and current, and add $(n/250)\%$ of reading to the n^{th} component of the power.
- The accuracy when the crest factor is 6 is the same as the accuracy when the crest factor is 3 after doubling the measurement range.
- The guaranteed accuracy ranges for frequency, voltage, and current, are the same as the guaranteed ranges for ordinary measurement.

If the amplitude of the high frequency component is large, influence of approximately 1% may appear in certain orders.

Because the influence depends on the size of the frequency component, if the frequency component is small with respect to the range rating, the influence is also negligible.

Delta Computation Feature

Item	Delta Computation Setting	Symbols and Meanings	
Voltage (V)	Difference	$\Delta F1[U_{diff}]$	Differential voltage between U1 and U2 determined through computation
	3P3W->3V3A	$\Delta F1[U_{rs}]$	Unmeasured line voltage computed in a three-phase, three-wire system
	Delta->Star	$\Delta F1[U_r], \Delta F2[U_s], \Delta F3[U_t]$	Phase voltage computed in a three-phase, three-wire (3V3A) system
	Star->Delta	$\Delta F1[U_{rs}], \Delta F2[U_{st}], \Delta F3[U_{tr}]$	Line voltage computed in a three-phase, four-wire system
Current (A)	Difference	$\Delta F2[I_{diff}]$	Differential current between I1 and I2 determined through computation.
	3P3W->3V3A	$\Delta F2[I_t]$	Unmeasured phase current
	Delta->Star	$\Delta F4[I_n]$	Neutral line current
	Star->Delta	$\Delta F4[I_n]$	Neutral line current

14.7 External Input and Output (Master and slave synchronization signals and clock input)

Item	Specifications
Connector	BNC connector. Same for both master and slave.
I/O level	TTL. Same for both master and slave.
Output logic	<input type="checkbox"/> Negative logic, falling edge. Applies to the master.
Measurement start delay time	Within (3 μ s + 1 sample interval). Applies to the master.
Output hold time	Low level, 500 ns or more. Applies to the master.
Input logic	<input type="checkbox"/> Negative logic, falling edge. Applies to the slave.
Minimum pulse width	Low level, 500 ns or more. Applies to the slave.
Input delay time	Within (1 μ s + 3 sample intervals) when the display is held. Applies to the slave. Within (70 μ s + 3 sample intervals) when the display is not held. Applies to the slave.

When Used as a Synchronization Source (Ext Clk) during Normal Measurement

Item	Specifications
Frequency range	Same as the frequency range listed in section 14.6, "Frequency Measurement."
Input waveform	50% duty ratio rectangular wave

When Used as a PLL Source (Ext Clk) during Harmonic Measurement (Optional)

Item	Specifications
Frequency range	10 Hz to 1.2 kHz
Input waveform	50% duty ratio rectangular wave

When Used as a Trigger

Item	Specifications
Minimum pulse width	1 μ s
Trigger delay time	Within (1 μ s + 3 sample intervals)

14.8 RGB Video Signal (VGA) Output (Optional)

Item	Specifications
Connector	D-sub 15 pin (receptacle)
Output type	VGA compatible

14.9 USB PC Interface

Item	Specifications
Connector	Type B connector (receptacle)
Electrical and mechanical specifications	USB 1.1
Data rate	12 Mbps max.
Ports	1
Power supply	Self powered
Supported services	Remote control
System requirements	A PC running Windows 2000 (SP4 or later), Windows XP, or Windows Vista and USB ports.

14.10 USB PERIPHERAL Interface

Item	Specifications
Connector type	USB type A (receptacle)
Electrical and mechanical specifications	USB 2.0
Data rate	480 Mbps max.
Supported keyboards ¹	104 (US) or 109 (Japanese) keyboards compliant with USB HID Class Version 1.1
Supported USB mass storage	USB flash memory (that meets the USB Mass Storage Class specifications)
Power supply	5 V, 500 mA ² (for each port)
Ports	2

- 1 For more detailed information about supported USB devices, contact your nearest YOKOGAWA dealer.
- 2 You cannot connect devices whose maximum current consumption exceeds 100 mA to two different ports on the WT500 at the same time.

14.11 GP-IB Interface Option

Item	Specifications
Usable devices	NATIONAL INSTRUMENTS <ul style="list-style-type: none">• AT-GPIB• PCI-GPIB or PCI-GPIB+• PCMCIA-GPIB, PCMCIA-GPIB+, or PCIe-GPIB Driver: NI-488.2M version 1.60 or later
Electrical and mechanical specifications	IEEE St'd 488-1978 (JIS C 1901-1987)
Functional specifications	SH1, AH1, T6, L4, SR1, RL1, PP0, DC1, DT1, and C0
Protocol	IEEE St'd 488.2-1992
Code	ISO (ASCII)
Addresses	0 to 30
Mode	Addressable mode
Clearing remote mode	The LOCAL key can be pressed to clear remote mode (except during Local Lockout).

14.12 Ethernet Interface Option

Item	Specifications
Ports	1
Connector	RJ-45
Electrical and mechanical specifications	IEEE802.3
Transmission system	Ethernet (100BASE-TX)
Data rate	100 Mbps max.
Communication protocol	TCP/IP
Supported services	FTP server, DHCP, DNS, and remote control (VXI-11)

14.13 Safety Terminal Adapter

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

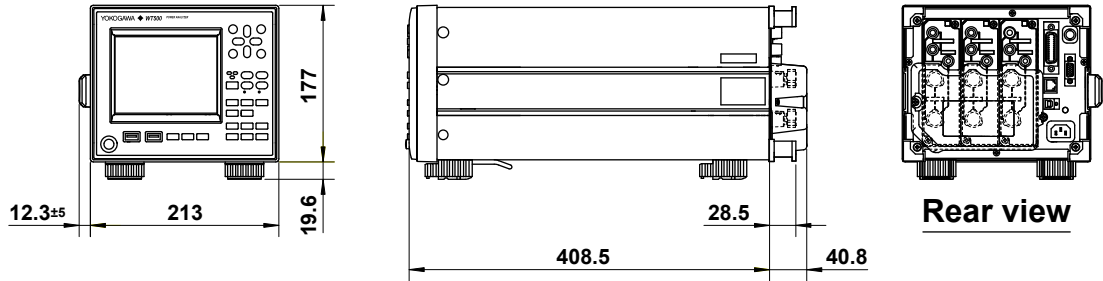
14.14 General Specifications

Item	Specifications
Warm-up time	Approx. 30 minutes
Operating environment	Temperature: 5 to 40°C Humidity: 20 to 80%RH (No condensation)
Elevation	2000 m or less
Location	Indoors
Storage environment	Temperature: -25 to 60°C Humidity: 20 to 80%RH (No condensation)
Rated supply voltage	100 to 240 VAC
Permitted supply voltage range	90 to 264 VAC
Rated supply frequency	50/60 Hz
Permitted supply voltage frequency range	48 to 63 Hz
Maximum power consumption	250 VA
External dimensions (For details, see section 14.15.)	Approx. 213 mm × 177 mm × 409 mm (W × H × D) (Excluding the handle and other protruding parts.)
Weight	Approx. 7 kg (the weight of the main unit with three input elements and all options installed)
Installation position	Horizontal (a stand can be used). Do not install vertically or stack.
Battery backup	Setup parameters and the internal time clock are backed up with a lithium battery.
Safety standard ¹	Standards EN61010-1 The overvoltage category (Installation category) is CAT II. ² The measurement category is CAT II. ³ The pollution degree is 2. ⁴
Emissions ¹	Standards EN61326-1 Class A EN55011 Class A, Group 1 EN61000-3-2 EN61000-3-3 This is a class A instrument designed for an industrial environment. Operation of this equipment in a residential area can cause radio interference, in which case users will be required to correct the interference. C-Tick EN55011 Class A, Group 1 Cable conditions <ul style="list-style-type: none"> • Ext Clk terminal Use a BNC cable.⁵ • GP-IB interface connector Use a shielded GP-IB cable.⁵ • RGB video signal output (VGA) connector Use a shielded D-sub 15 pin VGA cable.⁵ • USB port (PC) Use a shielded USB cable.⁵ • USB port (for peripheral devices) Use a USB keyboard that has a shielded cable. • Ethernet connector Use a category 5 or better Ethernet cable (STP).
Immunity ¹	Standards EN61326-1 Table 2 (Industrial Environment) Cable conditions The same as the cable conditions listed above for emissions.

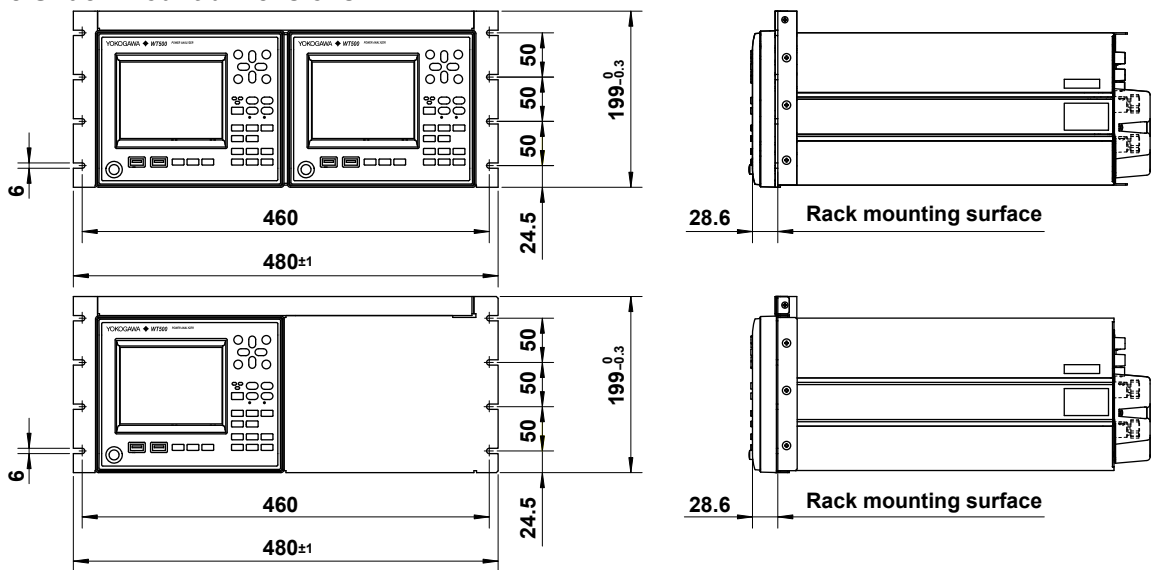
- 1 Applies to products with CE marks. For information concerning other products, contact your nearest YOKOGAWA dealer.
- 2 The overvoltage category is a value used to define the transient overvoltage condition and includes the rated impulse withstand voltage. CAT II applies to electrical equipment that is powered through a fixed installation, such as a wall outlet wired to a distribution board.
- 3 Measurement Category II (CAT II) applies to electrical equipment that is powered through a fixed installation, such as a wall outlet wired to a distribution board, and to measurement performed on such wiring.
- 4 The pollution degree refers to the degree of adhesion of a solid, liquid, or gas which deteriorates withstand voltage or surface resistivity. Pollution degree 1 applies to closed atmospheres (with no, or only dry, non-conductive pollution). Pollution degree 2 applies to normal indoor atmospheres (with only non-conductive pollution).
- 5 Use cables that are 3 m or shorter.

14.15 External Dimensions

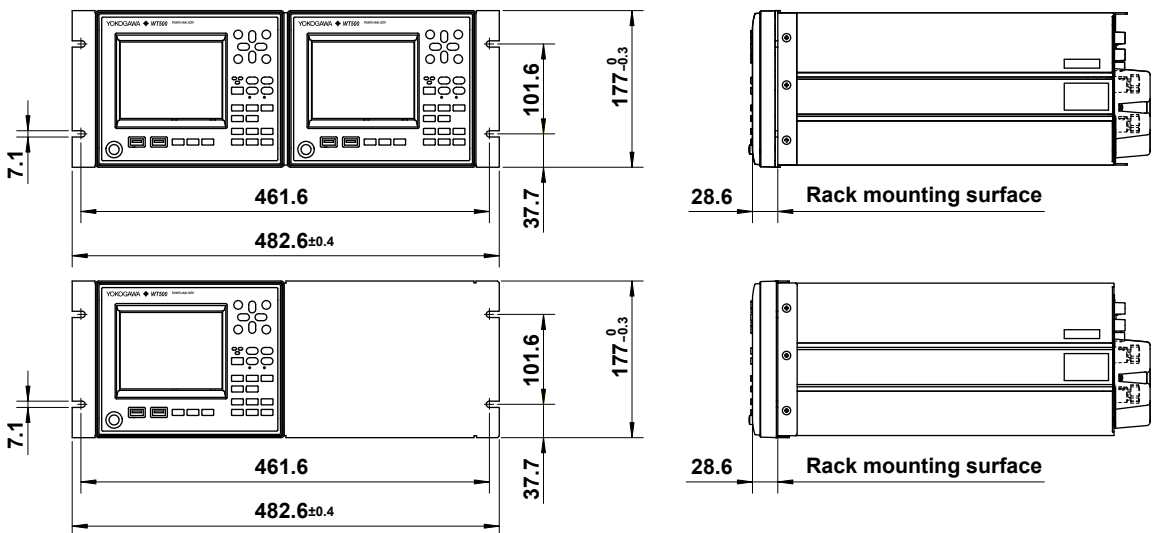
Unit: mm



• JIS rack mount dimensions



• EIA rack mount dimensions



Caution: Be sure not to block the instrument's ventilation holes when installing support under it. Provide 80 mm or more of space around the instrument for ventilation.

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

Appendix 1 Symbols and Determination of Measurement Functions

Measurement Functions Used in Normal Measurement

(Table 1/3)

Measurement Functions Used in Normal Measurement		Methods of Computation and Determination For information about the symbols in the equations, see the notes at the end of page App-3.				
Voltage U [V] True rms value: U _{rms} Rectified mean value calibrated to the rms value: U _{mn} Rectified mean value: U _{rmn} Simple average: U _{dc} AC component: U _{ac}		U_{rms}	U_{mn}	U_{rmn}	U_{dc}	U_{ac}
		$\sqrt{\text{AVG}[u(n)^2]}$	$\frac{\pi}{2\sqrt{2}} \text{AVG}[u(n)]$	$\text{AVG}[u(n)]$	$\text{AVG}[u(n)]$	$\sqrt{\text{RMS}^2\text{-DC}^2}$
Current I [A] True rms value: I _{rms} Rectified mean value calibrated to the rms value: I _{mn} Rectified mean value: I _{rmn} Simple average: I _{dc} AC component: I _{ac}		I_{rms}	I_{mn}	I_{rmn}	I_{dc}	I_{ac}
		$\sqrt{\text{AVG}[i(n)^2]}$	$\frac{\pi}{2\sqrt{2}} \text{AVG}[i(n)]$	$\text{AVG}[i(n)]$	$\text{AVG}[i(n)]$	$\sqrt{\text{RMS}^2\text{-DC}^2}$
Active power P [W]		$\text{AVG}[u(n) \cdot i(n)]$				
Apparent power S [VA]	TYPE1, TYPE2	$U \cdot I$				
	TYPE3	$\sqrt{P^2 + Q^2}$				
Reactive power Q [var]	TYPE1, TYPE2	$s \cdot \sqrt{S^2 - P^2}$ s is -1 for a lead phase and 1 for a lag phase				
	TYPE3	$\sum_{k=\min}^{\max} Q(k)$ $Q(k) = U_r(k) \cdot I_j(k) - U_j(k) \cdot I_r(k)$ U _r (k) and I _r (k) are the real number components of U(k) and I(k) U _j (k) and I _j (k) are the imaginary components of U(k) and I(k) Valid only when harmonics are being measured correctly.				
Power factor λ		$\frac{P}{S}$				
Phase difference φ [°]		$\cos^{-1}\left(\frac{P}{S}\right)$ The phase angle can be switched between lead (D)/lag (G) display and 360° display. See section 5.5 for details.				
Voltage frequency: f_U (FreqU) [Hz] Current frequency: f_I (FreqI) [Hz]		The two frequencies, f _U and f _I , can be measured simultaneously from any installed element. (The PLL source frequency is excluded.) On models with the frequency measurement add-on option, the f _U and f _I 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				
Voltage crest factor: Cf_U Current crest factor: Cf_I		Voltage crest factor $Cf_U = \frac{U_{pk}}{U_{rms}}$ U _{pk} = U + pk or U - pk whichever is larger		Current crest factor $Cf_I = \frac{I_{pk}}{I_{rms}}$ I _{pk} = I + pk or I - pk whichever is larger		

(Continues on next page)

(Table 2/3)

Measurement Functions Used in Normal Measurement		Methods of Computation and Determination For information about the symbols in the equations, see the notes at the end of page 3.				
Integration	Integration time [h:m:s] Time	Time from integration start to integration stop.				
	Watt hours [Wh] WP WP+ WP-	When the watt-hour integration method for each polarity is Charge/Discharge				
		$\left[\frac{1}{N} \sum_{n=1}^N \{u(n) \cdot i(n)\} \right] \cdot \text{Time}$ <p>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 values when u(n) · i(n) in the above equation is positive. WP- is the sum of the values when u(n) · i(n) in the above equation is negative.</p>				
	Ampere hours [Ah] q q+ q-	RMS, MEAN, RMEAN, AC	$\frac{1}{N} \sum_{n=1}^N I(n) \cdot \text{Time}$ <p>I(n) is the nth measured current value. N is the number of data updates. The unit of time is hours.</p>			
		DC	$\frac{1}{N} \sum_{n=1}^N i(n) \cdot \text{Time}$ <p>i(n) is the nth sampled data of the current signal. N is the number of data samples. q is the sum of positive and negative ampere hours. q+ is the sum of the values when i(n) in the above equation is positive. q- is the sum of the values when i(n) in the above equation is negative. The unit of time is hours.</p>			
	Volt-ampere hours WS[VAh]	$\frac{1}{N} \sum_{n=1}^N S(n) \cdot \text{Time}$ <p>S(n) is the nth measured apparent power value, and N is the number of data updates. The unit of Time is hours.</p>				
Var hours WQ[varh]	$\frac{1}{N} \sum_{n=1}^N Q(n) \cdot \text{Time} $ <p>Q(n) is the nth measured reactive power value, and N is the number of data updates. The unit of Time is hours.</p>					
S 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	
	US [V]	(U1 + U2) / 2		(U1 + U2 + U3) / 3		
	IS [A]	(I1 + I2) / 2		(I1 + I2 + I3) / 3		
	PS [W]	P1 + P2			P1 + P2 + P3	
	SS [VA]	TYPE1, TYPE2	S1 + S2	$\frac{\sqrt{3}}{2} (S1 + S2)$	$\frac{\sqrt{3}}{3} (S1 + S2 + S3)$	S1 + S2 + S3
		TYPE3	$\sqrt{PS^2 + QS^2}$			
	QS [var]	TYPE1	Q1 + Q2			Q1 + Q2 + Q3
TYPE2, TYPE3		$\sqrt{SS^2 - PS^2}$			Q1 + Q2 + Q3	

(Table 3/3)

Measurement Functions Used in Normal Measurement		Methods of Computation and Determination For information about the symbols in the equations see the notes.				
Σ functions	Wiring system	Single-phase, three-wire 1P3W	Three-phase, three-wire 3P3W	Three-phase, three-wire with three-voltage, three-current method. 3P3W(3V3A)	Three-phase, four-wire 3P4W	
	WPΣ [Wh]	WPΣ	WP1 + WP2			WP1 + WP2 + WP3
		WP+Σ	When the watt-hour integration method for each polarity is Charge/Discharge WP+1 + WP+2			WP+1 + WP+2 + WP+3
			When the watt-hour integration method for each polarity is Sold/Bought WP+Σ is the sum of the positive active power WPS values at each data update interval.			
		WP-Σ	When the watt-hour integration method for each polarity is Charge/Discharge WP-1 + WP-2			WP-1 + WP-2 + WP-3
	qΣ [Ah]	qΣ	q1 + q2			q1 + q2 + q3
		q+Σ	q+1 + q+2			q+1 + q+2 + q+3
		q-Σ	q-1 + q-2			q-1 + q-2 + q-3
	WSΣ [VAh]	$\frac{1}{N} \sum_{n=1}^N S_{\Sigma}(n) \cdot \text{Time}$ SΣ(n) is the nth apparent power Σ function. N is the number of data updates. The unit of time is hours.				
	WQΣ [varh]	$\frac{1}{N} \sum_{n=1}^N Q_{\Sigma}(n) \cdot \text{Time}$ 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 [°]	$\cos^{-1}\left(\frac{P_{\Sigma}}{S_{\Sigma}}\right)$					

Note

- u(n) denotes the instantaneous voltage. i(n) denotes the instantaneous current.
- n denotes the nth measurement period. The measurement period is determined by the synchronization source setting.
- AVG[] denotes the simple average of the item in brackets determined over the data measurement interval. The data measurement interval is determined by the synchronization source setting.
- PΣ denotes the active power of wiring unit Σ. Input elements are assigned to wiring unit Σ differently depending on the number of input elements that are installed in the WT500 and the selected wiring system pattern. For details, see section 2.3.
- The numbers 1, 2, and 3 used in the equations for UrmsΣ, UmnΣ, UrmnΣ, UdcΣ, UacΣ, IrmsΣ, ImnΣ, ImrnΣ, IdcΣ, IacΣ, PΣ, SΣ, QΣ, WPΣ, and qΣ indicate the case when input elements 1, 2, and 3 are set to the wiring system shown in the table.
- Equation Type 3 for SΣ and QΣ can only be selected on models with the harmonic measurement option.
- On the WT500, S, Q, λ, and φ are derived through the computation of the measured values of voltage, current, and active power (however, when Type 3 is selected, Q is calculated directly from the sampled data). Therefore, for distorted signal input, the value obtained on the WT500 may differ from that obtained on other instruments that use a different method.
- For Q [var], when the current leads the voltage, the Q value is displayed as a negative value; when the current lags the voltage, the Q value is displayed as a positive value. The value of QΣ may be negative, because it is calculated from the Q of each element with the signs included.

Measurement Functions Used in Harmonic Measurement

(Table 1/2)

Measurement Functions Used in Harmonic Measurement	Methods of Computation and Determination		
	Numbers and Characters in the Parentheses		Total Value (Total) (No parentheses)
	dc (when k = 0)	k (when k = 1 to max)	
Voltage U() [V]	$U(dc) = U_r(0)$	$U(k) = \sqrt{U_r(k)^2 + U_j(k)^2}$	$U = \sqrt{\sum_{k=\min}^{\max} U(k)^2}$
Current I() (A)	$I(dc) = I_r(0)$	$I(k) = \sqrt{I_r(k)^2 + I_j(k)^2}$	$I = \sqrt{\sum_{k=\min}^{\max} I(k)^2}$
Active power P() [W]	$P(dc) = U_r(0) \cdot I_r(0)$	$P(k) = U_r(k) \cdot I_r(k) + U_j(k) \cdot I_j(k)$	$P = \sum_{k=\min}^{\max} P(k)$
Apparent power S() [VA] (TYPE3)*	$S(dc) = P(dc)$	$S(k) = \sqrt{P(k)^2 + Q(k)^2}$	$S = \sqrt{P^2 + Q^2}$
Reactive power Q() [var] (TYPE3)*	$Q(dc) = 0$	$Q(k) = U_r(k) \cdot I_j(k) - U_j(k) \cdot I_r(k)$	$Q = \sum_{k=\min}^{\max} Q(k)$
Power factor $\lambda()$	$\lambda(dc) = \frac{P(dc)}{S(dc)}$	$\lambda(k) = \frac{P(k)}{S(k)}$	$\lambda = \frac{P}{S}$
Phase difference $\phi()$ [°]	—	$\phi(k) = \text{ATAN2}\{P(k), Q(k)\}$	$\phi = \text{ATAN2}(P, Q)$
Phase difference with U(1) $\phi_U()$ [°]	—	$\phi_U(k) =$ The phase difference between U(k) and U(1)	—
Phase difference with I(1) $\phi_I()$ [°]	—	$\phi_I(k) =$ The phase difference between I(k) and I(1)	—

(Continues on next page)

* For details about the S and Q formula type settings, see section 5.4.

Note

- k denotes a harmonic order, r denotes the real part, and j denotes the imaginary part.
- U(k), $U_r(k)$, $U_j(k)$, I(k), $I_r(k)$, and $I_j(k)$ 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 signal). For details, see section 6.4.
- The upper limit of harmonic analysis is denoted by max. max is determined automatically according to the PLL source frequency. It can go up to the 50th harmonic order.

(Table 2/2)

Measurement Functions Used in Harmonic Measurement	Methods of Computation and Determination					
	The numbers and characters in the parentheses are dc (when k = 0), or k (when k = 1 to max).					
	When the denominator of the distortion factor is the total value (Total)		When the denominator of the distortion factor is the fundamental signal (Fundamental)			
Harmonic voltage distortion factor $U_{hdf}()$ [%]	$\frac{U(k)}{U(\text{Total})^{*1}} \cdot 100$		$\frac{U(k)}{U(1)} \cdot 100$			
Harmonic current distortion factor $I_{hdf}()$ [%]	$\frac{I(k)}{I(\text{Total})^{*1}} \cdot 100$		$\frac{I(k)}{I(1)} \cdot 100$			
Harmonic active power distortion factor $P_{hdf}()$ [%]	$\frac{P(k)}{P(\text{Total})^{*1}} \cdot 100$		$\frac{P(k)}{P(1)} \cdot 100$			
Total harmonic voltage distortion U_{thd} [%]	$\frac{\sqrt{\sum_{k=2}^{\max} U(k)^2}}{U(\text{Total})^{*1}} \cdot 100$		$\frac{\sqrt{\sum_{k=2}^{\max} U(k)^2}}{U(1)} \cdot 100$			
Total harmonic current distortion I_{thd} [%]	$\frac{\sqrt{\sum_{k=2}^{\max} I(k)^2}}{I(\text{Total})^{*1}} \cdot 100$		$\frac{\sqrt{\sum_{k=2}^{\max} I(k)^2}}{I(1)} \cdot 100$			
Total harmonic active power distortion P_{thd} [%]	$\left \frac{\sum_{k=2}^{\max} P(k)}{P(\text{Total})^{*1}} \right \cdot 100$		$\left \frac{\sum_{k=2}^{\max} P(k)}{P(1)} \right \cdot 100$			
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	
	U_{Σ} [V]	$(U1 + U2) / 2$		$(U1 + U2 + U3) / 3$		
	I_{Σ} [A]	$(I1 + I2) / 2$		$(I1 + I2 + I3) / 3$		
	P_{Σ} [W]	$P1 + P2$			$P1 + P2 + P3$	
	S_{Σ} [VA] (TYPE3) ²	$\sqrt{P_{\Sigma}^2 + Q_{\Sigma}^2}$				
	Q_{Σ} [var] (TYPE3) ²	$Q1 + Q2$			$Q1 + Q2 + Q3$	
	λ_{Σ}	$\frac{P_{\Sigma}}{S_{\Sigma}}$				
	$\phi_{U1-U2}(^{\circ})$	Phase difference between $U1(1)$ and the fundamental voltage of element 2, $U2(1)$				
	$\phi_{U1-U3}(^{\circ})$	Phase difference between $U1(1)$ and the fundamental voltage of element 3, $U3(1)$				
	$\phi_{U1-I1}(^{\circ})$	Phase difference between $U1(1)$ and the fundamental current of element 1, $I1(1)$				
	$\phi_{U1-I2}(^{\circ})$	Phase difference between $U1(1)$ and the fundamental current of element 2, $I2(1)$				
	$\phi_{U1-I3}(^{\circ})$	Phase difference between $U1(1)$ and the fundamental current of element 3, $I3(1)$				

*1 $U(\text{Total}) = \sqrt{\sum_{k=\min}^{\max} U(k)^2}$, $I(\text{Total}) = \sqrt{\sum_{k=\min}^{\max} I(k)^2}$, $P(\text{Total}) = \sum_{k=\min}^{\max} P(k)$

*2 For details about the S_{Σ} and Q_{Σ} formula type settings, see section 5.4.

Note

- k denotes a harmonic order, r denotes the real part, and j denotes the imaginary part.
- The minimum harmonic order is denoted by min.
- The upper limit of harmonic analysis is denoted by max. max is determined automatically according to the PLL source frequency. It can go up to the 50th harmonic order.
- The numbers 1, 2, and 3 used in the equations for U_{Σ} , I_{Σ} , P_{Σ} , S_{Σ} , and Q_{Σ} 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 signal (1st harmonic) are computed for Σ .

Delta Computation (Optional)

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

	Delta computation type $\phi\Sigma$ [°]	Substituted Sampled Data		Data Determined with the Delta Computation and Corresponding Measurement Function Symbols The computation mode for $\Delta F1$ to $\Delta F4$ can be set to RMS, MEAN, RMEAN, DC, or AC.		Note
		u (t)	i (t)			
Delta functions	Difference	$u1-u2$	$i1-i2$	Differential voltage and differential current	$\Delta F1_{rms}[U_{diff}]$, $\Delta F2_{rms}[I_{diff}]$	---
	3P3W→3V3A	$u1-u2$	$-i1-i2$	Unmeasured line voltage and phase current computed in a three-phase, three-wire system	$\Delta F1_{rms}[U_{rs}]$, $\Delta F2_{rms}[I_t]$	It is assumed that $i1 + i2 + i3 = 0$
	Delta→Star	$u1 - \frac{(u1+u2)}{3}$	---	Phase voltage computed in a three-phase, three-wire (3V3A) system	$\Delta F1_{rms}[U_r]$	It is assumed that the center of the delta connection is computed as the center of the star connection.
		$u2 - \frac{(u1+u2)}{3}$	---		$\Delta F2_{rms}[U_s]$	
		$u3 - \frac{(u1+u2)}{3}$	---		$\Delta F3_{rms}[U_t]$	
	---	$i1+i2+i3$	Neutral phase current	$\Delta F4_{rms}[I_n]$		
	Star→Delta	$u1-u2$	---	Line voltage computed in a three-phase, four-wire system	$\Delta F1_{rms}[U_{rs}]$	---
		$u2-u3$	---		$\Delta F2_{rms}[U_{st}]$	
		$u3-u1$	---		$\Delta F3_{rms}[U_{tr}]$	
		---	$i1+i2+i3$	Neutral phase current	$\Delta F4_{rms}[I_n]$	

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

Note

- $u1$, $u2$, and $u3$ represent the sampled voltage data of elements 1, 2, and 3, respectively. $i1$, $i2$, and $i3$ represent the sampled current data of elements 1, 2, and 3, respectively.
- The numbers (1, 2, 3, and 4) that are attached to delta computation measurement function symbols have no relation to the element numbers.
- We recommend that you set the measurement range and scaling (conversion ratios and coefficients) of the elements that are undergoing delta computation as closely as possible. Using different measurement ranges or scaling causes the measurement resolutions of the sampled data to be different. This results in errors.

Appendix 2 List of Initial Settings and Numeric Data Display Order

Factory Default Settings (Example for a Model with Three Input Elements Installed)

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

Item	Setting
Wiring	
Wiring Setting	1P2W
Element Independent	Off
η Formula	
η 1	P3/P Σ
η 2	P Σ /P3
Udef1	P1+None+None+None
Udef2	P1+None+None+None
Ranges	
U Range	1000V
I input Terminal	Direct
I Direct input Range	40A
External Sensor Range	10V
Sensor Ratio	10.0000mV/A
Scaling	
Scaling	Off
Scaling Item	VT
VT	1.0000
CT	1.0000
Scaling Factor	1.0000
Sync Source	
Element Object	Element1
Sync Source	I1
	Element2
	I2
	Element3
	I3
Filters	
Line Filter	Off
Freq Filter	Off
Update Rate	
Update Rate	500ms
Averaging	
Averaging	Off
Averaging Type	Exp.
Exp. Count	2
Lin. Count	8
Integration	
Integrator Status	Reset condition
Integ Set	
Mode	Normal
Timer Setting	0000:00:00
Integ Start	2008/01/01 00:00:00
Integ End	2008/01/01 01:00:00
Auto Cal	Off
WP \pm Type	Charge/Discharge
qMode	dc
Measure	
S Formula	Urms·Irms
S, Q Formula	Type1
Phase	180 Lead/Lag
Sync Measure	Master

Appendix 2 List of Initial Settings and Numeric Data Display Order

Item	Setting		
User Function			
	ON/OFF	Expression	Unit
F1	OFF	WH(E1)/TI(E1)*3600	W
F2	OFF	URMSMAX(E1)	V
F3	OFF	IRMSMAX(E1)	A
F4	OFF	PMAX(E1)	W
F5	OFF	UPPEAKMAX(E1)	V
F6	OFF	UMPEAKMAX(E1)	V
F7	OFF	IPPEAKMAX(E1)	A
F8	OFF	IMPEAKMAX(E1)	A
Max Hold	OFF		
Freq Items			
Frequency1	U1		
Frequency2	I1		
Harmonics			
PLL Source	U1		
Measured Order	Min	Max	
	1	50	
Thd Formula	1/Total		
Delta Measure (Delta Measure Settings; displayed when the delta computation option is installed)			
Meas Type	—		
ΔF Mode	rms		
HOLD			
Hold	Off		
FORM (Numeric Form)			
Numeric Form	4 Items		
ITEM (Numeric)			
Item No.	1		
Function	Urms		
Element/Σ	Element1		
Order	—		
FORM (Wave Form)			
Format	Single		
Time/div	5ms		
Trigger Settings			
Mode	Auto		
Source	U1		
Slope	Rise		
Level	0.0%		
Display Settings			
Interpolate	Line		
Graticule	Grid(■)		
Scale Value	ON		
Label	OFF		
Wave Mapping			
Mode	Auto		
User Setting	U1:0, I1:0, U2:1, I2:1, U3:2, I3:2		
ITEM (Wave Item)			
	Display ON/OFF	Vertical Zoom	Vertical Position
U1	OFF	×1	0.000%
I1	OFF	×1	0.000%
U2	OFF	×1	0.000%
I2	OFF	×1	0.000%
U3	OFF	×1	0.000%
I3	OFF	×1	0.000%

Appendix 2 List of Initial Settings and Numeric Data Display Order

Item	Setting
ITEM (Bar Items; displayed when the harmonic measurement option is installed)	
	Function Element
Graph1	U Element1
Graph2	I Element1
Graph3	P Element1
FORM (Bar Form; displayed when the harmonic measurement option is installed)	
Format	Single
Start Order	1
End Order	50
FORM (Trend Form)	
Trend Format	Single
Trend T/div	3s/div
Display Settings	Same as those listed under FORM (Wave Form) on the previous page
ITEM (Trend Items)	
	Function Element/ Σ Order Scaling Manual Upper/Lower
T1	Urms Element1 — Auto —
T2	Irms Element1 — Auto —
T3	P Element1 — Auto —
T4	S Element1 — Auto —
T5	Q Element1 — Auto —
T6	λ Element1 — Auto —
T7	ϕ Element1 — Auto —
T8	FreqU Element1 — Auto —
FORM (Vector; displayed when the harmonic measurement option is installed)	
Object	ΣA
Numeric	On
U Mag	1.000
I Mag	1.000
CURSOR (Wave)	
Wave Cursor	OFF
Wave C1 + Trace	U1
Wave C2 \times Trace	I1
Wave C1 + Position	100
Wave C2 \times Position	400
Cursor Path	Max
Linkage	OFF
CURSOR (Trend)	
Trend Cursor	OFF
Trend C1 + Trace	T1
Trend C2 \times Trace	T2
Trend C1 +	100
Trend C2 \times	900
Linkage	OFF
CURSOR (Bar; displayed when the harmonic measurement option is installed)	
Bar Cursor	OFF
Bar C1 + Position	1
Bar C2 \times Position	15
Linkage	OFF

Appendix 2 List of Initial Settings and Numeric Data Display Order

Item	Setting
STORE(Store Set)	
Control Settings	
Store Mode	Manual
Count	100
Interval	00:00:00
Store Item	Numeric
Store Control Settings	
Element	Elem1
Function	Urms, Irms, P, S, Q, λ , ϕ , FreqU, FreqI
Store File Settings	
Save Path ¹	RAM0-0
File Name	—
Auto Naming	ON
CSV Convert	Auto
IMAGE SAVE	
Format	TIFF
Color	OFF
Save Path ¹	RAM0-0
AUTO Naming	ON
FILE	
File Item	Setup
NULL	
Null	OFF
MISC	
Remote Control	
GP-IB Address ¹	1
Date/Time	
Display ¹	ON
System Config	
Message Language ¹	ENG
Menu Language ¹	ENG
Crest Factor	CF3
USB	
Keyboard	JPN
Network	
TCP/IP Setup	
DHCP	OFF
DNS	OFF
User Account(User Account Setup)	
User Name	anonymous
Time Out(sec)	600
Self Test	
Test Item	Memory
KEY LOCK ²	OFF

1 This setting is not affected when the WT500 is initialized (MISC > Initialize Settings).

2 This setting is initialized when an RST command is received through the communication interface.

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

- When the numeric data order is reset, the data of each measurement function is displayed in the order indicated in the table below.
- For details about each displayed item of data, see section 5.1.

4 Item Display

				Page				
1	2	3	4	5	6	7	8	9
Urms1	Urms2	Urms3	UrmsΣ	P1	P2	P3	PΣ	η1
Irms1	Irms2	Irms3	IrmsΣ	WP1	WP2	WP3	WPΣ	η2
P1	P2	P3	PΣ	WP+1	WP+2	WP+3	WP+Σ	-----
λ1	λ2	λ3	λΣ	WP-1	WP-2	WP-3	WP-Σ	-----

8 Item Display

				Page				
1	2	3	4	5	6	7	8	9
Urms1	Urms2	Urms3	UrmsΣ	P1	P2	P3	PΣ	P1
Irms1	Irms2	Irms3	IrmsΣ	WP1	WP2	WP3	WPΣ	P2
P1	P2	P3	PΣ	WP+1	WP+2	WP+3	WP+Σ	P3
S1	S2	S3	SΣ	WP-1	WP-2	WP-3	WP-Σ	PΣ
Q1	Q2	Q3	QΣ	Irms1	Irms2	Irms3	IrmsΣ	η1
λ1	λ2	λ3	λΣ	q1	q2	q3	qΣ	η2
φ1	φ2	φ3	φΣ	q+1	q+2	q+3	q+Σ	—
fU(FreqU)1	fU(FreqU)2	fU(FreqU)3	—	q-1	q-2	q-3	q-Σ	—

16 Item Display

				Page				
1	2	3	4	5	6	7	8	9
Urms1	Urms2	Urms3	UrmsΣ	Time1	Time1	Time1	Time1	F1
Irms1	Irms2	Irms3	IrmsΣ	Urms1	Urms2	Urms3	UrmsΣ	F2
P1	P2	P3	PΣ	Irms1	Irms2	Irms3	IrmsΣ	F3
S1	S2	S3	SΣ	P1	P2	P3	PΣ	F4
Q1	Q2	Q3	QΣ	S1	S2	S3	SΣ	F5
λ1	λ2	λ3	λΣ	Q1	Q2	Q3	QΣ	F6
φ1	φ2	φ3	φΣ	—	—	—	—	F7
—	—	—	—	—	—	—	—	F8
fU(FreqU)1	fU(FreqU)2	fU(FreqU)3	P1	WP1	WP2	WP3	WPΣ	—
fl(Freql)1	fl(Freql)2	fl(Freql)3	P2	WP+1	WP+2	WP+3	WP+Σ	—
U+pk1	U+pk2	U+pk3	P3	WP-1	WP-2	WP-3	WP-Σ	—
U-pk1	U-pk2	U-pk3	—	q1	q2	q3	qΣ	—
I+pk1	I+pk2	I+pk3	η1	q+1	q+2	q+3	q+Σ	—
I-pk1	I-pk2	I-pk3	η2	q-1	q-2	q-3	q-Σ	—
CfU1	CfU2	CfU3	—	WS1	WS2	WS3	WSΣ	—
Cfl1	Cfl2	Cfl3	—	WQ1	WQ2	WQ3	WQΣ	—

Appendix 2 List of Initial Settings and Numeric Data Display Order

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(FreqU)	CfU	Cfl	WS	—	—	—	—	—
fl(Freql)	fU(FreqU)	fl(Freql)	WQ	—	—	—	—	—

ALL Item Display

				Page		
1	2	3	4	5	6	7
Urms	Urms	Irms	Time	F1	U(k)	Uthd
Irms	Umn	Imn	Wp	F2	I(k)	Ithd
P	Udc	Idc	WP+	F3	P(k)	Pthd
S	Urmn	Irmn	WP-	F4	S(k)	ϕ Ui-Uj
Q	Uac	Iac	q	F5	Q(k)	ϕ Ui-Uk
λ	U+pk	I+pk	q+	F6	λ (k)	ϕ Ui-li
ϕ	U-pk	-pk	q-	F7	ϕ (k)	ϕ Ui-lj
fU(FreqU)	CfU	Cfl	WS	F8	ϕ U(k)	ϕ Ui-lk
fl(Freql)			WQ	η 1	ϕ I(k)	
				η 2		
				Δ F1		
				Δ F2		
				Δ F3		
				Δ F4		

Left side of the screen in the Single List and Dual List displays*

Page				
1	2	3	4	5
Urms1	Urms2	Urms3	Urms Σ	F1
Irms1	Irms2	Irms3	Irms Σ	F2
P1	P2	P3	P Σ	F3
S1	S2	S3	S Σ	F4
Q1	Q2	Q3	Q Σ	F5
λ 1	λ 2	λ 3	λ Σ	F6
ϕ 1	ϕ 2	ϕ 3	ϕ Ui-Uj	F7
Uthd1	Uthd2	Uthd3	ϕ Ui-Uk	F8
Ithd1	Ithd2	Ithd3	ϕ Ui-li	
Pthd1	Pthd2	Pthd3	ϕ Ui-lj	
			ϕ Ui-lj	

* Single List and Dual List are only available on models with the harmonic measurement option.

Appendix 3 Power Basics (Power, harmonics, and AC RLC circuits)

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

Power

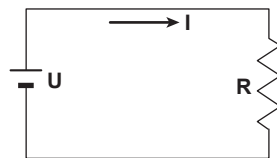
Electrical energy can be converted into other forms of energy and used. For example, it can be converted into the heat in an electric heater, the torque in a motor, or the light in a fluorescent or mercury lamp. In these kinds of examples, the work that electricity performs in a given period of time (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 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).

$$P = UI \text{ (W)}$$

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

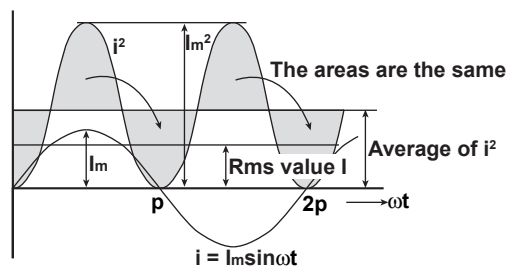


Alternating Current

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

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

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



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

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

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."

Appendix 3 Power Basics (Power, harmonics, and AC RLC circuits)

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 I_{mn} as the mean value of the instantaneous current i (which is equal to $I_m \sin \omega t$):

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

These relationships also apply to sinusoidal voltages.

The maximum value, rms value, and average 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

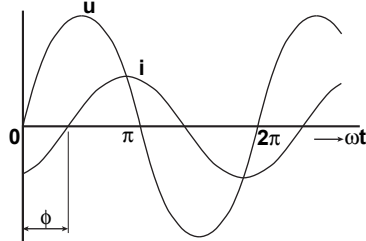
In general, instantaneous voltage and current values are expressed using the equations listed below.

Voltage: $u = U_m \sin \omega t$

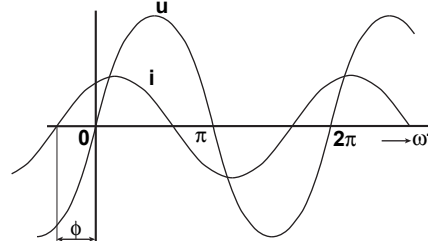
Current: $i = I_m \sin(\omega t - \phi)$

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

When the current lags the voltage



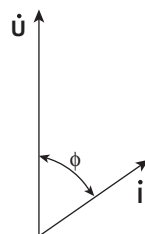
When the current leads the voltage



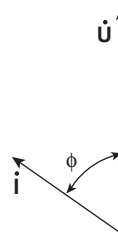
Vector display is used to clearly convey the magnitude and phase relationships between the voltage and current. A positive phase angle is represented by a counterclockwise angle with respect to the vertical axis.

Normally, a dot is placed above the symbol representing a quantity to explicitly indicate that it is a vector. The magnitude of a vector represents the rms value.

When the current lags the voltage



When the current leads the voltage



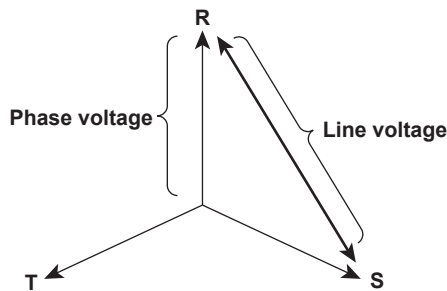
Three-Phase AC Wiring

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



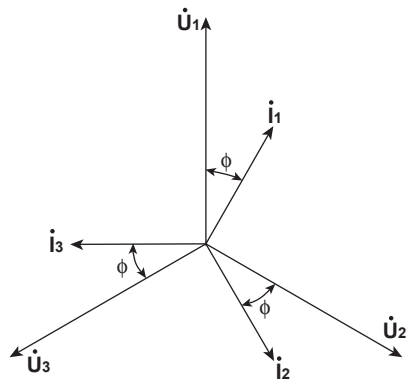
Vector Display of Three-Phase Alternating Current

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 line voltage is $\sqrt{3}$ times 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.

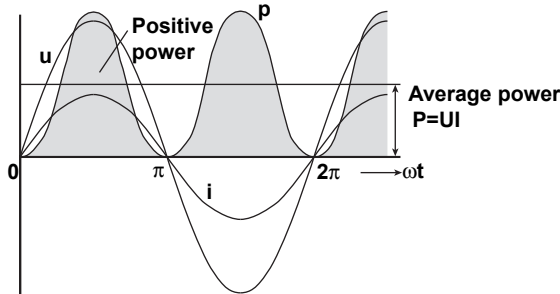
p is the sum of the time-independent term $UI \cos \phi$ and the AC component term of the voltage or current at twice the frequency $-UI \cos(2\omega t - \phi)$."

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

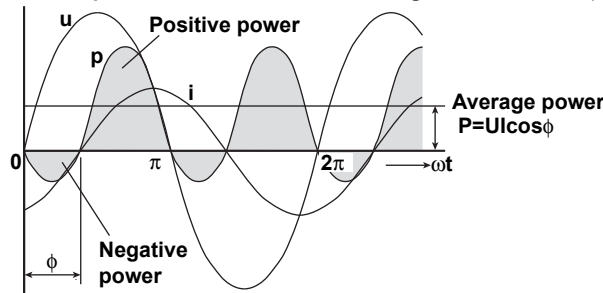
$$P = UI \cos \phi \text{ [W]}$$

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 axis represents negative power (power fed back from the load). The difference between the positive and negative powers is the power consumed by the load. As the phase difference between the voltage and current increases, the negative power increases. At $\phi = \pi/2$, the positive and negative powers are equal, and the load consumes no power.

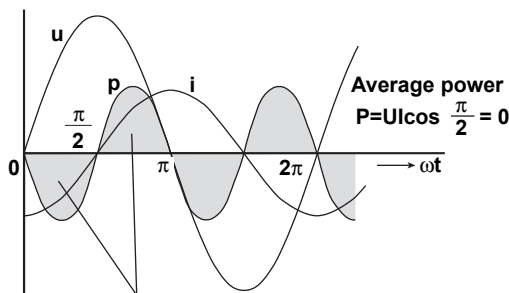
When the phase difference between voltage and current is 0



When the phase difference between voltage and current is ϕ



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



The positive and negative powers are the same

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.

$$S = UI \text{ [VA]}$$

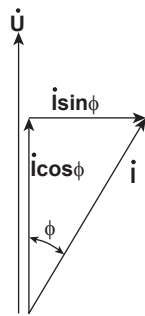
$$P = UI\cos\phi \text{ [W]}$$

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

Reactive Power

If current I lags voltage U by ϕ , current I can be broken down into a component in the same direction as voltage U , $I\cos\phi$, 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.

$$Q = UI\sin\phi \text{ [var]}$$



Below is the relationship between the apparent power, active power, and reactive power.

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

Harmonics

Harmonics refer to all sine waves whose frequency is an integer multiple of the fundamental signal (normally a 50-Hz or 60-Hz sinusoidal power line signal) except for the fundamental signal 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 and harmonic signals are combined, distortion occurs in the waveform, and interference sometimes occurs in the equipment connected to the power line.

Terminology

The terminology related to harmonics is described below.

- **Fundamental signal (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 signal.
- **Distorted wave**
A wave that differs from the fundamental signal.
- **Higher harmonic**
A sine wave with a frequency that is an integer multiple (twice or more) of the fundamental frequency.
- **Harmonic component**
A waveform component with a frequency that is an integer multiple (twice or more) of the fundamental frequency.
- **Harmonic distortion factor**
The ratio of the rms value of the specified n^{th} order harmonic contained in the distorted wave to the rms value of the fundamental signal (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 signal (or all signals).

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

- **Condensers 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.
- **Transformers**
Harmonics cause magnetostrictive noise in the iron core and increases iron and copper loss.
- **Breakers and fuses**
Excessive harmonic current can cause erroneous operation and fuse blowing.
- **Communication lines**
The electromagnetic induction caused by harmonics creates noise voltage.
- **Controllers**
Harmonic distortion of control signals can lead to malfunctions.
- **Audio visual equipment**
Harmonics can cause degradation of performance and service life, noise-related video flickering, and damaged parts.

AC RLC Circuits

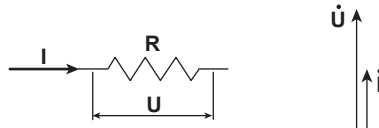
Resistance

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

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

Expressed using rms values, the equation is $I = U/R$.

There is no phase difference between the current flowing through a resistive circuit and the voltage.



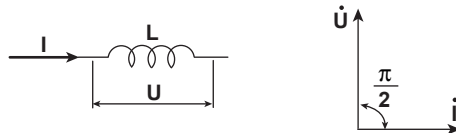
Inductance

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

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

Expressed using rms values, the equation is $I = U/X_L$. X_L is called inductive reactance and is defined as $X_L = \omega L$. The unit of inductive reactance is Ω .

Inductance works to counter current changes (increase or decrease), and causes the current to lag the voltage.



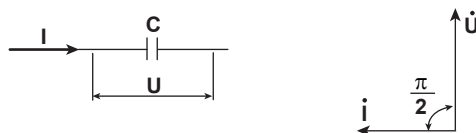
Capacity

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

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

Expressed using rms values, the equation is $I = U/X_C$. X_C is called capacitive reactance and is defined as $X_C = 1/\omega C$. The unit of capacitive reactance is Ω .

When the polarity of the voltage changes, the largest charging current with the same polarity as the voltage flows through the capacitor. When the voltage decreases, discharge current with the opposite polarity of the voltage flows. Thus, the current phase leads the voltage.



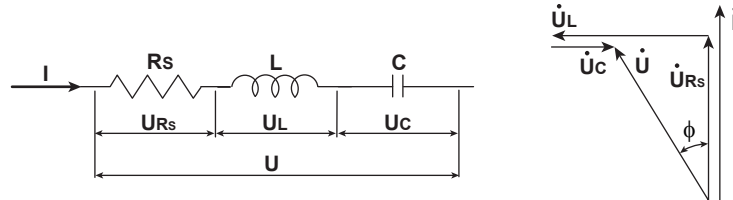
Series RLC Circuits

The equation below expresses the voltage relationships when resistance R_s [Ω], inductance L [H], and capacitance C [F] are connected in series.

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

$$= I\sqrt{(R_s)^2 + (X_L - X_C)^2} = I\sqrt{R_s^2 + X_s^2}$$

$$I = \frac{U}{\sqrt{R_s^2 + X_s^2}}, \quad \phi = \tan^{-1} \frac{X_s}{R_s}$$



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

$$X_s = X_L - X_C$$

$$Z = \sqrt{R_s^2 + X_s^2}$$

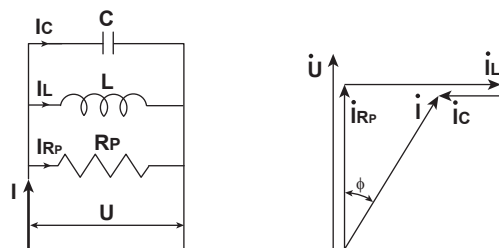
Parallel RLC Circuits

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

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

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

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



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

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

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

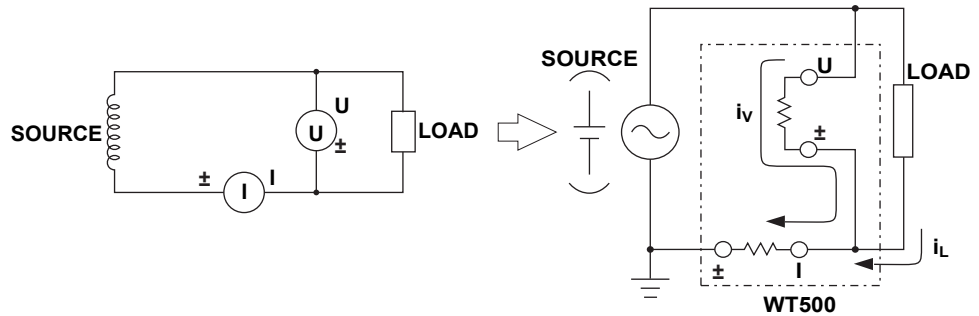
Appendix 4 How to Make Accurate Measurements

Effects of Power Loss

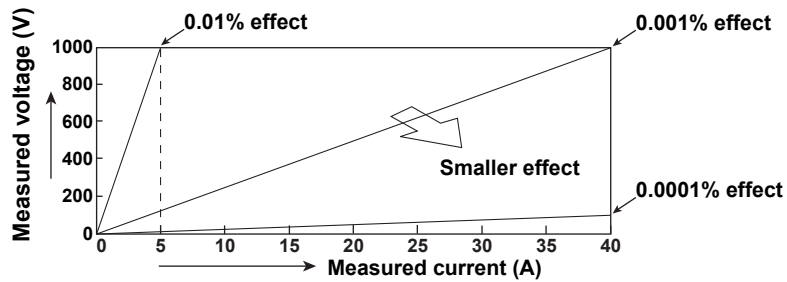
By wiring a circuit to match the load, you can minimize the effects of power loss on measurement accuracy. We will discuss the wiring of the current source and load resistance shown in the figure below.

When the Measured Current Is Relatively Large

Connect the voltage measurement circuit between the current measurement circuit and the load. The current measurement circuit measures the sum of i_L and i_V . i_L is the current flowing through the load of the circuit under measurement, and i_V is the current flowing through the voltage measurement circuit. Because the current flowing through the circuit under measurement is i_L , only i_V reduces measurement accuracy. The input resistance of the voltage measurement circuit of the WT500 is approximately $2\text{ M}\Omega$. If the input voltage is 1000 V , i_V is approximately 0.5 mA ($1000\text{ V}/2\text{ M}\Omega$). If the load current i_L is 5 A or more (load resistance is $200\ \Omega$ or less), the effect of i_V on the measurement accuracy is 0.01% or less. If the input voltage is 100 V and the current is 5 A , $i_V = 0.05\text{ mA}$ ($100\text{ V}/2\text{ M}\Omega$), so the effect of i_V on the measurement accuracy is 0.001% ($0.05\text{ mA}/5\text{ A}$).

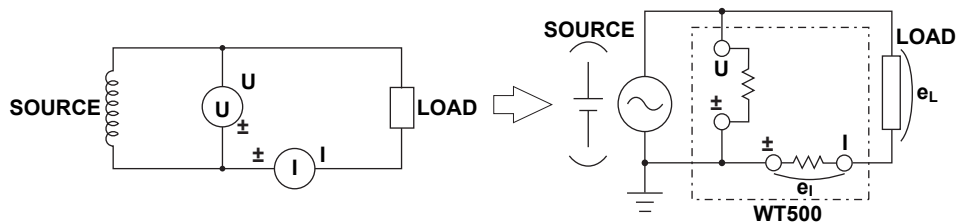


As a reference, the relationships between the voltages and currents that produce effects of 0.01% , 0.001% , and 0.0001% are shown in the figure below.



When the Measured Current Is Relatively Small

Connect the current measurement circuit between the voltage measurement circuit and the load. In this case, the voltage measurement circuit measures the sum of e_L and e_I . e_L is the load voltage, and e_I is the voltage drop across the current measurement circuit. Only e_I reduces measurement accuracy. The input resistance of the current measurement circuit of the WT500 is approximately $5\text{ m}\Omega$. If the load resistance is $1\text{ k}\Omega$, the effect of e_I on the measurement accuracy is approximately 0.0005% ($5\text{ m}\Omega/1\text{ k}\Omega$).

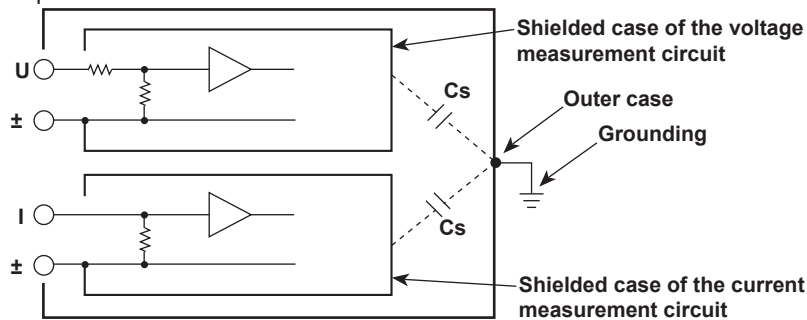


Effects of Stray Capacitance

The effects of stray capacitance on measurement accuracy can be minimized by connecting the WT500 current input terminal to the side that is closest to the earth potential of the power source (SOURCE).

The internal structure of the WT500 is as follows:

The voltage and current measurement circuits are each enclosed in shielded cases. These shielded cases are contained within an outer case. The shielded case of the voltage measurement circuit is connected to the positive and negative voltage input terminals, and the shielded case of the current measurement circuit is connected to the positive and negative current input terminals. Because the outer case is insulated from the shielded cases, there is stray capacitance, which is expressed as C_s . C_s is approximately 100 pF. The current generated by stray capacitance C_s causes errors.

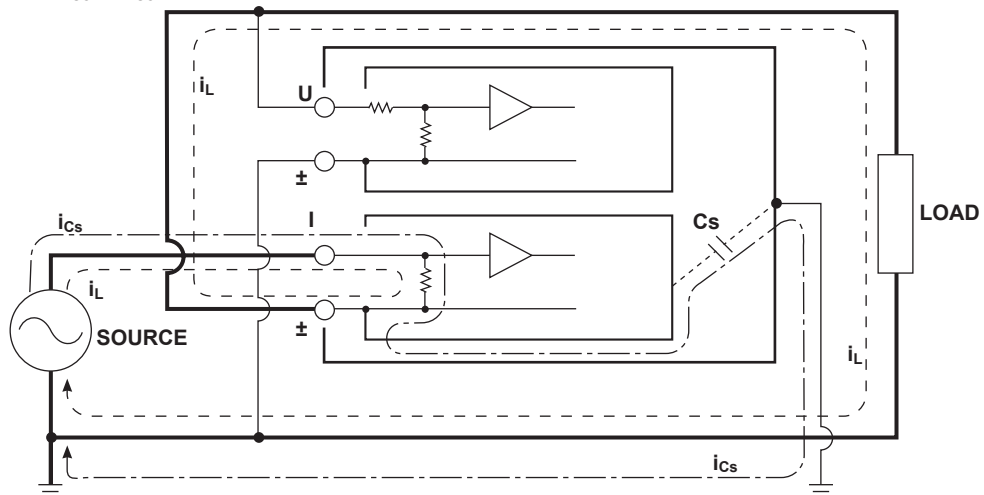


As an example, we will consider the case when the outer case and one side of the power source are grounded.

In this case, there are two conceivable current flows, load current i_L and the current that flows through the stray capacitance i_{C_s} . i_L flows through the current measurement circuit, then through the load, and returns to the power source (shown with a dotted line). i_{C_s} flows through the current measurement source, the stray capacitance, and the earth ground of the outer case, and then returns to the power source (shown with a dot-dash line).

Therefore, the current measurement circuit ends up measuring the sum of i_L and i_{C_s} , even if the objective is just to measure i_L . Only i_{C_s} reduces measurement accuracy. If the voltage applied to C_s is V_{C_s} (common mode voltage), i_{C_s} can be found using the equation shown below. Because the phase of i_{C_s} is ahead of the voltage by 90° , the effect of i_{C_s} on the measurement accuracy increases as the power factor gets smaller.

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



Because the WT500 measures high frequencies, the effects of i_{C_s} cannot be ignored. If you connect the WT500 current input terminal to the side that is close to the earth potential of the power source (SOURCE), the WT500 current measurement circuit positive and negative terminals are close to the earth potential, so V_{C_s} becomes approximately zero and very little i_{C_s} flows. This reduces the effect on measurement accuracy.

Appendix 5 Setting the Measurement Period

To make correct measurements on the WT500, you must set its measurement period properly.

The WT500 uses its frequency measurement circuit (see section 2.1 for details) to detect the period of the input signal that is selected using the measurement period setting (see section 4.7 for details). The measurement period is an integer multiple of this detected period. The WT500 determines the measured values by averaging the data sampled in the measurement period. The input signal used to define the measurement period is called the synchronization source.

The measurement period is automatically set inside the WT500 when you specify the synchronization source.

You can select the synchronization source signal from the choices listed below.

U1, I1, U2, I2, U3, I3, Ext Clk (external clock), and None

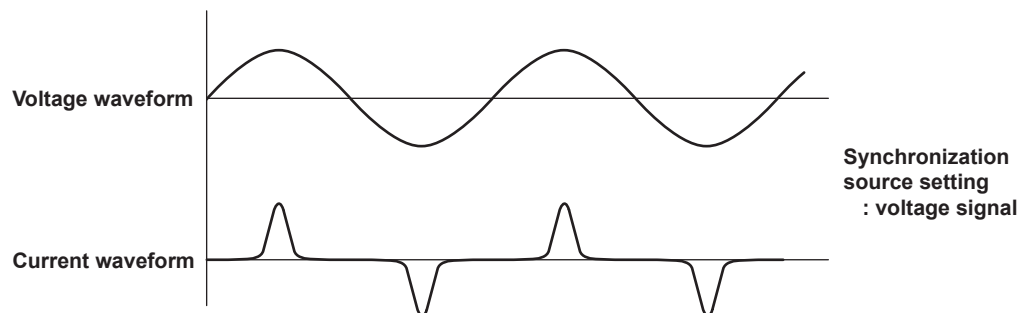
- * The selectable items vary depending on the installed elements. For the Ext Clk (external clock) specifications, see section 14.6.

For example, if the synchronization source for input element 1 is set to I1, an integer multiple of the period of I1 becomes the measurement period. By averaging the sampled data in this measurement period, the WT500 computes the measured values for input element 1, such as U1, I1, and P1.

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

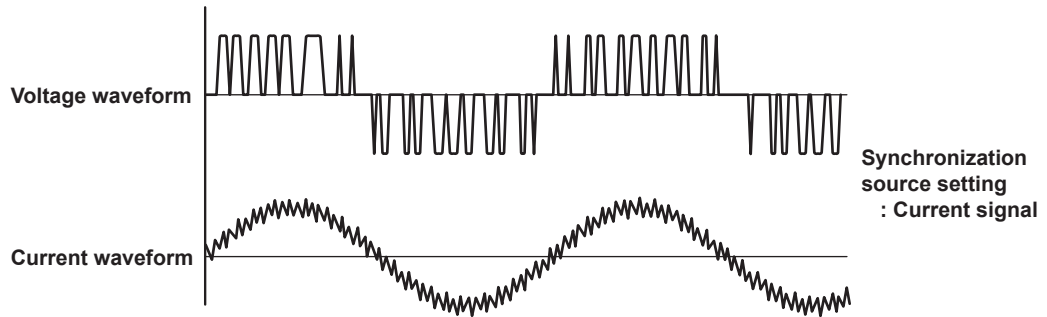
Select an input signal with a stable input level and frequency (with little distortion) for the synchronization source. Correct measured values can only be obtained if the period of the synchronization source signal is detected accurately. To see whether the frequency of the synchronization source signal is being measured correctly, follow the procedure in section 5.14, "Selecting What Frequency to Measure," to display the frequency of the selected input signal on the WT500. The most suitable synchronization source is the input signal whose measurement results are the most accurate and stable.

For example, if a switching power supply is being measured and the voltage waveform distortion is smaller than the current waveform distortion, set the synchronization source to the voltage signal.



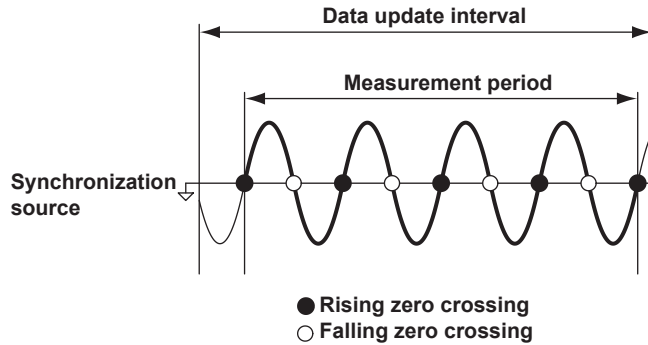
Appendix 5 Setting the Measurement Period

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



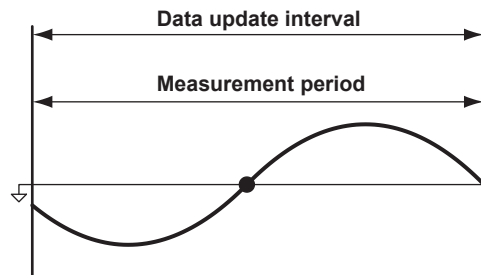
Zero crossing

- The rising (or falling) zero crossing is the time when the synchronization source passes through level zero (the center of the amplitude) on a rising (or falling) slope. The measurement period on the WT500 is between the first rising (or falling) zero crossing and the last rising (or falling) zero crossing in the data update interval.
- The WT500 determines whether to define the measurement period using the rising or falling zero crossing automatically by choosing the method that will result in the longest measurement period.



When the Period of the Synchronization Source Cannot Be Detected

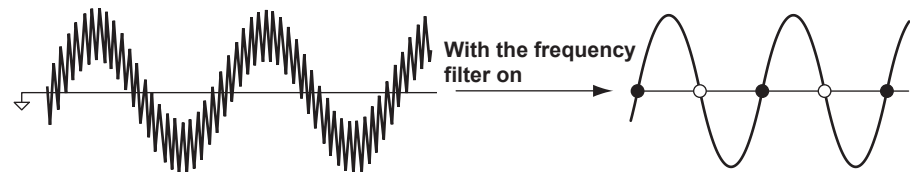
If there is not more than one rising or falling zero crossing on the input signal set as the synchronization source within the data update interval, the period cannot be detected. Also, the period cannot be detected if the AC amplitude is small. (See “Accuracy” under “Frequency Measurement” in Section 14.6, “Functions” for information about the detection levels of the frequency measurement circuit.) If this happens, the entire data update interval becomes the measurement period, and the sampled data of the entire period is averaged.



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

When the Waveform of the Synchronization Source Is Distorted

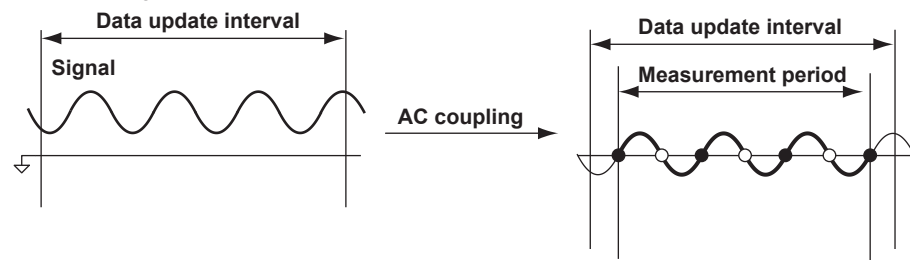
Change the synchronization source to a signal that allows for more stable detection of the period (switch from voltage to current or from current to voltage). Also, turn on the frequency filter. For information about setting the frequency filter, see section 4.7. The WT500 reduce the effects of noise by using hysteresis when it detects the zero crossing. If the synchronization source is distorted or harmonics and noise are superposed on the signal to a level exceeding this hysteresis, harmonic components will cause zero crossing detection to occur frequently, and the zero crossing of the fundamental frequency will not be detected stably. Consequently, the measured values of 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 the zero crossing. Use of the filter is appropriate if it makes the frequency measurement result more stable. Because frequency filter can be used to facilitate the detection of the zero crossing of the synchronization source, it is sometimes called the synchronization source filter or the zero-crossing filter.



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

The measured values may be unstable if the period of the AC signal cannot be detected accurately. Change the synchronization source to a signal that allows for more stable detection of the period (switch from voltage to current or from current to voltage). The frequency detection circuit is AC coupled. The period of AC signals that have no zero crossing because of an offset can be detected if the AC amplitude is greater than or equal to the detection level of the frequency measurement circuit (see “Accuracy” under “Frequency Measurement” in Section 14.6, “Functions” for details).

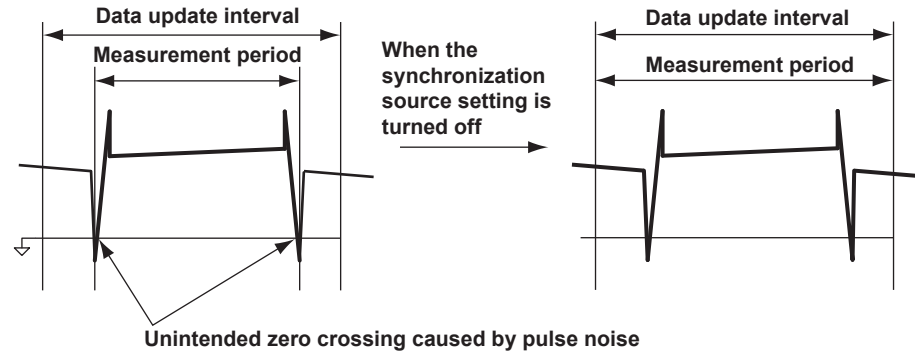
With this feature, the measurement period is set to an integer multiple of the period of the AC signal.



When Measuring a DC Signal

When there are ripples on the DC signal, if the level of the ripples is greater than or equal to the detection level of the frequency measurement circuit (see “Accuracy” under “Frequency Measurement” in Section 14.6, “Functions” for details) 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. If the synchronization source is set to None, these types of erroneous detections can be prevented. All of the sampled data in the data update interval is used to determine the measured values. Set the synchronization source according to the signal under measurement and the measurement objective.

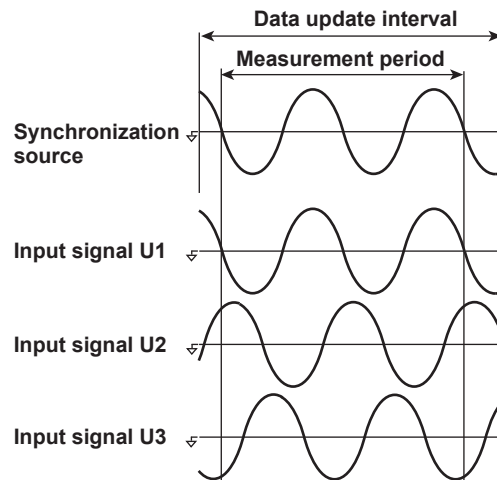


Setting the Synchronization Period When Measuring a Three-Phase Device

If a three-phase device is measured with input elements 1 and 2 using a three-phase, three-wire system, set the synchronization source of input elements 1 and 2 to the same signal. For example, set the synchronization source of input elements 1 and 2 to U1. The measurement periods of input elements 1 and 2 will match, and the Σ voltage, Σ current, and Σ power of a three-phase device can be measured more accurately.

Likewise, if a three-phase device is measured with input elements 1, 2, and 3 using a three-phase, four-wire system, set the synchronization source of input elements 1, 2, and 3 to the same signal.

To facilitate this sort of configuration, the synchronization source setting on the WT500 is linked to the Σ wiring unit of the wiring system (when independent input element configuration is off). If independent input element configuration (see section 4.2 for details) is turned on, the synchronization source of each input element in the Σ wiring unit can be set independently.



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

Setting the Synchronization Period When Measuring the Efficiency of a Power Conversion Device

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

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

The measurement periods of input element 1 (input end) and input element 2 (output end) will match, and the power conversion efficiency of the device can be measured more accurately.



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

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



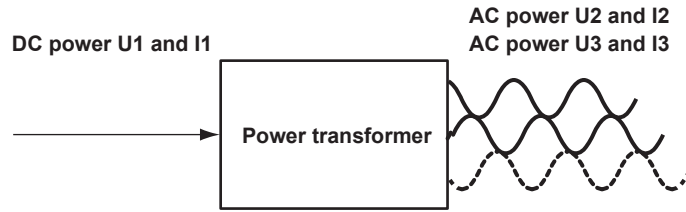
Synchronization Source Setup Example	
Input element 1	U2 (or I2)
Input element 2	

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

If a device that converts single-phase DC power to three-phase AC power is connected and measured as shown on the next page, set the synchronization source of all input elements to the same signal: the voltage or current of element 2 or 3 on the AC power end.

In this example, set the synchronization source of input elements 1, 2, and 3 to U2 (or I2, U3, or I3). The measurement periods of the input signal and all output signals will match, and the power conversion efficiency of the power conversion device can be measured more accurately.

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



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

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

If a device that converts single-phase AC power to three-phase AC power is connected and measured as shown in the figure below, set the synchronization source of input elements on the input end to the same signal and do the same for input elements on the output end.

In this example, set the synchronization source of input element 1 to U1 (or I1), and set the synchronization source of input elements 2 and 3 to U2 (or I2, U3, or I3). In this case, AC signals of different frequencies are measured. If the synchronization source of all input elements is set to the same signal, the measurement period of either the input signal or the output signal will not be an integer multiple of the signal.

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



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

Note

- The measurement period for determining the numeric data of the peak voltage or peak current is the entire span of the data update interval, regardless of the measurement period settings discussed above. Therefore, the measurement period for the measurement functions that are determined using the maximum voltage or current value (U+pk, U-pk, I+pk, I-pk, CfU, and CfI) is also the entire span of the data update interval.
- The measurement period of harmonic measurement functions is from the beginning of the data update interval to 1024 points at the harmonic sampling frequency, regardless of the measurement period settings discussed above.

Appendix 6 USB Keyboard Character Assignments

104 Keyboard (US)

Key	When the Ctrl Key Is Held Down on the USB Keyboard		When the Soft Keyboard Is Displayed on the WT500		Other	
		When the WT500 Shift is On		+Shift on the USB keyboard		When the WT500 Shift is On
a	SETUP menu	Execute INPUT INFO	a	A		
b	Execute STORE	STORE SET menu	b	B		
c	Execute CAL	Same as left	c	C		
d	Execute HOLD	Execute Single	d	D		
e	Execute ELEMENT	Execute ELEMENTALL	e	E		
f	FILE menu	Same as left	f	F		
g	Execute START/STOP	Execute (INTEG) RESET	g	G		
h			h	H		
i	Execute IMAGE SAVE	IMAGE SAVE menu	i	I		
j			j	J		
k	Execute SHIFT LOCK	Release SHIFT LOCK	k	K		
l	Execute LOCAL	Execute/Release KEY LOCK	l	L		
m	MISC menu	Execute/Release NULL	m	M		
n	Execute NUMERIC		n	N		
o	OTHERS menu		o	O		
p			p	P		
q	FORM menu	CORSOR menu	q	Q		
r	Execute RESET	Same as left	r	R		
s	SHIFT on	SHIFT off	s	S		
t	ITEM menu		t	T		
u			u	U		
v			v	V		
w	Execute WAVE		w	W		
x			x	X		
y			y	Y		
z			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	Execute CAL	Commit	Same as left	Execute Set	Execute CAL
Esc	Execute Esc	Execute RESET	Escape	Same as left	Execute Esc	Execute RESET
Back Space			Back Space	Same as left		
Tab						
Space Bar			Space	Same as left		
`			`	~		
-			-	_		
=			=	+		
[[{		
]]	}		
\			\			
;			;	:		
'			'	"		
,			,	<		
.			.	>		
/			/	?		
Caps Lock						

Appendix 6 USB Keyboard Character Assignments

Key	When the Ctrl Key Is Held Down on the USB Keyboard		When the Soft Keyboard Is Displayed on the WT500		Other	
		When the WT500 Shift is On		+Shift on the USB keyboard		When the WT500 Shift is On
F1	VOLTAGE up					
F2	VOLTAGE down	Execute VOLTAGE AUTO				
F3	Execute VOLTAGE AUTO					
F4	CURRENT up					
F5	CURRENT down	Execute CURRENT AUTO				
F6	Execute CURRENT AUTO					
F7	Execute ELEMENT					
F8	Execute U, I, P					
F9	Execute S, Q, λ, φ					
F10	Execute WP, q, TIME					
F11	Execute FU, FI, η		μ	Same as left		
F12	Execute mode		Ω	Same as left		
Print Screen	Execute IMAGE SAVE	IMAGE SAVE menu				
Scroll Lock						
Pause						
Insert						
Home						
Page Up	Execute PAGE PREVIOUS	Execute PAGE FIRST			Execute PAGE PREVIOUS	Execute PAGE FIRST
Delete						
End						
Page Down	Execute PAGE NEXT	Execute PAGE LAST			Execute PAGE NEXT	Execute PAGE LAST
→	Move cursor to the right	Same as left*	Move cursor to the right	Same as left	Move cursor to the right	Same as left*
←	Move cursor to the left	Same as left*	Move cursor to the left	Same as left	Move cursor to the left	Same as left*
↓	Move cursor down	Same as left*			Move cursor down	Same as left*
↑	Move cursor up	Same as left*			Move cursor up	Same as left*

Numeric Keypad	When the Ctrl Key Is Held Down on the USB Keyboard		When the Soft Keyboard Is Displayed on the WT500		Other	
		When the WT500 Shift is On		+Shift on the USB keyboard		+Shift on the USB keyboard
Num Lock						
/			/	Same as left		
*			*	Same as left		
-			-	Same as left		
+			+	Same as left		
Enter	Execute Set	Execute CAL	Enter	Same as left		Execute Set
1			1			
2	Move cursor down	Same as left	2			Move cursor down
3	Execute PAGE NEXT	Execute PAGE LAST	3			Execute PAGE NEXT
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 PREVIOUS	Execute PAGE FIRST	9			Execute PAGE PREVIOUS
0			0			
.			.			

* The WT500 shift will switch off if it is on. However, the shift will remain on if the shift lock is on.

109 Keyboard (Japanese)

Key	When the Ctrl Key Is Held Down on the USB Keyboard		When the Soft Keyboard Is Displayed on the WT500		Other	
		When the WT500 Shift is On		+Shift on the USB keyboard		When the WT500 Shift is On
a	SETUP menu	Execute INPUT INFO	a	A		
b	Execute STORE	STORE SET menu	b	B		
c	Execute CAL	Same as left	c	C		
d	Execute HOLD	Execute Single	d	D		
e	Execute ELEMENT	Execute ELEMENTALL	e	E		
f	FILE menu	Same as left	f	F		
g	Execute START/STOP	Execute (INTEG) RESET	g	G		
h			h	H		
i	Execute IMAGE SAVE	IMAGE SAVE menu	i	I		
j			j	J		
k	Execute SHIFT LOCK	Release SHIFT LOCK	k	K		
l	Execute LOCAL	Execute/Release KEY LOCK	l	L		
m	MISC menu	Execute/Release NULL	m	M		
n	Execute NUMERIC		n	N		
o	OTHERS menu		o	O		
p			p	P		
q	FORM menu	CORSOR menu	q	Q		
r	Execute RESET	Same as left	r	R		
s	SHIFT on	SHIFT off	s	S		
t	ITEM menu		t	T		
u			u	U		
v			v	V		
w	Execute WAVE		w	W		
x			x	X		
y			y	Y		
z			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	Execute CAL	Commit	Same as left	Execute Set	Execute CAL
Esc	Execute Esc	Execute RESET	Escape	Same as left	Execute Esc	Execute RESET
Back Space			BS	Same as left		
Tab						
Space Bar			Space	Same as left		
-			-	=		
^			^	~		
¥			\			
@			@	`		
[[{		
;			;	+		
:			:	*		
]]	}		
,			,	<		
.			.	>		
/			/	?		
\			\	_		
Caps Lock						

Appendix 6 USB Keyboard Character Assignments

Key	When the Ctrl Key Is Held Down on the USB Keyboard		When the Soft Keyboard Is Displayed on the WT500		Other	
		When the WT500 Shift is On		+Shift on the USB keyboard		When the WT500 Shift is On
F1	VOLTAGE up					
F2	VOLTAGE down	Execute VOLTAGE AUTO				
F3	Execute VOLTAGE AUTO					
F4	CURRENT up					
F5	CURRENT down	Execute CURRENT AUTO				
F6	Execute CURRENT AUTO					
F7	Execute ELEMENT					
F8	Execute U, I, P					
F9	Execute S, Q, λ, φ					
F10	Execute WP, q, TIME					
F11	Execute FU, FI, η		μ	Same as left		
F12	Execute mode		Ω	Same as left		
Print Screen	Execute IMAGE SAVE	IMAGE SAVE menu				
Scroll Lock						
Pause						
Insert						
Home						
Page Up	Execute PAGE PREVIOUS	Execute PAGE FIRST			Execute PAGE PREVIOUS	Execute PAGE FIRST
Delete						
End						
Page Down	Execute PAGE NEXT	Execute PAGE LAST			Execute PAGE NEXT	Execute PAGE LAST
→	Move cursor to the right	Same as left*	Move cursor to the right	Same as left	Move cursor to the right	Same as left*
←	Move cursor to the left	Same as left*	Move cursor to the left	Same as left	Move cursor to the left	Same as left*
↓	Move cursor down	Same as left*			Move cursor down	Same as left*
↑	Move cursor up	Same as left*			Move cursor up	Same as left*

Numeric Keypad	When the Ctrl Key Is Held Down on the USB Keyboard		When the Soft Keyboard Is Displayed on the WT500		Other	
		When the WT500 Shift is On		+Shift on the USB keyboard		+Shift on the USB keyboard
Num Lock						
/			/	Same as left		
*			*	Same as left		
-			-	Same as left		
+			+	Same as left		
Enter	Execute Set	Execute CAL	Enter	Same as left		Execute Set
1			1			
2	Move cursor down	Same as left	2			Move cursor down
3	Execute PAGE NEXT	Execute PAGE LAST	3			Execute PAGE NEXT
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 PREVIOUS	Execute PAGE FIRST	9			Execute PAGE PREVIOUS
0			0			
.			.			

* The WT500 shift will switch off if it is on. However, the shift will remain on if the shift lock is on.

Appendix 7 User-Defined Function Operands

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

Measurement Function	User-Defined Function		Parameter in ()	
			Element	Wiring Unit
			E1 to E3	E4
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
CfU	CFU()	CFU(E1)	Yes	No
CfI	CFI()	CFI(E1)	Yes	No
η_1	ETA1()	ETA1()	None or space ¹	
η_2	ETA2()	ETA2()	None or space ¹	
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

User-Defined Function

F1	F1()	F1()	None or space ¹
F2	F2()	F2()	None or space ¹
F3	F3()	F3()	None or space ¹
F4	F4()	F4()	None or space ¹
F5	F5()	F5()	None or space ¹
F6	F6()	F6()	None or space ¹
F7	F7()	F7()	None or space ¹
F8	F8()	F8()	None or space ¹

¹ The parentheses cannot be omitted.

Appendix 7 User-Defined Function Operands

MAX Hold

Measurement Function	User-Defined Function		Parameter in ()	
			Element	Wiring Unit
			E1 to E3	E4
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
Var hours	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

• The following measurement functions can be used on models with the delta computation option.

			Parameter in () for E4
ΔF1rms()	DELTA F1RMS()	DELTA F1RMS(E4)	Yes
ΔF2rms()	DELTA F2RMS()	DELTA F2RMS(E4)	Yes
ΔF3rms()	DELTA F3RMS()	DELTA F3RMS(E4)	Yes
ΔF4rms()	DELTA F4RMS()	DELTA F4RMS(E4)	Yes
ΔF1mn()	DELTA F1MN()	DELTA F1MN(E4)	Yes
ΔF2mn()	DELTA F2MN()	DELTA F2MN(E4)	Yes
ΔF3mn()	DELTA F3MN()	DELTA F3MN(E4)	Yes
ΔF4mn()	DELTA F4MN()	DELTA F4MN(E4)	Yes
ΔF1dc()	DELTA F1DC()	DELTA F1DC(E4)	Yes
ΔF2dc()	DELTA F2DC()	DELTA F2DC(E4)	Yes
ΔF3dc()	DELTA F3DC()	DELTA F3DC(E4)	Yes
ΔF4dc()	DELTA F4DC()	DELTA F4DC(E4)	Yes
ΔF1rmn()	DELTA F1RMN()	DELTA F1RMN(E4)	Yes
ΔF2rmn()	DELTA F2RMN()	DELTA F2RMN(E4)	Yes
ΔF3rmn()	DELTA F3RMN()	DELTA F3RMN(E4)	Yes
ΔF4rmn()	DELTA F4RMN()	DELTA F4RMN(E4)	Yes
ΔF1ac()	DELTA F1AC()	DELTA F1AC(E4)	Yes
ΔF2ac()	DELTA F2AC()	DELTA F2AC(E4)	Yes
ΔF3ac()	DELTA F3AC()	DELTA F3AC(E4)	Yes
ΔF4ac()	DELTA F4AC()	DELTA F4AC(E4)	Yes

Appendix 7 User-Defined Function Operands

• The following measurement functions can be used on models with the harmonic measurement option.

Measurement Function	User-Defined Function		Left Parameter in (,) or Parameter in ()		Right parameter in (,)			
			Element	Wiring Unit	Harmonic order			
					Total Value	DC	Fundamental	Harmonics
Example	E1 to E3	E4	ORT	OR0	OR1	OR2 to OR50		
ϕU	UPHI(,)	UPHI(E1,OR3)	Yes	No	No	No	No	Yes
ϕI	IPHI(,)	IPHI(E1,OR3)	Yes	No	No	No	No	Yes
UhdF	UHDF(,)	UHDF(E1,OR3)	Yes	No	No	Yes	Yes	Yes
IhdF	IHDF(,)	IHDF(E1,OR3)	Yes	No	No	Yes	Yes	Yes
PhdF	PHDF(,)	PHDF(E1,OR3)	Yes	No	No	Yes	Yes	Yes
U_k	UK(,)	UK(E1,OR3)	Yes	Yes	Yes	Yes	Yes	Yes
I_k	IK(,)	IK(E1,OR3)	Yes	Yes	Yes	Yes	Yes	Yes
P_k	PK(,)	PK(E1,OR3)	Yes	Yes	Yes	Yes	Yes	Yes
S_k	SK(,)	SK(E1,OR3)	Yes	Yes	Yes	Yes	Yes	Yes
Q_k	QK(,)	QK(E1,OR3)	Yes	Yes	Yes	Yes	Yes	Yes
λ_k	LAMBDAK(,)	LAMBDAK(E1,OR3)	Yes	Yes	Yes	Yes	Yes	Yes
ϕ_k	PHIK(,)	PHIK(E1,OR3)	Yes	No	Yes	Yes	Yes	Yes
Uthd	UTHD()	UTHD(E1)	Yes	No	/			
Ithd	ITHD()	ITHD(E1)	Yes	No				
Pthd	PTHD()	PTHD(E1)	Yes	No				
$\phi U1-U2$	PHIU1U2()	PHIU1U2(E4)	No	Yes				
$\phi U1-U3$	PHIU1U3()	PHIU1U3(E4)	No	Yes				
$\phi U1-I1$	PHIU1I1()	PHIU1I1(E4)	No	Yes				
$\phi U1-I2$	PHIU1I2()	PHIU1I2(E4)	No	Yes				
$\phi U1-I3$	PHIU1I3()	PHIU1I3(E4)	No	Yes				

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