# WT310E/WT310EH/WT332E/WT333E

Digital Power Meter

# USER'S MANUAL

**User's Manual**

YOKOGAWA
Yokogawa Test & Measurement Corporation

IM WT310E-01EN
2nd Edition

Thank you for purchasing the WT310E, WT310EH, WT332E, or WT333E Digital Power Meter. This instrument is a power measurement instrument that can measure parameters such as voltage, current, and power.
This User's Manual explains the features of this instrument and how to use them. To ensure correct use, please read this manual thoroughly before beginning operation.
Keep this manual in a safe place for quick reference in the event that a question arises.

## List of Manuals

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

| Manual Title | Manual No. | Description |
|---|---|---|
| WT310E/WT310EH/WT332E/WT333E Digital Power Meter User's Manual | IM WT310E-01EN | This manual. The manual explains all features of this instrument, except for the communication interface features, and how to use them. |
| WT310E/WT310EH/WT332E/WT333E Digital Power Meter Getting Started Guide | IM WT310E-02EN | Provided as a printed manual. This manual explains the handling precautions and basic operations of this instrument and provides an overview of its features. |
| WT310E/WT310EH/WT332E/WT333E Digital Power Meter Communication Interface User's Manual | IM WT310E-17EN | This manual explains the communication interface features of this instrument and how to use them. |
| WT310E/WT310EH/WT332E/WT333E Digital Power Meter | IM WT310E-92Z1 | Document for China |

PDF files of all the manuals above are included in the accompanying CD.
The "EN" and "Z1" in the manual numbers are the language codes.

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

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

## Notes

- The contents of this manual are subject to change without prior notice as a result of continuing improvements to the instrument's performance and functionality. The figures given in this manual may differ from those that actually appear on your screen.
- Every effort has been made in the preparation of this manual to ensure the accuracy of its contents. However, should you have any questions or find any errors, please contact your nearest YOKOGAWA dealer.
- Copying or reproducing all or any part of the contents of this manual without the permission of YOKOGAWA is strictly prohibited.
- Safety precautions are provided in the Getting Started Guide, IM WT310E-02EN. Be sure to observe the safety precautions.
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## Revisions

- September 2015 1st Edition
- October 2017 2nd Edition

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# Symbols and Notation Used in This Manual

## Units

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

## Notes

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 user's 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.

French

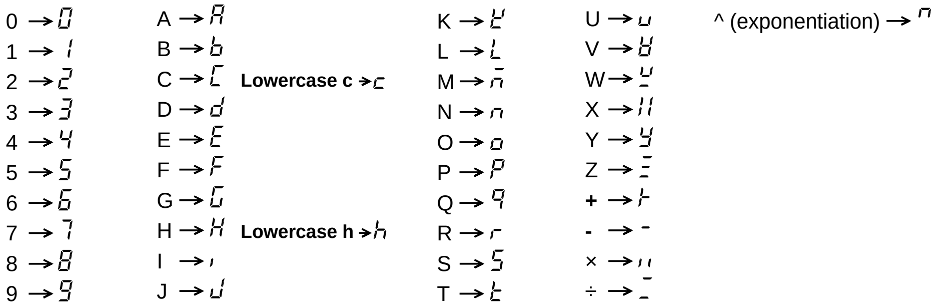
**AVERTISSEMENT** Attire l'attention sur des gestes ou des conditions susceptibles de provoquer des blessures graves (voire mortelles), et sur les précautions de sécurité pouvant prévenir de tels accidents.

**ATTENTION** Attire l'attention sur des gestes ou des conditions susceptibles de provoquer des blessures légères ou d'endommager l'instrument ou les données de l'utilisateur, et sur les précautions de sécurité susceptibles de prévenir de tels accidents.

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

## Characters That Appear on the 7-Segment LED

Because this instrument uses a 7-segment LED display, numbers, letters, and mathematical symbols are displayed using special characters in the manner shown below. Some of the characters shown below are not used by this instrument.



## Symbols and Conventions Used in Procedural Explanations

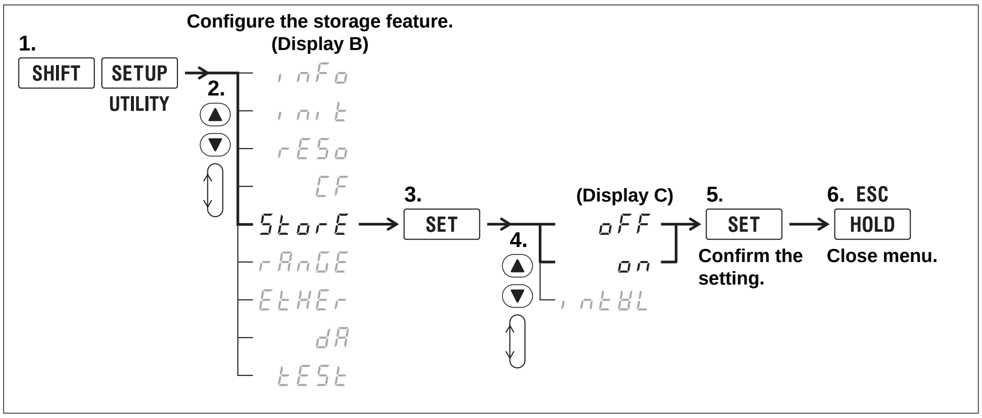
The contents of the procedural explanations are indicated using the following symbols.

**WTViewerFreePlus**

This mark appears on the right side of the page to indicate features and settings that can be operated and configured using the WTViewerFreePlus application software, which comes with the instrument.

**Procedure** Operations are explained using flowcharts. See the example below for an explanation of how various operations are indicated. All procedures are written under the assumption that you are starting operation at the beginning of the procedure, so you may not need to carry out all the steps in a procedure when you are changing the settings.

Example: Operations for turning the storage feature on and off




The above flow chart indicates the following operations.
You can configure items that are blinking.

1. Press the **SHIFT** key so that it illuminates, and then press **SETUP (UTILITY)**.
   A menu appears in display B.
2. Use ▲ or ▼ to select StorE.
   Pressing either key cycles through 9 menu items.
3. Press **SET** to confirm the selection of StorE.
   The StorE function menu that you selected in step 2 appears in display C.
4. Use ▲ or ▼ to select oFF or on.
   Pressing either key cycles through 3 menu items.
5. Press **SET** to confirm the selection of oFF.
   The selected or set item is confirmed when you press SET.
   A menu appears in display B.
6. Press **HOLD (ESC)** to return the menu display to the measured data display.

- When you are making a number positive (no sign) or negative (–) or setting a number, when the digit in the display that the input will be added to is blank, an underscore flashes at the position of the digit.
- While you are performing menu operations, to leave the menu display, press HOLD (ESC). All setting changes that you have confirmed by pressing the SET key will be reflected in the settings.

**Explanation** This section describes the setup items and the limitations regarding the procedures. It may not give a detailed explanation of the feature. For a detailed explanation of the feature, see chapter 1.

# Entering Values

## Selecting a Value

The digit that is blinking is the one that is currently being set.

Use ▲ or ▼ to select a number.

## Moving the Digit That Is Being Set

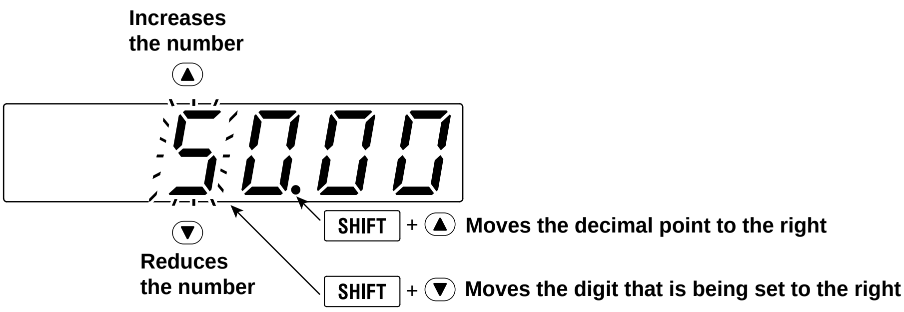
Press **SHIFT+▼** (▶) to move the digit that is being set to the right.

If you press **SHIFT+▼** (▶) when the digit that is being set is the digit that is furthest to the right, the digit that is being set will switch to the leftmost digit that can be set.

## Moving the Decimal Point

Press **SHIFT+▲** (.) to move the decimal point to the right.

If you press SHIFT+▲ (.) when the decimal point is as far to the right as it can be, the decimal point will move to the leftmost possible position.



# Contents

# 1.1 Items That This Instrument Can Measure (Measurement functions)

The items that you can measure with this instrument are listed below. For details about how the values of measurement functions are determined, see appendix 1. For explanations of the terms measurement function, input element, wiring unit, and Σ function, see “What Is a Measurement Function?” (page 1-4).

### WT310E and WT310EH

The WT310E and WT310EH are only equipped with one input element. Because of this, they can only measure single-phase measurement functions. They cannot measure comprehensive measurement functions that treat multiple input elements as a single wiring unit (Σ functions).

### WT332E/WT333E

The WT332E/WT333E is equipped with two or three input elements. Because of this, the WT332E/WT333E can measure not only single-phase measurement functions for each input element but also measure measurement functions that treat multiple phases as a single wiring unit (Σ functions).

The measurement functions that you can measure using this instrument are divided into normal measurement and harmonic measurement and listed in the following table.

## Measurement Functions Used in Normal Measurement

### Voltage

| Measurement Function (Symbol) | Panel Indicator Light[1] | Description | Measured for Each Input Element | Measured for Wiring Units (WT332E/WT333E only) |
|---|---|---|---|---|
| U (RMS) | V | True rms voltage | Yes | Yes |
| U (VOLTAGE MEAN) | V | Rectified mean voltage calibrated to the rms value | Yes | Yes |
| U (DC) | V | Linear voltage average | Yes | Yes |
| U+pk | Vpk | Maximum voltage | Yes | No |
| U-pk | Vpk | Minimum voltage | Yes | No |
| Cf U[2] | MATH | Voltage crest factor | Yes | No |

Yes: Measured. No: Not measured.

1 Panel indicators indicate the unit of the measured value and the item that is being measured. They appear on the right or left side of the 7-segment LED display that shows the measured data.

2 This measurement function is set using the MATH feature of this instrument.

### Current

| Measurement Function (Symbol) | Panel Indicator Light | Description | Measured for Each Input Element | Measured for Wiring Units (WT332E/WT333E only) |
|---|---|---|---|---|
| I (RMS) | A | True rms current | Yes | Yes |
| I (DC) | A | Linear current average | Yes | Yes |
| I+pk | Apk | Maximum current | Yes | No |
| I-pk | Apk | Minimum current | Yes | No |
| Cf I* | MATH | Current crest factor | Yes | No |

* This measurement function is set using the MATH feature of this instrument.

## Power

| Measurement Function (Symbol) | Panel Indicator Light | Description | Measured for Each Input Element | Measured for Wiring Units (WT332E/ WT333E only) |
|---|---|---|---|---|
| P | W | Active power | Yes | Yes |
| S | VA | Apparent power | Yes | Yes |
| Q | var | Reactive power | Yes | Yes |
| λ | PF | Power factor | Yes | Yes |
| Φ | ° | Phase difference | Yes | Yes |
| P+pk | Wpk | Maximum power | Yes | No |
| P-pk | Wpk | Minimum power | Yes | No |

## Frequency

| Measurement Function (Symbol) | Panel Indicator Light | Description | Measured for Each Input Element | Measured for Wiring Units (WT332E/ WT333E only) |
|---|---|---|---|---|
| fU | VHz | Voltage frequency | Yes | No |
| fI | AHz | Current frequency | Yes | No |
| fPLL (PLL U) | VHz | Frequency of PLL voltage* | Yes | No |
| fPLL (PLL I) | AHz | Frequency of PLL current* | Yes | No |

* Only on models with the harmonic measurement option

## Integrated Power (Watt hour)

| Measurement Function (Symbol) | Panel Indicator Light | Description | Measured for Each Input Element | Measured for Wiring Units (WT332E/ WT333E only) |
|---|---|---|---|---|
| Time | Time | Integration time | Yes | No |
| WP | Wh | Sum of positive and negative watt hours | Yes | Yes |
| WP± | Wh± | Positive or negative watt hours | Yes | Yes |
| q | Ah | Sum of positive and negative ampere hours | Yes | Yes |
| q± | Ah± | Positive or negative ampere hour | Yes | Yes |
| AV P* | MATH | Average active power during integration | Yes | Yes |

* This measurement function is set using the MATH feature of this instrument.

## Efficiency (WT332E/WT333E only)*

| Measurement Function (Symbol) | Panel Indicator Light | Description |
|---|---|---|
| EFFi | MATH | Efficiency |

* This measurement function is set using the MATH feature of the WT332E/WT333E.

## Basic Arithmetic*

| Measurement Function (Symbol) | Panel Indicator Light | Description |
|---|---|---|
| A+B | MATH | A+B |
| A-B | MATH | A-B |
| A×B | MATH | A×B |
| A÷B | MATH | A÷B |
| A÷B^2 | MATH | $A \div B^2$ |
| A^2÷B | MATH | $A^2 \div B$ |

* This measurement function is set using the MATH feature of this instrument.

## Measurement Functions Used in Harmonic Measurement (Option)

Harmonic measurement functions are measured for each input element and only work with single-phase measurement. They cannot measure comprehensive measurement functions that treat multiple phases as a single wiring unit (Σ functions).

| Measurement Function (Symbol) | Panel Indicator Light | Description |
|---|---|---|
| U(k) | V | Rms voltage value of harmonic order k |
| I(k) | A | Rms current value of harmonic order k |
| P(k) | W | Active power of harmonic order k |
| λ(k) | PF | Power factor of the fundamental wave (1st harmonic) |
| Φ(k) | V° or A° | Phase difference between the fundamental voltage and fundamental current when the harmonic order k is the 1st harmonic (fundamental wave) |
| Uthd | THD V% | Total harmonic voltage distortion |
| Ithd | THD A% | Total harmonic current distortion |
| Uhdf(k) | V% | Harmonic distortion factor of voltage for harmonic order k |
| Ihdf(k) | A% | Harmonic distortion factor of current for harmonic order k |
| Phdf(k) | W% | Harmonic distortion factor of power for harmonic order k |
| ΦU(k) | V° | Phase difference between the voltage of harmonic order k and and the fundamental voltage |
| ΦI(k) | A° | Phase difference between the current of harmonic order k and the fundamental current |

k: The harmonic order, which is indicated in display A.

## Harmonic Measurement Function Orders

The harmonic orders that you can specify are indicated below.

| Measurement Function (Symbol) | Panel Indicator Light | Total Value (Total rms value) | 1 (fundamental wave) | Harmonics |
|---|---|---|---|---|
| U(k) | V | Yes | Yes | 2 to 50* |
| I(k) | A | Yes | Yes | 2 to 50* |
| P(k) | W | Yes | Yes | 2 to 50* |
| λ(k) | PF | No | Yes | No |
| Φ(k) | V° or A° | No | Yes | No |
| Uthd | THD V% | Yes | No | No |
| Ithd | THD A% | Yes | No | No |
| Uhdf(k) | V% | No | Yes | 2 to 50* |
| Ihdf(k) | A% | No | Yes | 2 to 50* |
| Phdf(k) | W% | No | Yes | 2 to 50* |
| ΦU(k) | V° | No | No | 2 to 50* |
| ΦI(k) | A° | No | No | 2 to 50* |

k: The harmonic order

* The maximum measured harmonic order varies depending on the frequency of the fundamental wave. (See section 7.4, “Harmonic Measurement,” in the Getting Started Guide, IM WT310E-02EN.)

# What Is a Measurement Function?

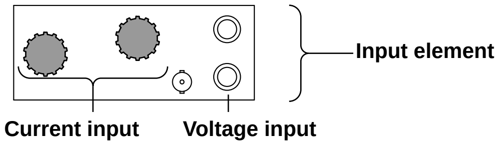
## Measurement Function

The physical values—such as rms voltage, average current, power, and phase difference—that this instrument measures and displays are called measurement functions. Each measurement function is displayed using a symbol that corresponds to its physical value. For example, "U" corresponds to the voltage. The unit is "V." When the measurement mode is RMS (see section 1.2, "Measurement Conditions"), the true rms voltage is displayed.

## WT310E and WT310EH

### Input Element

An input element is a set of input terminals that a single phase of voltage and current that you want to measure can be applied to. The WT310E/WT310EH has one input element.




### Wiring System

The WT310E/WT310EH uses a single-phase, two-wire system.

### Wiring Units and Σ Functions

The WT310E/WT310EH does not have multiple input elements that can be combined into wiring units and Σ functions.

## WT332E/WT333E

### Input Elements

An input element is a set of input terminals that a single phase of voltage and current that you want to measure can be applied to. The WT333E can be equipped with three input elements. The element numbers range from 1 to 3.

### Wiring Systems

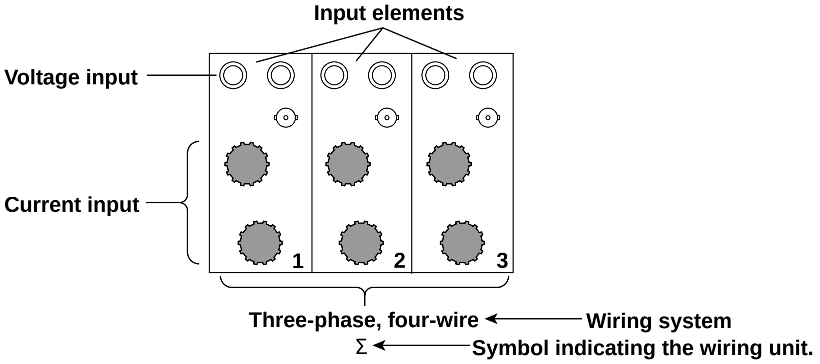
To measure the power of various single-phase and three phase power transmission systems using the WT332E/WT333E, not only can you specify a single-phase, two-wire system, you can also specify a single-phase, three-wire system; a three-phase, three-wire system; a three-phase, four-wire system; or a three-phase, three-wire system that uses the three-voltage, three-current method.

### Wiring Unit

A wiring unit is a set of two or three input elements that are grouped to measure three-phase power. Wiring units are represented by the Σ symbol.

### Σ Functions

A measurement function of a wiring unit is called a Σ function. For example, "UΣ" corresponds to the average of the voltages of the input elements that are assigned to wiring unit Σ. When the measurement mode is RMS, the true rms voltage is displayed.



# 1.2 Measurement Conditions

## Voltage and Current Measurement Modes (For procedures, see section 2.1)

You can select one of the following three voltage measurement modes: RMS, MEAN (VOLTAGE MEAN), and DC.

You can select one of the following two current measurement modes: RMS and DC.

### RMS (True RMS)

The true voltage or current rms value.

$$\sqrt{\frac{1}{T}\int_0^T f(t)^2\,dt}$$

**f(t) : Input signal**
**T : One period of the input signal**

### MEAN (VOLTAGE MEAN, rectified mean value calibrated to the rms value)

One period of the voltage is rectified and the resulting average is multiplied by the factor that would yield the true rms value if the applied signal were a sine wave. When sine waves are measured, the values obtained in this mode are the same as those obtained in RMS mode. The values differ from those obtained in RMS mode when distorted waves or DC waves are measured.

$$\frac{\pi}{2\sqrt{2}} \cdot \frac{1}{T}\int_0^T |f(t)|\,dt$$

**f(t) : Input signal**
**T : One period of the input signal**

### DC (Linear average)

The average of one period of the voltage or current. This mode is useful for determining the average value of a DC input signal or the value of a DC signal that is superimposed on an AC signal.

$$\frac{1}{T}\int_0^T f(t)\,dt$$

**f(t) : Input signal**
**T : One period of the input signal**

# Wiring Systems (For procedures, see section 2.1)

The wiring systems that you can select vary depending on the model.

## WT310E and WT310EH

The WT310E and WT310EH are only equipped with one input element. You can measure single-phase, two-wire systems. Because there is only one input element, you cannot select different wiring systems.

## WT332E (Two Input Element Model)

The WT332E is equipped with two input elements (element 1 and element 3). On the WT332E, you can select the following wiring systems.

| Wiring System | Description | Elements |
|---|---|---|
| 1P3W | Single-phase, three-wire | Element 1 and element 3 |
| 3P3W | Three-phase, three-wire | Element 1 and element 3 |

The measured data when a single-phase, two-wire system (1P2W) has been specified is the measured data for elements 1 and 3.

The measured data for a single-phase, two-wire system will be measured correctly regardless of which of the above wiring systems you select.

## WT333E (Three Input Element Model)

The WT333E is equipped with three input elements (element 1, element 2, and element 3). On the WT333E, you can select the following wiring systems.

| Wiring System | Description | Elements |
|---|---|---|
| 1P3W | Single-phase, three-wire | Element 1 and element 3. Element 2 is 1P2W. |
| 3P3W | Three-phase, three-wire | Element 1 and element 3. Element 2 is 1P2W. |
| 3P4W | Three-phase, four-wire | Elements 1, 2, and 3 |
| 3V3A | Three-voltage, three-current method | Elements 1, 2, and 3 |

The measured data when a single-phase, two-wire system (1P2W) has been specified is the measured data for elements 1, 2, and 3. The measured data for a single-phase, two-wire system will be measured correctly regardless of which of the above wiring systems you select.

# Measurement Ranges (For procedures, see section 2.3)

Specify the measurement ranges in accordance with the rms values of the voltage and current that you want to measure. You can specify fixed measurement ranges or have the ranges set automatically.

## Fixed Ranges

You can select a range from various options. Even if the size of the input signal changes, the selected range will not change. For voltage, when the crest factor is set to 3, the maximum range that you can select is 600 V, and the minimum range that you can select is 15 V.
When the crest factor is set to 6 or 6a, the maximum range that you can select is 300 V, and the minimum range that you can select is 7.5 V.

## Auto Range

This instrument automatically switches the range according to the size of the input signal. The ranges that this instrument switches between are the same ranges that you can select as fixed ranges.

### Range Increase

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

- Crest factor 3
  Urms or Irms exceeds 130% of the measurement range.
  Upk or Ipk exceeds approximately 300% of the currently set measurement range.
- Crest factor 6
  Urms or Irms exceeds 130% of the measurement range.
  Upk or Ipk exceeds approximately 600% of the currently set measurement range.
- Crest factor 6A
  Urms or Irms exceeds 260% of the measurement range.
  Upk or Ipk exceeds approximately 600% of the currently set measurement range.

On the WT332E/WT333E, when any of the equipped input elements meets any of the above conditions, the measurement range is increased.

### Range Decrease

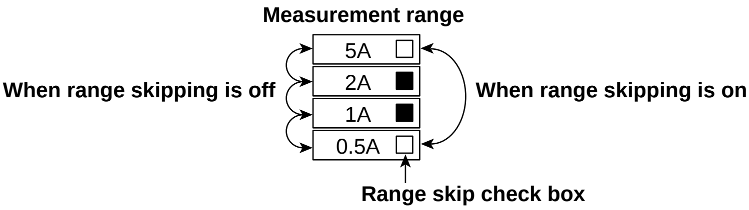
The range is decreased when all of the following conditions are met.

- Crest factor 3
  - Urms or Irms is less than or equal to 30% of the measurement range.
  - Urms or Irms is less than or equal to 125% of the next lower measurement range.
  - Upk or Ipk is less than or equal to 300% of the next lower measurement range.
- Crest factor 6, 6A
  - Urms or Irms is less than or equal to 30% of the measurement range.
  - Urms or Irms is less than or equal to 125% of the next lower measurement range.
  - Upk or Ipk is less than or equal to 600% of the next lower measurement range.

On the WT332E/WT333E, when all the input elements meet all the above conditions, the measurement range is decreased.

## Range Skipping (For procedures, see section 2.6)

You can select which measurement ranges to skip (range configuration). Measurement ranges that are not used are skipped, and this instrument switches between the measurement ranges that you have chosen to enable. For example, when using the auto range feature to measure the current of a device that produces 5 A in operation mode and 500 mA in standby mode, you can configure range skipping so that the 1 A and 2 A ranges are disabled. When you are measuring the current of the device in standby mode in the 500 mA range and the device switches to operation mode, the intermediate 1 A and 2 A ranges are skipped, and the device switches to the 5 A range. Range skipping can reduce the loss of measured data that can occur when ranges are switched one by one.
You can turn range skipping on and off from the display menu of this instrument. You can specify which measurement ranges to skip by sending communication commands through the communication interface or by using WTViewerFreePlus.




### Peak Over Jump

You can set the measurement range to switch to when a peak over-range occurs and the auto range feature is enabled. You can set this feature by sending communication commands through the communication interface or by using WTViewerFreePlus. When this feature is disabled and a peak over-range occurs, this instrument raises the measurement range to the next range that has not been set to be skipped.

## Setting Measurement Ranges (For procedures, see section 2.3)

There are two ways to set measurement ranges.

### Setting Measurement Ranges Using the Measurement Range Menu

The measurement range menu appears when you press VOLTAGE or CURRENT. Set the measurement range using the ▼ and ▲ keys, and then press SET. The measurement range will change, and the measured data display will reappear.

### Setting Measurement Ranges without Displaying the Measurement Range Menu

The measurement range menu does not appear when you press VOLTAGE or CURRENT. You can set the measurement range using the ▼ and ▲ keys.
Press ▼ or ▲ to switch the measurement range. For a fixed period of time, after the current range is displayed, the measured data display will reappear.
There is no need to press SET, so this way of setting the measurement range is convenient in the following situations.

- When you switch the measurement range frequently
- When you want to switch between measurement ranges one by one and check the measured data each time
  Example: When you are searching for a measurement range within which over ranges and peak over-ranges do not occur.

## Power Range

The measurement range (power range) for measuring active power, apparent power, and reactive power is determined as indicated below in accordance with the wiring system, voltage range, and current range. See appendix 3 for specific power range values.

| Wiring System | Power Range |
|---|---|
| 1P2W (single-phase, two-wire) | Voltage range × current range |
| 1P3W (single-phase, three-wire)<br>3P3W (three-phase, three-wire)<br>3V3A (three-voltage, three-current method) | Voltage range × current range × 2 |
| 3P4W (three-phase, four-wire) | Voltage range × current range × 3 |

## External Current Sensor Range (Option; for procedures, see section 2.4)

The output of current sensors that produce voltage, such as shunts and clamps, can be applied to an element's external current sensor input terminal (EXT) and measured.
The auto range feature can be used for this applied voltage as well.

## External Current Sensor Conversion Ratio (Option; for procedures, see section 2.4)

Set the conversion ratio used to measure the signal received by the external current sensor input terminal (EXT) from a current sensor that produces voltage. Set how many millivolts the current sensor transmits when 1 A of current is applied (conversion ratio).
When using a current sensor that produces current, set the conversion ratio as the CT ratio.

# Scaling (For procedures, see section 2.5)

You can set coefficients for when you apply a voltage or current signal from an external voltage transformer[1] or current transformer.[2]

1 VT (voltage transformer)
2 CT (current transformer)

## VT Ratio and CT Ratio

You can set the VT or CT ratio to convert the values in the applied signal and display the voltage or current values or waveform from before the voltage or current transformation.

## Power Coefficient

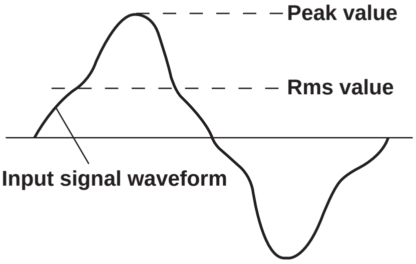
By setting the power coefficient (F), you can display the measured active power, apparent power, and reactive power after they have been multiplied by a coefficient.

| Measurement Function | Data before Transformation | Transformation Result | |
|---|---|---|---|
| Voltage U | $U_2$ (secondary output 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 | $P_2$ | $P_2 \times V \times C \times F$ | F: Power coefficient |
| Apparent power S | $S_2$ | $S_2 \times V \times C \times F$ | |
| Reactive power Q | $Q_2$ | $Q_2 \times V \times C \times F$ | |
| Max./min. voltage Upk | $Upk_2$ (secondary output of the VT) | $Upk_2 \times V$ | |
| Max./min. current Ipk | $Ipk_2$ (secondary output of the CT) | $Ipk_2 \times C$ | |

# Crest Factor (For procedures, see section 2.7)

The crest factor is defined as the ratio of the peak value of the waveform to the rms value. It is also referred to as the peak-to-rms ratio.

$$\text{Crest factor (CF, peak-to-rms ratio)} = \frac{\text{Peak value}}{\text{Rms value}}$$




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

$$\text{Crest factor (CF, peak-to-rms ratio)} = \frac{\text{Peak value that can be input}}{\text{Measurement range}}$$

You can set the crest factor to 3, 6 or 6A. The measurable crest factor is as follows.

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

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

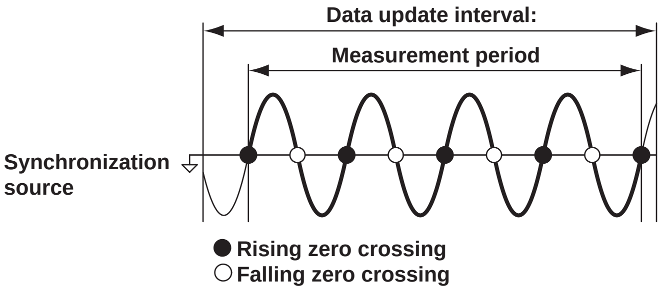
If the crest factor of the input signal is greater than the specifications of this instrument (the crest factor defined at the rated input), you can measure the signal by setting a greater measurement range. For example, even if the crest factor is set to 3, measurement is possible for signals with a crest factor greater than or equal to 5 when the measured value (rms value) is less than 60% of the measurement range. If the minimum effective input (1% of the measurement range) is being applied when the crest factor is set to 3, measurement at a crest factor of 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 7 in the Getting Started Guide, IM WT310E-02EN.

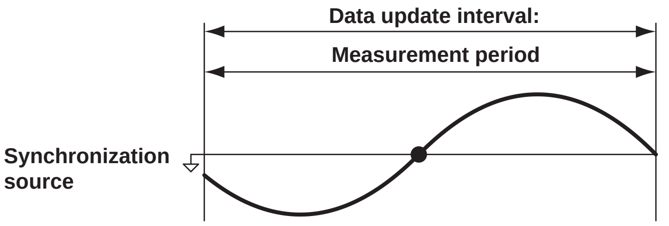
# Measurement Period (For procedures, see section 2.8)

## Measurement Period for Measurement Functions Used in Normal Measurement

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




The measurement period for determining the numeric data of the peak voltage or peak current is always the entire span of the data update interval. Therefore, the measurement period for the following measurement functions, which are determined on the basis of the maximum voltage or current, is also the entire span of the data update interval.

Peak voltage (U+pk/U-pk), peak current (I+pk/I-pk), and peak power (P+pk/P-pk)

For details, see appendix 5.

## Measurement Period for Measurement Functions Used in Harmonic Measurement (Option)

The measurement period extends from the first sample in the data update interval for 1024 points, counted at the harmonic sampling frequency.

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

# Data Update Interval (For procedures, see section 2.10)

The data update interval is the interval at which sampled data is acquired and measurement functions are computed, displayed, transmitted, and output through D/A conversion.

You can select the data update interval from the options below.

0.1 s, 0.25 s, 0.5 s, 1 s, 2 s, 5 s, 10 s, 20 s or Auto

At each data update interval, the numeric data is updated, stored, converted and output as analog signals, and transmitted through the communication interface.

When set to Auto, every time a period of the input waveform specified as the synchronization source is detected, measured data is updated, output as analog signals, and transmitted through the communication interface.

To capture relatively fast load fluctuations in the power system, select a fast data update interval. To capture low frequency signals, select a slow data update interval.

If the fluctuation in the input signal period is large, select Auto.

# Input Filters (For procedures, see section 2.9)

There are two types of input filters: the line filter and the frequency filter.

## 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 appendix 7). When the line filter is turned on, measured values do not contain high frequency components. Thus, the voltage, current, and power of inverter waveforms, distorted waveforms, etc., can be measured with their high frequency components eliminated.

## Frequency Filter

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

# Averaging (For procedures, see section 2.11)

You can take exponential or moving averages of the numeric data. The averaging function is useful when because of large changes in the power or load or a low input signal frequency, the numeric display fluctuates and is difficult to read.

## Turning Averaging On and Off

### Measurement Functions Used in Normal Measurement

You can select whether to average values. When you enable averaging (ON), the AVG indicator illuminates.

### Measurement Functions Used in Harmonic Measurement (Option)

- If averaging is turned on, and the averaging type is EP (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.

## Averaging Types

You can use exponential or moving averages.

### Exponential Averaging

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

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

Dn: Displayed value that has been exponentially averaged n times. (The first displayed value, $D_1$, is equal to $M_1$.)

Dn–1: Displayed value that has been exponentially averaged n–1 times.

Mn: Numeric data at the $n^{th}$ time.

K: Attenuation constant (select from 8, 16, 32, and 64)

### Moving Average

The specified average count is used to compute linear averages according to the equation below.

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

$D_n$: Displayed value of the linear average of m items of numeric data from the n–(m–1)th to the nth time

$M_{n-(m-1)}$: Numeric data at the n–(m–1)th time

………………………………………………

………………………………………………

$M_{n-2}$: Numeric data at the n–2th time

$M_{n-1}$: Numeric data at the n–1th time

$M_n$: Numeric data at the nth time

m: Average count (select 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 the values of measurement functions are determined, see appendix 1 in the Getting Started Guide, IM WT310E-02EN.

### Measurement Functions Used in Normal Measurement

- U, I, P, S, and Q
- λ, Φ, Cf U, and Cf I are computed using the averaged values of Urms, Irms, P, S, and Q.

### Measurement Functions Used in Harmonic Measurement (Option)

- U(k), I(k), and P(k)
- λ(k) and Φ(k) are computed using the averaged values of P(k) and Q(k).
- Uthd, Ithd, Uhdf(k), Ihdf(k), and Phdf(k) are computed using the averaged values of U(k), I(k), and P(k).

k: The harmonic order

Q(k): reactive power of harmonic order k

## Measurement Functions That Are Not Averaged

The following measurement functions are not averaged.

### Measurement Functions Used in Normal Measurement

fU, fI, U+pk, U–pk, I+pk, I–pk, P+pk, P−pk, Time, WP, WP+, WP–, q, q+, and q–

### Measurement Functions Used in Harmonic Measurement (Option)

ΦU(k), ΦI(k), and fPLL

# 1.3 Holding Measured Values and Performing Single Measurements

## Holding Measured Values (HOLD; for procedures, see section 3.1)

You can use the hold operation to stop measuring and displaying the measured data at each data update interval and hold the display of all measurement function data. The D/A output, communication output, and other values reflect the held values.

## Single Measurement (SINGLE; for procedures, see section 3.2)

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

# 1.4 Measuring Power

## Displaying Measured Data (For procedures, see section 4.1 to 4.5)

You can display voltage, current, and power values and other measurement data on the display. The measured data is displayed on four red, high-intensity, 7-segment LED displays. You can observe 4 values at the same time. For information about the measurement function symbols that are displayed and their meanings, see “Items That This Instrument Can Measure.”

## MAX Hold (For procedures, see section 4.6)

You can hold the maximum values of U, I, P, S, Q, U+pk, U-pk, I+pk, I-pk, P+pk, and P-pk. While the MAX hold feature is on, maximum values are held.

## Computation Functions

### Efficiency (Only applies to the WT332E/WT333E; for procedures, see section 4.5)

You can compute the efficiency.

### Crest Factor (For procedures, see section 4.5)

Determines the voltage or current crest factor by dividing the peak value by the rms value.

### Basic Arithmetic (For procedures, see section 4.5)

Displays six types of computed results. (A+B, A–B, A*B, A/B, $A^2$/B, and A/$B^2$)

### Average Active Power during Integration (For procedures, see section 4.5)

You can compute the average active power within the integrated period. This instrument determines the average active power by dividing the watt hour (integrated active power) by the integration time.

# 1.5 Integrated Power (Watt hour)

You can integrate the active power (watt hour) and current (ampere hour).
For information about the measurement function symbols for integrated power (watt hour) and their meanings, see “Items That This Instrument Can Measure.”

## Integration Modes (For procedures, see section 5.2)

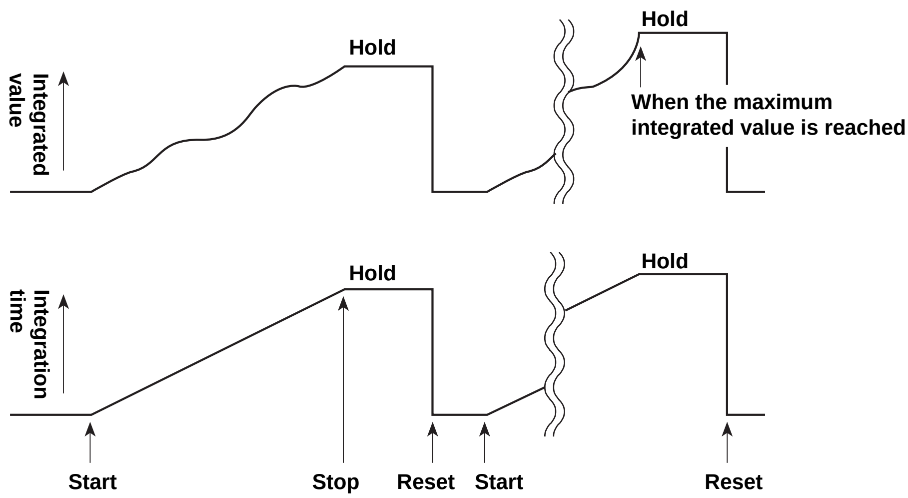
The integration feature has the following three modes.

| Integration Mode | Start | Stop | Repetition |
|---|---|---|---|
| Manual integration mode | Key operation | Key operation | --- |
| Standard integration mode | Key operation | Stopped by the timer | --- |
| Continuous (repetitive) integration mode | Key operation | Key operation | Repeats when the timer expires |

### Manual Integration Mode

When you set the integration mode to standard integration mode (nor) and set the integration timer to 00000:00:00, this instrument performs integration in manual integration mode. When you press START, integration starts, and it continues until you press STOP. However, if either of the conditions below is met, integration is stopped, and the integration time and integrated value are held.

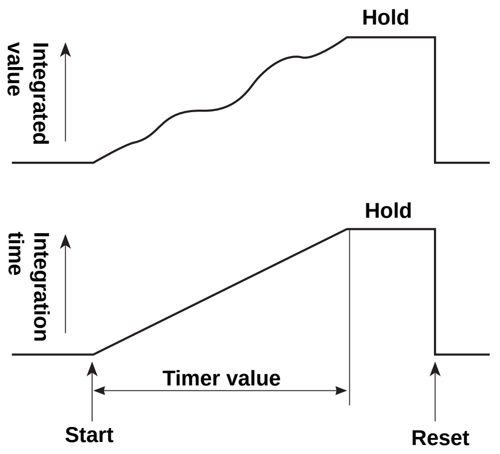
- The integration time reaches the maximum integration time (10000 hours).
- The integrated value reaches its maximum or minimum displayable value.



## Standard Integration Mode

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

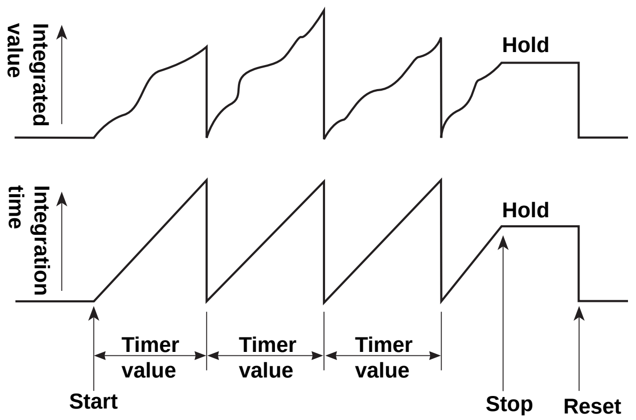
- The specified timer time elapses.
- You press STOP.
- The integrated value reaches its maximum or minimum displayable value.




## Continuous Integration Mode

You can set a relative integration time. Integration starts when you press START. When the specified integration timer time elapses, integration is automatically reset and restarted. Integration repeats until you press Stop. If either of the conditions below is met, integration is stopped, and the integration time and integrated value are held.

- You press STOP.
- The integrated value reaches its maximum or minimum displayable value.




## Integration Methods (Equations)

For information on the equations used for integration, see appendix 1.

# 1.6 Harmonic Measurement (Option)

Using harmonic measurement, you can measure voltage, current, and active power up to the 50th harmonic; the harmonic distortion factor for each harmonic order; and the phase angle of each harmonic order with respect to the fundamental wave (1st harmonic). You can also compute the total rms values (fundamental wave + harmonics) for voltage, current, and active power and the total harmonic distortion (THD).
For a list of the symbols for the measurement functions that can be measured with harmonic measurement and their descriptions, see “Harmonic Measurement Functions” under “Items That This Instrument Can Measure.”

## PLL Source (For procedures, see section 6.3)

For harmonics to be measured, the fundamental period (the period of the fundamental signal) that will be used to analyze the harmonics must be determined. The signal for determining the fundamental period is the PLL (phase locked loop) source. For stable harmonic measurement, use an input signal with low distortion and few fluctuations as the PLL source.
For explanations of the terms fundamental wave, harmonics, harmonic orders, and other terms, see appendix 2.

## Measured Harmonic Order (For procedures, see section 6.3)

You can set the upper limit of measured harmonic order in the range of 2 to 50. However, the range varies depending on the fundamental (1st harmonic) frequency. This is because the upper limit of harmonics that are computed varies depending on the fundamental frequency. The default value is 50.

## Total Harmonic Distortion Equation (For procedures, see section 6.3)

You can select the equation for determining the total harmonic distortion from the options listed below. The following explanations are for when the upper limit of measured harmonic order is 50. If the maximum number of measured harmonic orders is less than 50, the equation will be applied to the harmonic orders up to the specified maximum number.

- IEC: The ratio of the rms value of harmonics 2 to 50 to the rms value of the fundamental wave (1st harmonic) is calculated.
- CSA: The ratio of the rms value of harmonics 2 to 50 to the rms value of harmonics 1 to 50 is calculated.

# 1.7 Storing Measured Data and Saving and Loading Setup Parameters

Measured data and setup parameters are stored in internal memory.

## Storing Measured Data (For procedures, see section 7.1)

All of the data obtained in a single data update interval is stored as a single block. The number of data items varies depending on the number of equipped input elements. As a result, the number of blocks that can be stored varies depending on the device. You cannot load and display stored measurement data on the display of this instrument. You can use communication functions to send stored measurement data to a PC, and you can then view the data on the PC.

## Saving and Loading Setup Parameters (For procedures, see section 7.2)

You can save four sets of setup parameters on this instrument.
You can load saved setup parameters and restore the saved settings.

# 1.8 Communication Functions

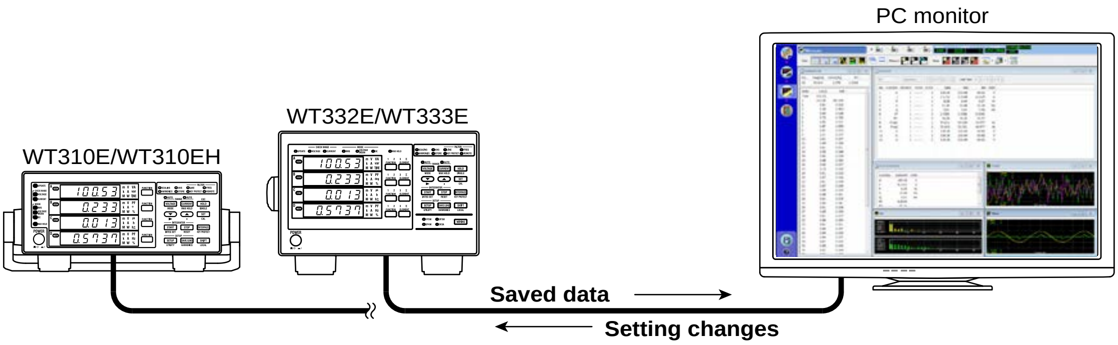
When you connect this instrument to a PC, you can save measured data to the PC and change the settings of this instrument from the PC.

This instrument can be equipped with the following communication interfaces.

- USB
- GP-IB (suffix code: -C1)
- RS-232 (suffix code: -C2)
- Ethernet (suffix code: /C7)

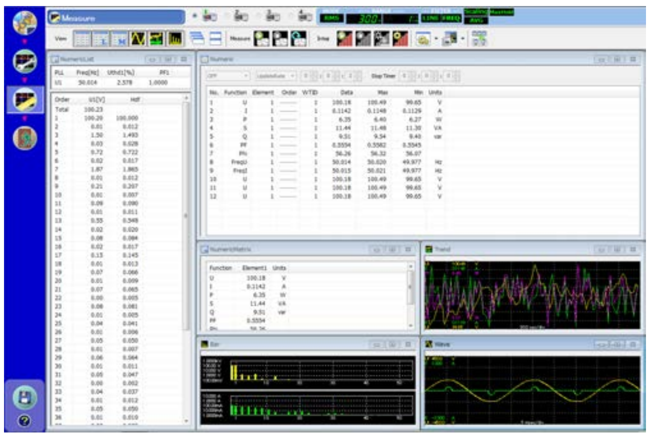
## WTViewerFreePlus

You can use the WTViewerFreePlus application that comes with this instrument to save measured data to a PC and change the settings of this instrument without creating your own communication control programs.




**Example of a window for configuring this instrument**

**Example of a window showing measured data**



# 1.9 Other Features

## Initializing Setup Parameters (For procedures, see section 8.2)

You can use this feature to restore the setup parameters to the factory default settings.

## Zero-Level Compensation (For procedures, see section 8.3)

Zero-level compensation refers to the process wherein this instrument creates a zero input condition in its internal circuitry and sets the zero level to the level at that point. Zero-level compensation must be performed to satisfy the specifications of this instrument. When the measurement range is changed, zero-level compensation is performed automatically. However, if the measurement range is not changed for a long time, the zero level may shift due to environmental changes around the instrument. In this case, you can manually perform zero-level compensation.

## D/A Output (Option; for procedures, see section 8.4)

You can output voltage, current, active power, apparent power, reactive power, power factor, phase angle, frequency, voltage peak, current peak, and integrated values as a ±5 V FS DC voltage. You can output values using 4 output channels on the WT310E/WT310EH and 12 output channels on the WT332E/WT333E.

## Remote Control (Option; for details, see chapter 5 of the Getting Started Guide, IM WT310E-02EN)

On models with the /DA4 or /DA12 option, you can control this instrument using a negative TTL pulse signal and output logic signals.

### External Input

The following five types of control signals are available.

- EXT HOLD
  Holds displayed values or releases the held state.
- EXT TRIG
  Updates the displayed values when they are being held.
- EXT START
  Starts integration.
- EXT STOP
  Stops integration.
- EXT RESET
  Resets the integration result.

### External Output

The following signal is output during integration.

INTEG BUSY

This signal is output continuously from the start to the stop of integration.

## Key Protection (For procedures, see section 8.5)

You can disable all panel keys other than the power switch and the KEY PROTECT switch.

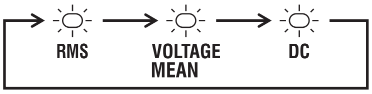
# 2.1 Setting the Measurement Mode



WTViewerFreePlus

## Procedure

Press **SHIFT+VOLTAGE (MODE)** to select the measurement mode.
Each time you press SHIFT+VOLTAGE (MODE), the measurement mode changes in the order shown below.




## Explanation

### Measurement Mode

One of the following measurement modes can be selected for the measurement of voltage and current. The default setting is RMS.

| Indicator | Voltage | Current |
|---|---|---|
| RMS | True rms value | True rms value |
| VOLTAGE MEAN | Rectified mean value calibrated to the rms value | True rms value |
| DC | Linear average | Linear average |

### Theoretical Equations

#### RMS

Select this mode to display the true rms values of the voltage and current.

$$\sqrt{\frac{1}{T}\int_0^T f(t)^2\,dt}$$

**f(t) : Input signal**
**T : One period of the input signal**

#### VOLTAGE MEAN

Select this mode to display the voltage as a rectified mean value calibrated to the rms value. A sine wave is used to calibrate the value to the rms value, so when sine waves are measured, the values obtained in this mode are the same as those obtained in RMS mode. The values differ from those obtained in RMS mode when waves other than sine waves, such as distorted waves and DC waves, are measured.

$$\frac{\pi}{2\sqrt{2}} \cdot \frac{1}{T}\int_0^T |f(t)|\,dt$$

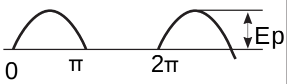
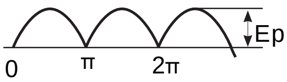
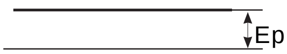
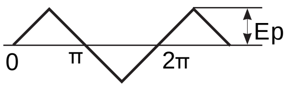
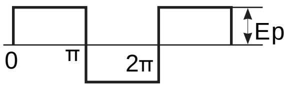
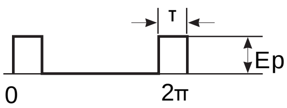
**f(t) : Input signal**
**T : One period of the input signal**

#### DC

Select this mode when the input voltage or current is DC. The input signal is linearly averaged, and the result is displayed.

# Typical Waveform Types and Differences in Measured Values between Measurement Modes

This instrument does not support the rectified mean value measurement mode shown in the table below.

| Name | Measurement Mode / Display / Waveform | Rms Value | Rectified Mean Value | Rectified Mean Value Calibrated to the Rms Value | Linear Average |
|---|---|---|---|---|---|
| | | RMS | — | VOLTAGE MEAN | DC |
| **Sine wave** |   | $\frac{Ep}{\sqrt{2}}$ | $\frac{2}{\pi} \cdot Ep$ | $\frac{Ep}{\sqrt{2}}$ | 0 |
| **Half-wave rectification** |   | $\frac{Ep}{2}$ | $\frac{Ep}{\pi}$ | $\frac{Ep}{2\sqrt{2}}$ | $\frac{Ep}{\pi}$ |
| **Full-wave rectification** |   | $\frac{Ep}{\sqrt{2}}$ | $\frac{2}{\pi} \cdot Ep$ | $\frac{Ep}{\sqrt{2}}$ | $\frac{2}{\pi} \cdot Ep$ |
| **Direct current** |   | Ep | Ep | $\frac{\pi}{2\sqrt{2}} \cdot Ep$ | Ep |
| **Triangular wave** |   | $\frac{Ep}{\sqrt{3}}$ | $\frac{Ep}{2}$ | $\frac{\pi}{4\sqrt{2}} \cdot Ep$ | 0 |
| **Square wave** |   | Ep | Ep | $\frac{\pi}{2\sqrt{2}} \cdot Ep$ | 0 |
| **Pulse** |   | $\sqrt{\frac{\tau}{2\pi}} \cdot Ep$ | $\frac{\tau}{2\pi} \cdot Ep$ | $\frac{\pi\tau}{4\pi\sqrt{2}} \cdot Ep$ | $\frac{\tau}{2\pi} \cdot Ep$ |
| | | When the above is expressed using duty D (= $\frac{\tau}{2\pi}$) | | | |
| | | $\sqrt{D} \cdot Ep$ | $D \cdot Ep$ | $\frac{\pi D}{2\sqrt{2}} \cdot Ep$ | $D \cdot Ep$ |

# 2.2 Configuring the Wiring System Settings (WT332E/WT333E only)

WTViewerFreePlus

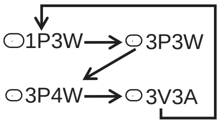


## Procedure

Press **WIRING** to select the wiring system.
Each time you press WIRING, the wiring system changes in the order shown below.
The WT310E and WT310EH only have one input element, so there is no wiring system selection.

**WT332E**
**(2 input elements)**


**WT333E**
**(3 input elements)**




## Explanation

### Wiring System

The wiring systems that you can select vary depending on the model.

#### WT310E and WT310EH

The WT310E and WT310EH are only equipped with one input element. You can measure single-phase, two-wire systems. Because there is only one input element, you cannot select different wiring systems.

#### WT332E (Two Input Element Model)

The WT332E is equipped with two input elements (element 1 and element 3).
On the WT332E, you can select the following wiring systems.

| Wiring System | Description | Elements |
|---|---|---|
| 1P3W | Single-phase, three-wire | Element 1 and element 3. |
| 3P3W | Three-phase, three-wire | Element 1 and element 3. |

The measured data when a single-phase, two-wire system (1P2W) has been specified is the measured data for elements 1 and 3.
The measured data for a single-phase, two-wire system will be measured correctly regardless of which of the above wiring systems you select.

#### WT333E (Three Input Element Model)

The WT333E is equipped with three input elements (element 1, element 2, and element 3). On the WT333E, you can select the following wiring systems.

| Wiring System | Description | Elements |
|---|---|---|
| 1P3W | Single-phase, three-wire | Element 1 and element 3. Element 2 is for a single-phase, two-wire system. |
| 3P3W | Three-phase, three-wire | Element 1 and element 3. Element 2 is for a single-phase, two-wire system. |
| 3P4W | Three-phase, four-wire | Elements 1, 2, and 3. |
| 3V3A | Three-voltage, three-current method | Elements 1, 2, and 3. |

The measured data when a single-phase, two-wire system (1P2W) has been specified is the measured data for elements 1, 2, and 3. The measured data for a single-phase, two-wire system will be measured correctly regardless of which of the above wiring systems you select.

***Note***

- Select a wiring system that matches the connected circuit under measurement. The internal processing of this instrument varies depending on the selected wiring system. If the selected wiring system does not match the actual circuit, measurements and computation will not be correct.
- For the relationship between the wiring systems and the method of determining the measured values or computed values, see page appendix 1.

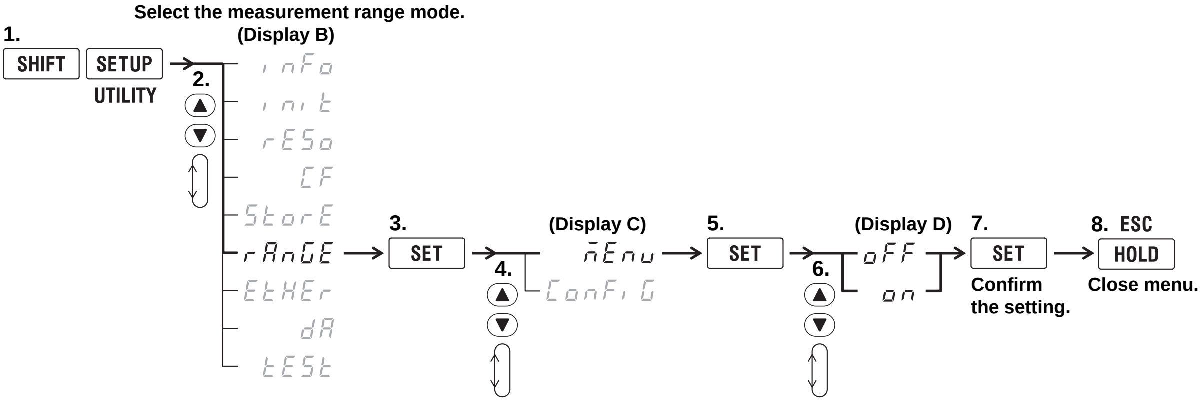
# 2.3 Setting the Measurement Range When Using Direct Input

WTViewerFreePlus

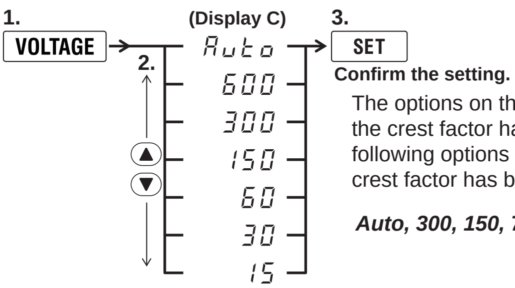
## Procedure

Follow the procedure indicated by the thick lines in the following menu.

### Measurement Range Mode




### Voltage Range in Menu Configuration Mode

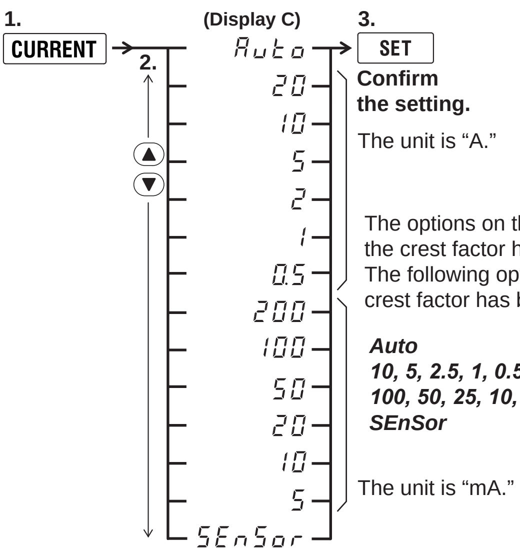



The options on the left appear when the crest factor has been set to 3. The following options appear when the crest factor has been set to 6 or 6A.

***Auto, 300, 150, 75, 30, 15, 7.5***

### Current Range in Menu Configuration Mode

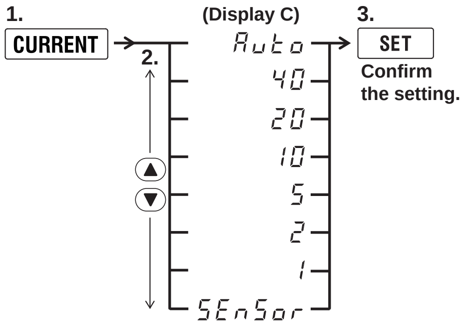
#### WT310E




The options on the left appear when the crest factor has been set to 3. The following options appear when the crest factor has been set to 6 or 6A.

***Auto***
***10, 5, 2.5, 1, 0.5, 0.25 ←A***
***100, 50, 25, 10, 5, 2.5 ←mA***
***SEnSor***

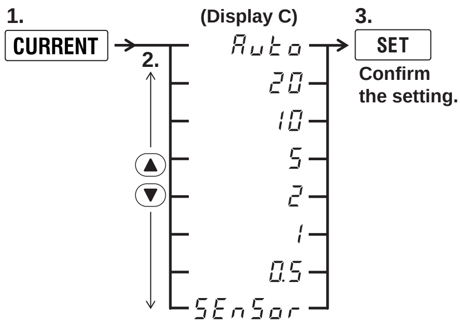
## WT310EH




The above options appear when the crest factor has been set to 3. The following options appear when the crest factor has been set to 6 or 6A.

***Auto, 20, 10, 5, 2.5, 1, 0.5, SEnSor***

## WT332E/WT333E




The above options appear when the crest factor has been set to 3. The following options appear when the crest factor has been set to 6 or 6A.

***Auto, 10, 5, 2.5, 1, 0.5, 0.25, SEnSor***

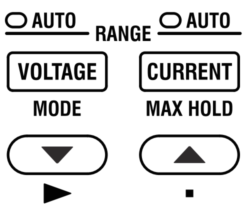
### *Note*

SEnSor only appears when the external current sensor input option is installed. For details about the procedure when selecting SEnSor, see section 2.4.

# Voltage and Current Range in Quick Configuration Mode

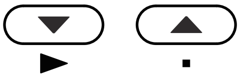
***1.*** Press the **VOLTAGE** or **CURRENT** key.

In quick configuration mode, the VOLTAGE or CURRENT key and the ▼ and ▲ keys illuminate. No display appears on the menu. The currently set range appears temporarily in display B, for the voltage range, or display D, for the current range, and then the measured data reappears.

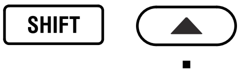


**2.** Use ▲ or ▼ to select the range.

While you are changing the range, the range appears temporarily in display B, for the voltage range, or display D, for the current range.



**3.** Press **SHIFT+▲** (■) to turn the auto range feature on and off.




**4.** Press the **VOLTAGE** or **CURRENT** key to confirm the setting.

The VOLTAGE or CURRENT key light and the ▼ and ▲ key lights turn off.

## Explanation

## Measurement Range Modes

There are two modes for setting the measurement range: menu configuration mode (on) and quick configuration mode (oFF). The default setting is menu configuration mode (on).

### Menu Configuration Mode (on)

A menu for setting the range is displayed. You can select the measurement range in display C. Measured data is not displayed while you are configuring the setting.

### Quick Configuration Mode (oFF)

You can switch the measurement range or enable the auto range feature while displaying the measured data. The settings that you can choose from are the same as those that you can choose from in menu configuration mode. This mode is useful in the following circumstances.

- When you switch the measurement range frequently
- When you want to switch between measurement ranges one by one and check the display in each range (when you are searching for a measurement range within which over ranges and peak over-ranges do not occur)

***Note***

- In quick configuration mode, when you press the VOLTAGE or CURRENT key, the VOLTAGE or CURRENT key and the ▼ and ▲ keys illuminate.
- When you press SETUP or some other menu key in quick configuration mode, quick configuration mode is temporarily disabled. When you return to the display of the measured data, quick setup mode is enabled again.

## Fixed (Manual) Ranges and Auto Range

Set the measurement ranges according to the rms value levels. You can specify fixed measurement ranges or have the ranges set automatically. The default setting is to have the ranges set automatically.

### Fixed Ranges

You can select a fixed voltage range from a list of options. Even if the size of the input signal changes, the selected voltage range will not change. Set the ranges according to the rms values of the input signal.

#### Voltage Ranges

- When the crest factor is 3, you can select 600 V, 300 V, 150 V, 60 V, 30 V, or 15 V.
- When the crest factor is 6 or 6A, you can select 300 V, 150 V, 75V, 30 V, 15V, or 7.5 V.

### Current Range

**WT310E**

- When the crest factor is 3, you can select 20 A, 10 A, 5 A, 2 A, 1 A, 0.5 A, 200 mA, 100 mA, 50 mA, 20 mA, 10 mA, or 5 mA.
- When the crest factor is 6 or 6A, you can select 10 A, 5 A, 2.5 A, 1 A, 0.5 A, 0.25 A, 100 mA, 50 mA, 25 mA, 10 mA, 5 mA, or 2.5 mA.

**WT310EH**

- When the crest factor is 3, you can select 40 A, 20 A, 10 A, 5 A, 2 A, or 1 A.
- When the crest factor is 6 or 6A, you can select 20 A, 10 A, 5 A, 2.5 A, 1 A, or 0.5 A.

**WT332E/WT333E**

- When the crest factor is 3, you can select 20 A, 10 A, 5 A, 2 A, 1 A, or 0.5 A.
- When the crest factor is 6 or 6A, you can select 10 A, 5 A, 2.5 A, 1 A, 0.5 A, or 0.25 A.

***Note***

When the WT310E is measuring using one of the following fixed current ranges and receives excessive input for a given period of time, to protect the input circuit, the WT310E forcefully changes the current range to 1 A (0.5 A if the crest factor is 6 or 6A) and switches from fixed range mode to auto range mode.

- When the crest factor is 3, you can select 200 mA, 100 mA, 50 mA, 20 mA, 10 mA, or 5 mA.
- When the crest factor is 6 or 6A, you can select 100 mA, 50 mA, 25 mA, 10 mA, 5 mA, or 2.5 mA.

## Auto Range (Auto)

This instrument automatically switches the range according to the size of the input signal.

### Range Increase

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

- Crest factor 3
  Urms or Irms exceeds 130% of the measurement range.
  Upk or Ipk exceeds approximately 300% of the currently set measurement range.
- Crest factor 6
  Urms or Irms exceeds 130% of the measurement range.
  Upk or Ipk exceeds approximately 600% of the currently set measurement range.
- Crest factor 6A
  Urms or Irms exceeds 260% of the measurement range.
  Upk or Ipk exceeds approximately 600% of the currently set measurement range.

On the WT332E/WT333E, when any of the equipped input elements meets any of the above conditions, the measurement range is increased.

### Range Decrease

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

- Crest factor 3
  - Urms or Irms is less than or equal to 30% of the measurement range.
  - Urms or Irms is less than or equal to 125% of the next lower measurement range.
  - Upk or Ipk is less than or equal to 300% of the next lower measurement range.
- Crest factor 6 or 6A
  - Urms or Irms is less than or equal to 30% of the measurement range.
  - Urms or Irms is less than or equal to 125% of the next lower measurement range.
  - Upk or Ipk is less than or equal to 600% of the next lower measurement range.

On the WT332E/WT333E, when all the input elements meet all the above conditions, the measurement range is decreased.

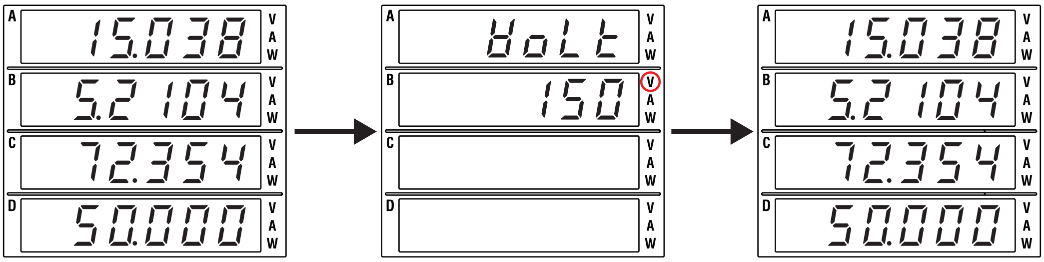
***Note***

When the auto range feature is enabled and an irregular pulse waveform is applied, a steady range may not be maintained. If this occurs, specify a fixed range.

## Checking a Range

To check the currently set range during measurement, press VOLTAGE or CURRENT. The set range will appear on the display.

To return to the measured value display in menu configuration mode, press the same key again. In quick configuration mode, the range is only displayed for the duration of the data update interval before the measured value display is restored.




Measured value display　　　　Measured value display

## Power Range

The measurement range (power range) for measuring active power, apparent power, and reactive power is determined as indicated below in accordance with the wiring system, voltage range, and current range.

| Wiring System | Power Range |
|---|---|
| 1P2W (single-phase, two-wire) | Voltage range × current range |
| 1P3W (single-phase, three-wire) | Voltage range × current range × 2 |
| 3P3W (three-phase, three-wire) | |
| 3V3A (three-voltage, three-current method) | |
| 3P4W (three-phase, four-wire) | Voltage range × current range × 3 |

- The maximum display is 99999 (when the number of displayed digits is set to 5).
- When the result of multiplying the voltage range by the current range reaches or exceeds 1000 W, the unit on the display will change to “kW.” When the result exceeds 1000 kW, the unit on the display will change to “MW.”
- For specific voltage and current range combinations and power range values, see appendix 3.

### *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 measured or computed power value.
- If you open the voltage input terminal, a voltage value of up to 0.3 V may be displayed due to hum noise at the power line frequency of 50 Hz or 60 Hz and other phenomena. This is because of the high input resistance of the voltage input terminal. Shorting the terminal will result in a value of 0 V.

## 2.4 Setting the Measurement Ranges When Using an External Current Sensor (Option)

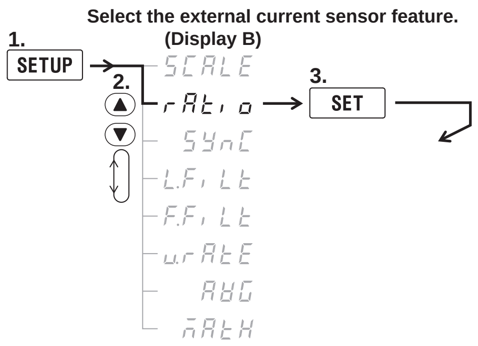
WTViewerFreePlus



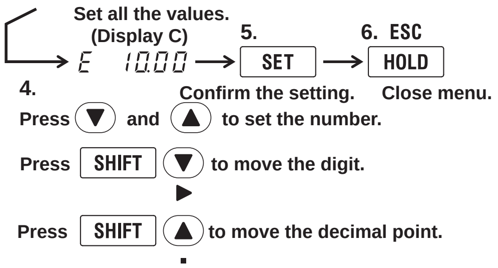
### Procedure

Follow the procedure indicated by the thick lines in the following menu.

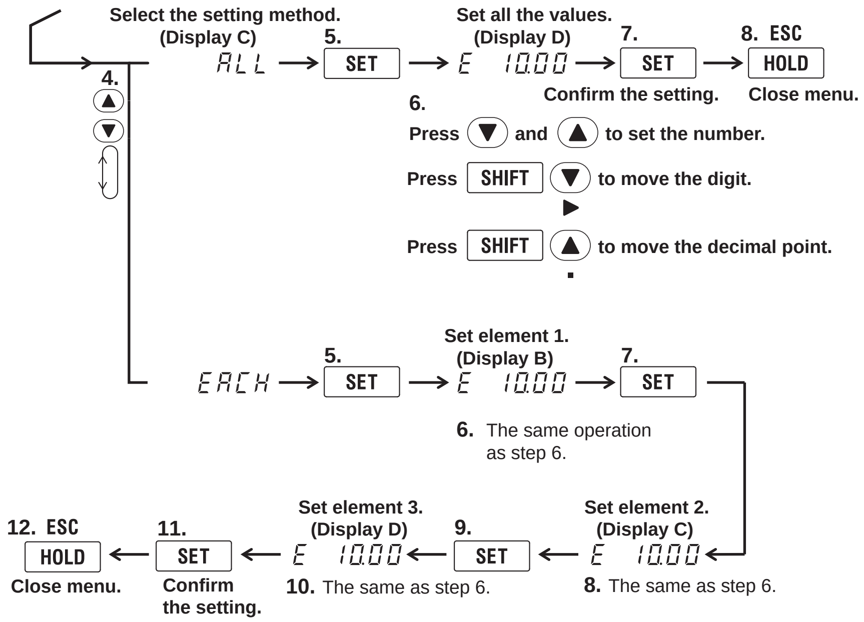
## External Current Sensor Scaling Constant




**On the WT310E/WT310EH**



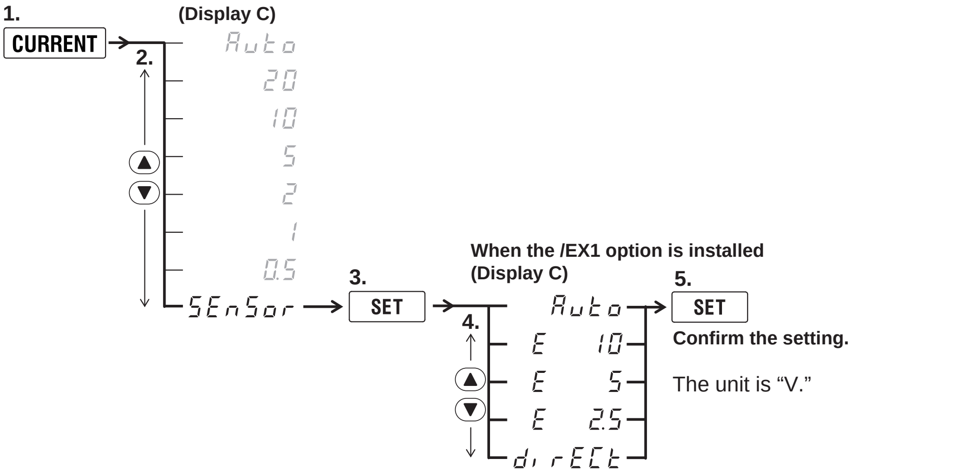

**On the WT332E/WT333E**




### *Note*

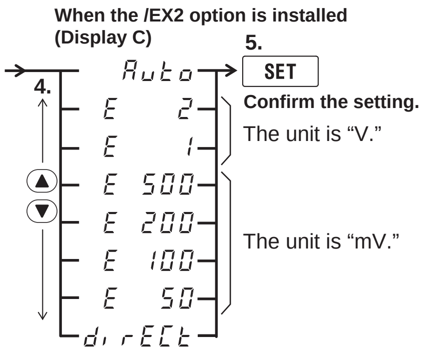
The setting method selection menu (which allows you to select ALL or EACH) will not appear on the WT310E or WT310EH.

# External Current Sensor Measurement Range in Menu Configuration Mode




The above options appear when the crest factor has been set to 3. The following options appear when the crest factor has been set to 6 or 6A.

***Auto, E 5, E 2.5, E 1.25, dirECt***




The above options appear when the crest factor has been set to 3. The following options appear when the crest factor has been set to 6 or 6A.

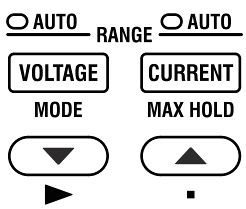
***Auto, E 1, E 0.5, E 250, E 100, E 50, E 25, dirECt***

The above menu is displayed on the WT332E/WT333E.
On the WT310E, SEnSor appears after the 5 mA range.
On the WT310EH, SEnSor appears after the 1 A range.

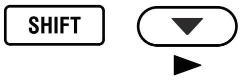
# External Current Sensor Measurement Range in Quick Configuration Mode

***1.*** Press **CURRENT**.

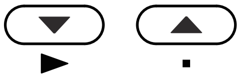
In quick configuration mode, the CURRENT key and the ▼ and ▲ keys illuminate. No display appears on the menu.



*2.* Press **SHIFT+▼(►)** to switch between direct input and external current sensor input.




*3.* Use ▲ or ▼ to select the range.
Display D shows the range temporarily while you are changing it.



*4.* Press **CURRENT** to confirm the setting.
The CURRENT and ▼ and ▲ key lights turn off.

***Note***

For information on how to switch between the menu configuration and quick configuration modes for the menu range, see section 2.3.

## Explanation

### External Current Sensor

The output of current sensors that produce voltage, such as shunts and clamps, can be applied to an element's external current sensor input terminal (EXT) and measured. Set the scaling constant and the measurement range according to the external sensor's conversion ratio before using the external sensor for measurement.

***Note***

When using a current sensor that produces current, set the conversion ratio as the CT ratio.

### External Current Sensor Scaling Constant

The conversion ratio is the number of mV that the external current sensor outputs when a current of 1 A flows through it. Set the scaling constant to the conversion ratio.

#### Determining the Scaling Constant

For example, if you use the Yokogawa 96030 Clamp-on Probe, the conversion ratio is 2.5 mV/A, so when 1 A of current flows through the probe, the current sensor output is 2.5 mV. Set the scaling constant to 2.500.
In the same manner, when you use the 96031, the conversion ratio is 1 mV/A, so set the scaling constant to 1.000.
When you use the 96001, the conversion ratio is 10 mV/A, so set the scaling constant to 10.00.

***Note***

The method of computing the scaling constant will be different if you use this instrument and an external current sensor to replace the WT110, WT110E, WT130, WT200, WT210, or WT230, so you may have to change the scaling constant. Set the scaling constant to the correct value in accordance with the above explanation.

#### Setting All the Values or Individual Values (WT332E/WT333E)

On the WT332E/WT333E0, you can set the method for setting the scaling constant to ALL or EACH. The default setting is ALL. The setting method selection menu will not appear on the WT310E or WT310EH.

- ALL: Select this option to set all the scaling constants of each element to the same value.
- EACH: Select this option to set the scaling constants of each element individually.

### Scaling Constant

The procedure for setting scaling constants varies depending on the setting method that you have selected. You can set a scaling constant to a value between 0.001 and 9999. The default setting is 10.00. On the WT310E and WT310EH, the scaling constant is set in display C.

- When the Setting Method Has Been Set to ALL
  In display D, you can set the scaling constant for all the elements.
- When the Setting Method Has Been Set to EACH
  - In display B, you can set the scaling constant for element 1.
  - In display C, you can set the scaling constant for element 2. The setting menu for element 2 is not displayed on the WT332E.
  - In display D, you can set the scaling constant for element 3.

## External Current Sensor Measurement Range

After you have set the scaling constant, select a measurement range that corresponds to the rated output of the external current sensor. You can also select to enable the auto range feature.
In menu configuration mode, the measurement range is set from the current measurement range setting menu. In quick configuration mode, you can set the measurement range while continuing to display the measured data.
For information about how to select menu configuration mode or quick configuration mode, see section 2.3.

### Selecting a Current Range (External Current Sensor Range)

**Example 1:**

If you are using the 96030 Clamp-on Probe (which has a 2.5 mV/A conversion ratio) to measure a current of 200 A, the output voltage of the probe will be 2.5 mV/A × 200 A = 500 mV.
Therefore, you should set the current range (external current sensor range) this instrument to the 500 mV range that is available when the /EX2 option is installed.

**Example 2:**

If you are using the 96030 Clamp-on Probe (which has a 2.5 mV/A conversion ratio) to measure a current of 60 A, the output voltage of the probe will be 2.5 mV/A × 60 A = 150 mV.
Therefore, you should set the current range (external current sensor range) of this instrument to the 200 mV range that is available when the /EX2 option is installed.

**Example 3:**

If you are using the 96031 Clamp-on Probe (which has a 1 mV/A conversion ratio) to measure a current of 200 A, the output voltage of the probe will be 1 mV/A × 200 A = 200 mV.
Therefore, you should set the current range (external current sensor range) of this instrument to the 200 mV range that is available when the /EX2 option is installed.

**Example 4:**

If you are using the 96001 Clamp-on Probe (which has a 10mV/A conversion ratio) to measure a current of 200 A, the output voltage of the probe will be 10mV/A × 200 A = 2000 mV = 2 V.
Therefore, you should set the current range (external current sensor range) of this instrument to the 2.5 V range that is available when the /EX1 option is installed.

# 2.5 Setting the Scaling Feature When Using a VT or CT

WTViewerFreePlus

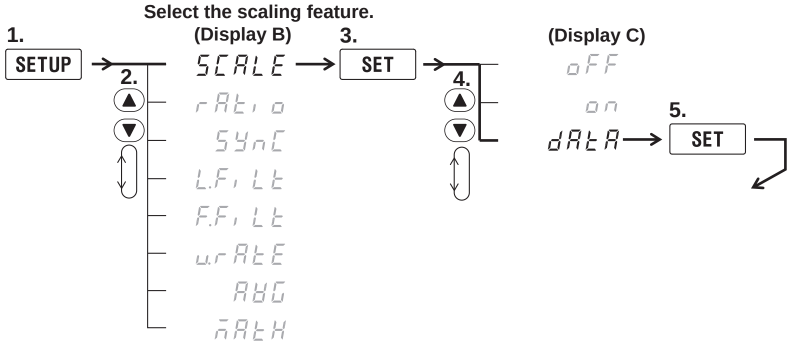
2

Measurement Conditions

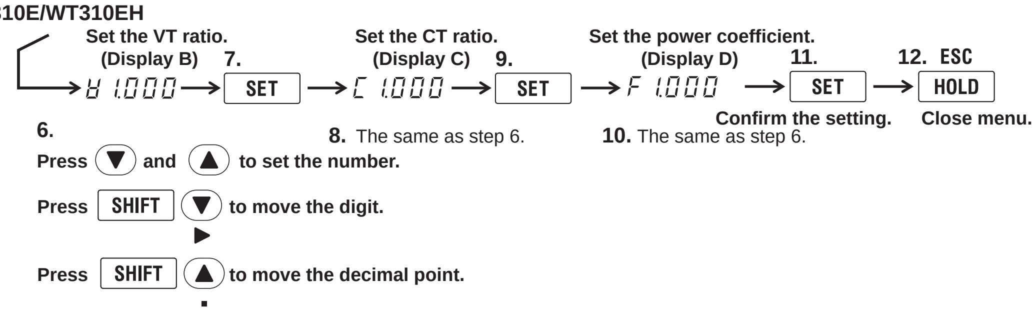
## Procedure

Follow the procedure indicated by the thick lines in the following menu.

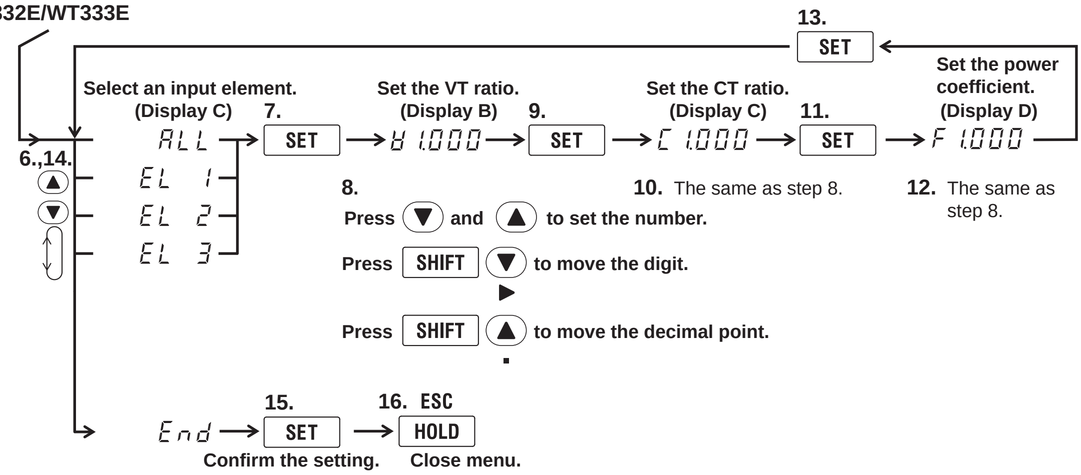
### Scaling Coefficients




On the WT310E/WT310EH



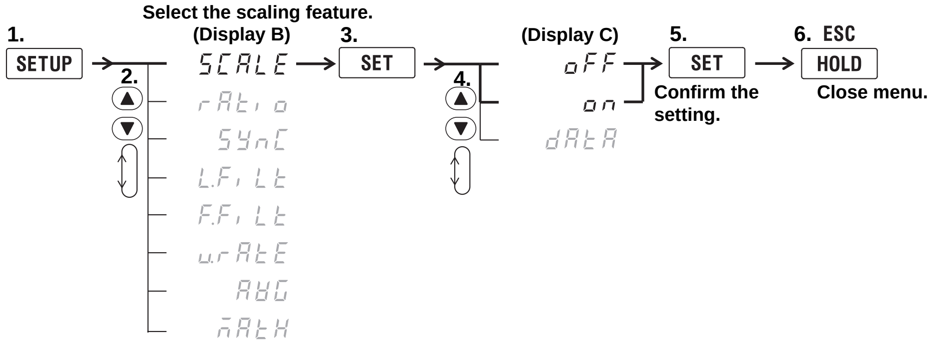

On the WT332E/WT333E




***Note***

The input element selection menu (ALL/EL1/EL2/EL3/End) will not appear on the WT310E or WT310EH.

# Turning Scaling On and Off




## Explanation

# Scaling

You can set coefficients for when you apply a voltage or current signal from an external voltage transformer[1] or current transformer.[2]

The coefficients that you can set using scaling are the VT ratio, CT ratio, and power coefficient (SF).

1 VT (voltage transformer)

2 CT (current transformer)

## VT Ratio and CT Ratio

You can set the VT or CT ratio to convert measured data to numeric data or waveform display data of voltage or current at the point before the voltage or current transformation.

## Power Coefficient

By setting the power coefficient (F), 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 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 | $P_2$ | $P_2 \times V \times C \times F$ | F: Power coefficient |
| Apparent power S | $S_2$ | $S_2 \times V \times C \times F$ | |
| Reactive power Q | $Q_2$ | $Q_2 \times V \times C \times F$ | |
| Max./min. voltage Upk | $Upk_2$ (secondary output of the VT) | $Upk_2 \times V$ | |
| Max./min. current Ipk | $Ipk_2$ (secondary output of the CT) | $Ipk_2 \times C$ | |

# Scaling Coefficient

## Setting All the Coefficients or Individual Coefficients

On the WT332E/WT333E, you can select the elements whose coefficients you want to set. The default setting is ALL. The setting method selection menu will not appear on the WT310E or WT310EH.

- ALL: Select this option to set all the coefficients of each element to the same value.
- EL: Select this option to set the coefficient of element 1.
- EL2: Select this option to set the coefficient of element 2. On the WT332E, this option does not appear.
- EL3: Select this option to set the coefficient of element 3.
- End: Select this option after you have finished configuring the settings or if you have chosen not to change the settings.

### Types of Coefficients and the Order in Which They Are Set

You can set coefficients in the following order. You can set a coefficient to a value between 0.001 and 9999. The default setting is 1.000.

- V: The VT ratio is shown on display B.
- C: The CT ratio is shown on display C.
- F: The power coefficient is shown on display D.

On the WT310E and WT310EH, coefficients are set in the following order: V, C, F. When you have finished setting the coefficients, press SET.

On the WT332E/WT333E, select End in the input element selection menu after you have finished setting the coefficients.

## Turning Scaling On and Off

After you have set the coefficients, select whether to set scaling to on or oFF. The default setting is oFF.

- on: Scaling starts, and the SCALING indicator illuminates.
- oFF: Scaling is stopped. The SCALING indicator turns off.

**Note**

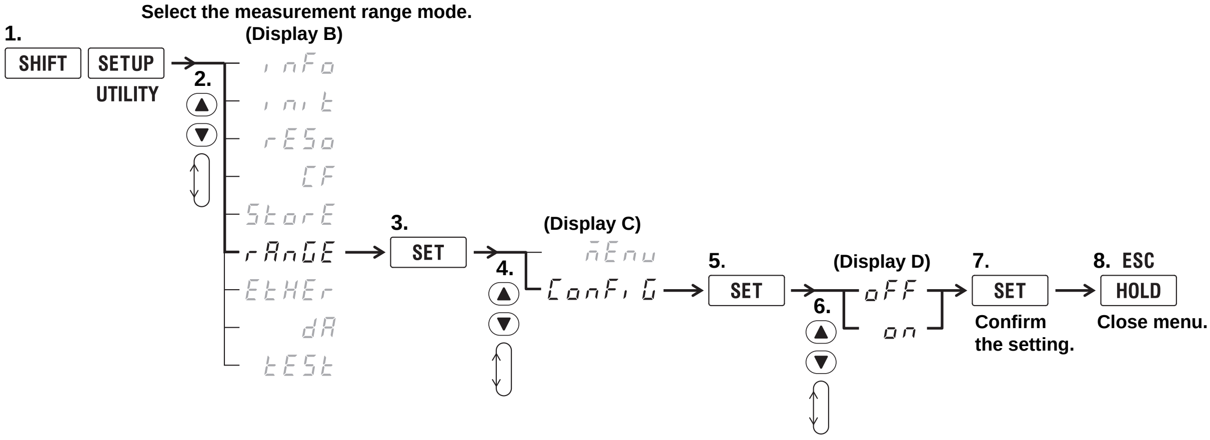
- When the product of the coefficient and the measurement range exceeds 9999 M ($10^6$) , the computation overflow indication (--oF--) appears.
- When you use an external current sensor for measurement and scaling is enabled, the external current sensor's scaling constant is further multiplied by the VT or CT ratio. The scaling constant is different from the scaling feature that is explained in this section. For details, see section 2.4.

# 2.6 Configuring Measurement Range Skipping

WTViewerFreePlus

## Procedure

Follow the procedure indicated by the thick lines in the following menu.




## Explanation

### Turning Measurement Range Skipping On and Off

You can select which measurement ranges to skip (range configuration). When the auto range feature is enabled, measurement ranges that are not used are skipped, and this instrument switches between the measurement ranges that you have chosen to enable. Range skipping can reduce the loss of measured data that can occur when ranges are switched one by one. The default setting is oFF.

- on: Range skipping is enabled.
- oFF: Range skipping is disabled.

### Measurement Ranges That Are Skipped (Range configuration)

You can specify which measurement ranges to skip by sending communication commands through the communication interface. You cannot specify which measurement ranges to skip from the display men of this instrument. For details, see the Communication Interface User's Manual, IM WT310E-17EN. You can also specify which measurement ranges to skip using the WTViewerFreePlus software. When using communication commands, select the enabled measurement ranges, not the ranges to skip.

### Peak Over Jump

In addition to measurement range skipping, you can set the measurement range to switch to when a peak over-range occurs and the auto range feature is enabled. You can set this feature by sending communication commands through the communication interface. You cannot set this feature from the display men of this instrument. For details, see the Communication Interface User's Manual, IM WT310E-17EN. You can also specify which measurement ranges to skip using the WTViewerFreePlus software.

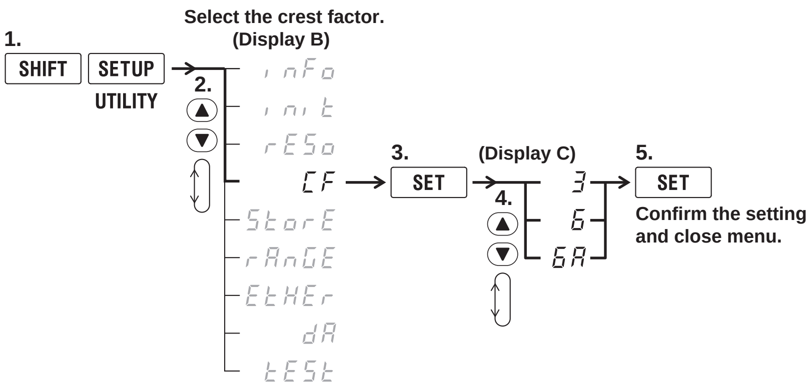
- If set to OFF, the measurement range will increase in order through the enabled measurement ranges when a peak over-range occurs.
- If measurement range skip is set to OFF, peak over jump will also not function.

# 2.7 Setting the Crest Factor

WTViewerFreePlus

## Procedure

Follow the procedure indicated by the thick lines in the following menu.




## Explanation

### Crest Factor

The crest factor is defined as the ratio of the peak value of the waveform to the rms value. It is also referred to as the peak-to-rms ratio.

$$\text{Crest factor (CF, peak-to-rms ratio)} = \frac{\text{Peak value}}{\text{Rms value}}$$

On this instrument, the crest factor indicates the maximum multiple of the measurement range that can be applied as a peak value. The crest factor can be set to 3, 6, or 6A. The default setting is 3.

When the crest factor is set to 6A, the input range of the measurement range is expanded as follows as compared to when the crest factor is set to 6. This is used to suppress frequent range changes when measuring a distorted waveform in auto range mode.

- Condition for increasing the range in auto range mode (for details, see section 2.3).
  The voltage or current exceeds 260% of the currently set measurement range.
- Condition that cause an over-range indication (“- - - o L -”) (for details, see section 7.4 in the Getting Started Guide, IM WT310E-02EN)
  The measured voltage or current exceeds 280%* of its rated range.
  * 220% for the maximum range (20 A range for crest factor 6) on the WT310EH

**Note**

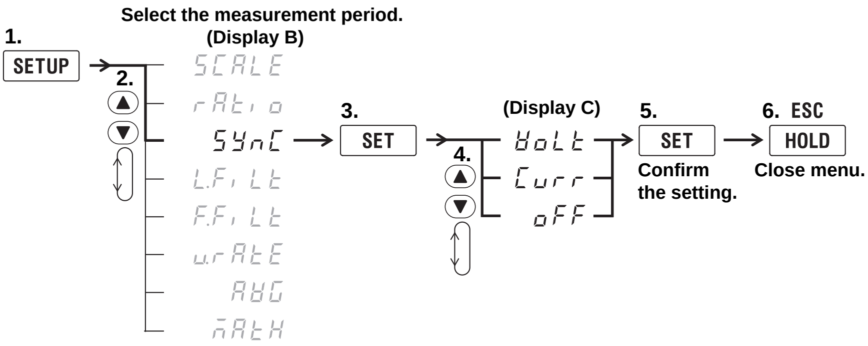
- When you set the crest factor and are using fixed ranges, the voltage and current ranges are set to their maximum values.
- If you set the crest factor when auto range is in use, the voltage and current ranges are set to their maximum ranges, and then auto range is applied.
- Set the crest factor to six to meet the measurement condition of a crest factor of 5 or greater, which is required by IEC62018, etc.
- The voltage range, current range, effective input range, and measurement accuracy vary depending on the crest factor value. For details, see chapter 7 in the Getting Started Guide, IM WT310E-02EN.

# 2.8 Setting the Measurement Period

WTViewerFreePlus

## Procedure

Follow the procedure indicated by the thick lines in the following menu.




## Explanation

### Measurement Period

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

### Synchronization Source

Because the periods of input signal are detected from both voltage and current signals, you can set the synchronization source to a voltage signal (VoLt) or a current signal (Curr). The default setting is VoLt for the WT310E and WT310EH and Curr for the WT332E/WT333E.

- VoLt
  Priority is given to the detection of the period of the voltage signal, and the voltage signal is used as the synchronization source. The voltage signal of each element is used as the synchronization source for the element. When the period of the voltage signal cannot be detected, the current signal is used as the synchronization source. When the period of the current signal cannot be detected either, the measurement period is set to the entire duration of the data update interval.
- Curr
  Priority is given to the detection of the period of the current signal, and the current signal is used as the synchronization source. The current signal of each element is used as the synchronization source for the element. When the period of the current signal cannot be detected, the voltage signal is used as the synchronization source. When the period of the voltage signal cannot be detected either, the measurement period is set to the entire duration of the data update interval.
- oFF
  Measurement is not performed in sync with the voltage or current signal. Instead, the measurement period is set to the entire duration of the data update interval.

**Note**

- The measurement period for determining the numeric data of the peak voltage or peak current (peak values) is always the entire span of the data update interval.
- For details about setting the measurement period, see appendix 4.
- When the data update interval (see section 2.10) is set to Auto, the measurement period is determined by the synchronization source set from the menu described in section 2.10.
- For information about the measurement period for measurement functions used in harmonic measurement (option), see section 6.3.

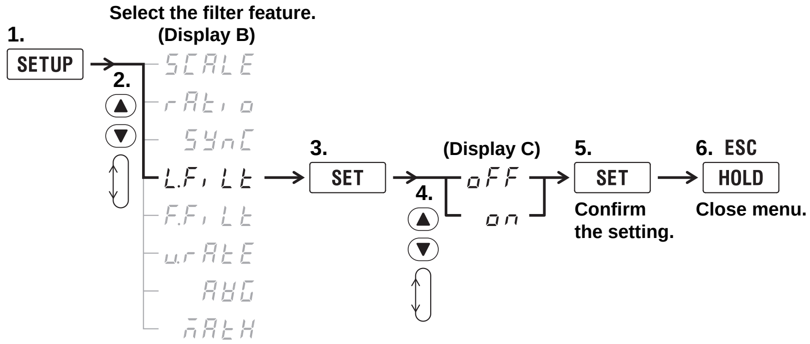
# 2.9 Configuring the Input Filters

WTViewerFreePlus

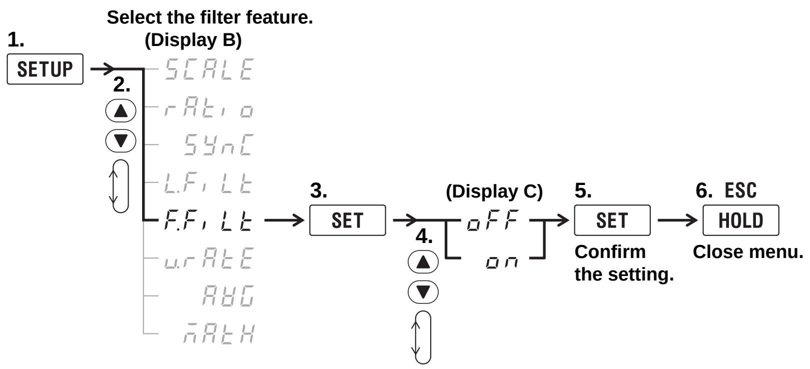
## Procedure

Follow the procedure indicated by the thick lines in the following menu.

### Turning the Line Filter On or Off




### Turning the Frequency Filter On or Off




## Explanation

There are two types of input filters: the line filter and the frequency filter. You can use these filters to eliminate the noise of inverter waveforms, distorted waveforms, and the like, and acquire stable measured values.

### Line Filter

The line filter is only applied to the measurement circuit. The line filter removes noise components from the input signal. The cutoff frequency is 500 Hz. The default setting is oFF.

- on: The line filter is enabled and the LINE indicator illuminates.
- oFF: The line filter is disabled. The LINE indicator turns off.

## Frequency Filter

This filter is only applied to the frequency measurement circuit. The cutoff frequency is 500 Hz.
Because this instrument makes measurements in sync with the input signal, the frequency of the input signal must be measured correctly. The default setting is oFF.

- on: The frequency filter is enabled and the FREQ indicator illuminates.
- oFF: The frequency filter is disabled. The FREQ indicator turns off.

Even if you enable the frequency filter, the measured voltage and current values will include harmonic components.

***Note***

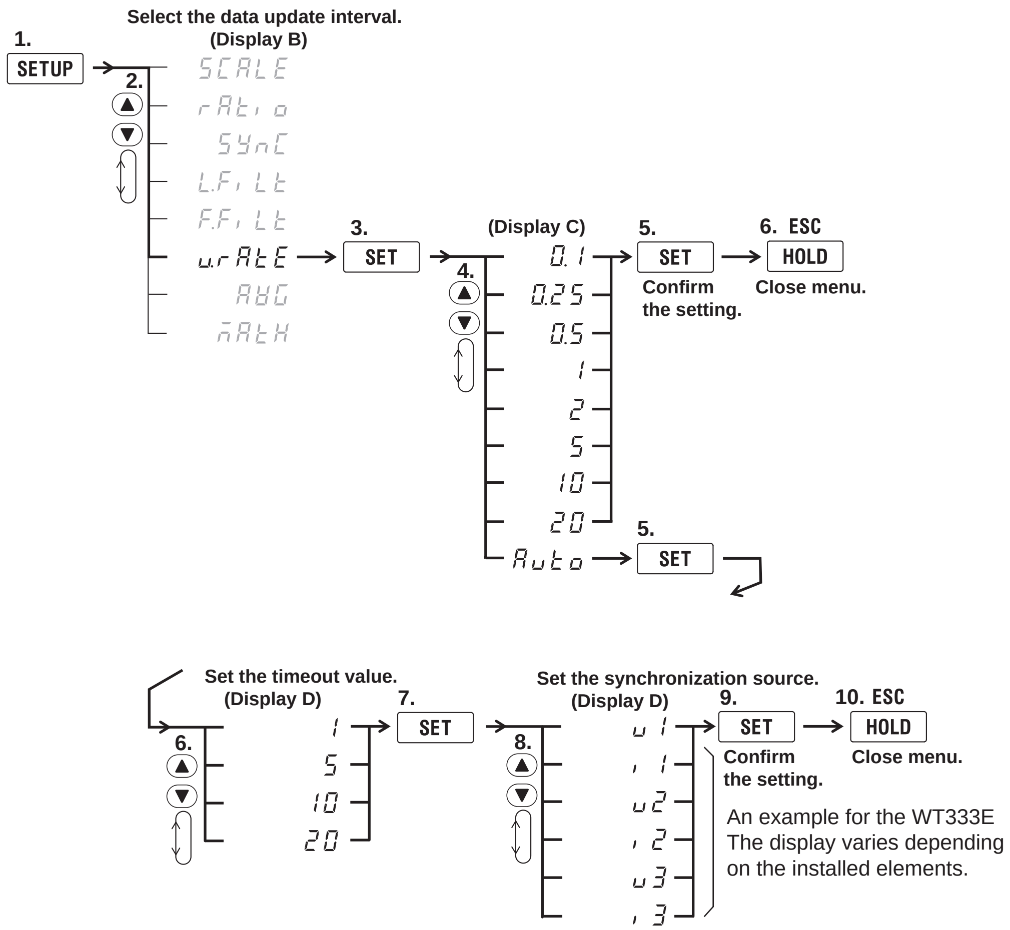
You cannot enable or disable input filters between the time when integration is started and the time when it is stopped and reset.

# 2.10 Setting the Data Update Interval

WTViewerFreePlus

## Procedure

Follow the procedure indicated by the thick lines in the following menu.




## Explanation

### Data Update Interval

The data update interval is the period at which sampling data for determining measurement functions is acquired.

You can select the data update interval from the options below. The default setting is 0.25 s.

0.1 s, 0.25 s, 0.5 s, 1 s, 2 s, 5 s, 10 s, 20 s or Auto

- At each data update interval, the numeric data is updated, stored, converted, and output as analog signals, and transmitted through the communication interface.
- The UPDATE indicator blinks in sync with the selected interval.
- When set to Auto, every time a period* of the input waveform specified as the synchronization source (described later) is detected, the UPDATE indicator blinks, measured data is updated, output as analog signals, and transmitted through the communication interface.
  * 100 ms or more.
- To capture relatively fast load fluctuations in the power system, select a fast data update interval. To capture low frequency signals, select a slow data update interval.
- If the fluctuation in the input signal period is large, select Auto.

## Configuration When the Data Update Interval Is Auto

Set the following items.

### Synchronization Source

- The synchronization source that you will set in this section is a special synchronization source that is used only when the data update interval is Auto is used.*
  * For details on synchronization sources, see section 2.8.
- You can select the synchronization source from the options listed below. The default value is U1 for the WT310E/WT310EH and I1 for the WT332E/WT333E.
  - U1: The synchronization source is set to the voltage of element 1.
  - I1: The synchronization source is set to the current of element 1.
  - U2: The synchronization source is set to the voltage of element 2. (WT333E only)
  - I2: The synchronization source is set to the current of element 2. (WT333E only)
  - U3: The synchronization source is set to the voltage of element 3. (WT332E and WT333E)
  - I3: The synchronization source is set to the current of element 3. (WT332E and WT333E)

### Timeout

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

### Functional Limitations

The following limitations apply when the data update interval is set to Auto.

- The integration function cannot be used. If you try to start it, error 886 will occur.
- The measurement data storage function cannot be used. If you try to start it, error 886 will occur.

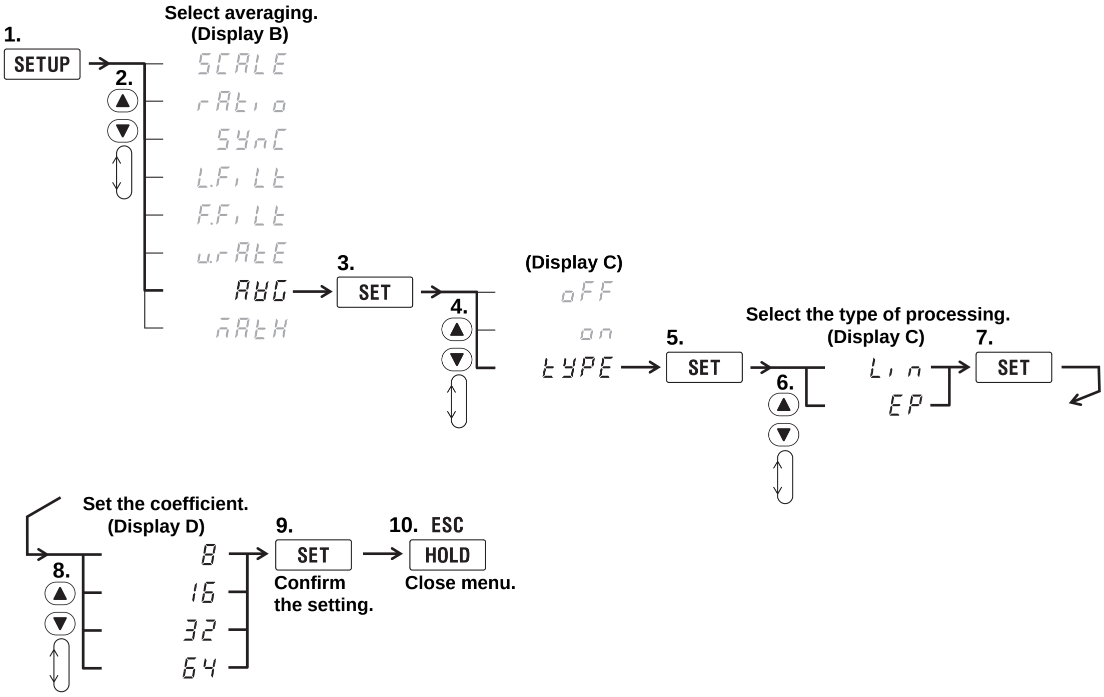
# 2.11 Setting Averaging

WTViewerFreePlus

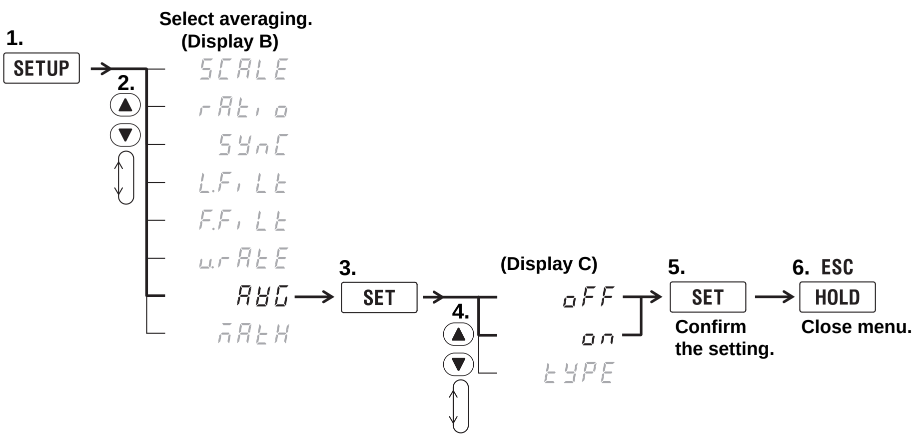
## Procedure

Follow the procedure indicated by the thick lines in the following menu.

### Averaging Type




### Turning Averaging On and Off



# Explanation

## Averaging

You can take exponential or moving averages of the numeric data. The averaging function is useful when because of large changes in the power or load or a low input signal frequency, the numeric display fluctuates and is difficult to read.

### 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.

- U, I, P, S, and Q
- λ, Φ, Cf U, and Cf I are computed using the averaged values of Urms, Irms, P, S, and Q.

### Measurement Functions That Are Not Averaged

Measurement functions that would lose their meaning if they were averaged, such as the peak values (Upk and Ipk), are not averaged.

- fU, fI, U+pk, U–pk, I+pk, I–pk, P+pk, P−pk, Time, WP, WP+, WP–, q, q+, and q-

## Averaging Type

You can use exponential (EP) or moving (Lin) averages. The default setting is Lin.

### Exponential Averaging (EP)

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

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

$D_n$: Displayed value that has been exponentially averaged n times. (The first displayed value, $D_1$, is equal to $M_1$.)

$D_{n-1}$: Displayed value that has been exponentially averaged n–1 times.

$M_n$: Numeric data at the nth time

K: Attenuation constant

### Moving Average (Lin)

The specified average count is used to compute linear averages according to the equation below.

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

$D_n$: Displayed value of the linear average of a total of m items of numeric data from the n–(m–1)$^{th}$ to the n$^{th}$ time

$M_{n-(m-1)}$: Numeric data at the n–(m–1)$^{th}$ time

………………………………………………

………………………………………………

$M_{n-2}$: Numeric data at the n–2$^{th}$ time

$M_{n-1}$: Numeric data at the n–1$^{th}$ time

$M_n$: Numeric data at the n$^{th}$ time

m: Average count

## Averaging Coefficient (Attenuation Constant or Average Count)

You can select the attenuation constant (for exponential averages) or average count (for moving averages) from the following options. The default setting for both values is 8.
8, 16, 32, and 64

***Note***

You can set separate averaging coefficients for exponential averages and moving averages.

## Turning Averaging On and Off

After you set the averaging coefficient (the attenuation constant or average count), select whether to set averaging to on or oFF. The default setting is oFF.

- on: Averaging starts, and the AVG indicator illuminates.
- oFF: Averaging is stopped. The AVG indicator turns off.

***Note***

- When you start integration, averaging is disabled. Even after integration stops and is reset, averaging is not enabled again.
- In harmonic measurement, only exponential averaging is available. For details, see section 6.1.

# 3.1 Holding Measured Values

WTViewerFreePlus

## Procedure

### Holding Measured Values

Press **HOLD**. The HOLD key illuminates, and the display of the measured values is held.

HOLD

### Releasing the Held State

Press **HOLD** when the measured values are being held. The hold key light will turn off and the display will be updated.

HOLD

## Explanation

### Hold

You can use the hold operation to stop measuring and displaying the measured data at each data update interval and hold the display of all measurement function data. The D/A output, communication output, and other values reflect the held values.

***Note***

For information about holding during integration, see section 5.1.

# 3.2 Performing Single Measurements

WTViewerFreePlus

## Procedure

### Single Measurement

Press **SHIFT+HOLD** (SINGLE) when the measured values are being held. A single measurement is performed, and then this instrument holds the measured values.

SHIFT HOLD
SINGLE

## Explanation

### Single Measurement

While the display is held, measurement is performed once. After the measured data is updated, the display is re-held. If you press SHIFT+HOLD (SINGLE) when the display is not held, measurement restarts from that point.

Holding the SHIFT key for at least two seconds makes the shifted state continuous (SHIFT lock feature). If you plan on performing single measurements frequently, you can enable the SHIFT lock and perform single measurements just by pressing HOLD. To disable the SHIFT lock, press SHIFT.

# 4.1 Displaying Voltages, Currents, and Active Powers

**WTViewerFreePlus**

## Procedure

### Displayed Function

Press **FUNCTION** to select V (voltage), A (current), or W (active power).
Each time you press FUNCTION, the displayed function changes in the order shown below.

**Display**

A: V → A → W → VA → var → TIME → (back to V)

B: V → A → W → PF → ° → (back to V)

C: V → A → W → Vpk(+) → Vpk(-) → Apk(+) → Apk(-) → Wpk(+) → Wpk(-) → Wh → Wh±(+) → Wh±(-) → Ah → Ah±(+) → Ah±(-) → MATH → (back to V)

D: V → A → W → PF → VHz → AHz → THD V% → THD A% → (back to V)

- Vpk, Apk, Wpk, Wh±, and Ah± all illuminate twice. The first time is for the positive measurements and the second time is for the negative measurements.
- The MATH and THD indications are on the left side of the 7-segment LED display.
- Press SHIFT before pressing FUNCTION to change the displayed function in reverse order.

### Input Element (WT332E/WT333E only)

Press **ELEMENT** to select which element to display.
Each time you press ELEMENT, the input element changes in the order shown below.
The WT310E and WT310EH only have one input element, so there is no input element selection.

**WT332E (2 input elements)**: 1 → 3 → Σ → (back to 1)

**WT333E (3 input elements)**: 1 → 2 → 3 → Σ → (back to 1)

## Explanation

### Displayed Function

Select which measurement function to show on the display.

- V: Voltage U is displayed.
- A: Current I is displayed.
- W: Active power P is displayed.

## Continuous Maximum Allowable Input

### Voltage

Peak voltage of 1.5 kV or rms value of 1.0 kV, whichever is less.

### Current

#### Direct Input

- **WT310E/WT332E/WT333E**

  When the crest factor is 3: 0.5 A to 20 A
  When the crest factor is 6 or 6A: 0.25 A to 10 A
  Peak value of 100 A or rms value of 30 A, whichever is less.

- **WT310E**

  When the crest factor is 3: 5 mA to 200 mA
  When the crest factor is 6 or 6A: 2.5 mA to 100 mA
  Peak value of 30 A or rms value of 20 A, whichever is less.

- **WT310EH**

  When the crest factor is 3: 1 A to 40 A
  When the crest factor is 6 or 6A: 0.5 A to 20 A
  Peak value of 100 A or rms value of 44 A, whichever is less.

#### External Current Sensor Input

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

## Maximum Displayed Value, Units, and Unit Prefixes

- Maximum displayed value: 99999 for voltage, current, and active power (when the number of displayed digits is set to 5)
- Units: V for voltage, A for current, and W for active power
- Unit prefix: m, k, or M

# Input Element (WT332E/WT333E only)

The elements that you can select vary depending on the model. Check the model when selecting elements.

- 1, 2, or 3: Display the measured values of element 1, 2, or 3.
- Σ: The displayed values vary as indicated below depending on the displayed function and the wiring system.

| Wiring System | UΣ | IΣ | PΣ | SΣ | QΣ |
|---|---|---|---|---|---|
| 1P3W | $\frac{U_1+U_3}{2}$ | $\frac{I_1+I_3}{2}$ | $P_1+P_3$ | $U_1I_1+U_3I_3$ | $Q_1+Q_3$ |
| 3P3W | $\frac{U_1+U_3}{2}$ | $\frac{I_1+I_3}{2}$ | $P_1+P_3$ | $\frac{\sqrt{3}}{2}(U_1I_1+U_3I_3)$ | $Q_1+Q_3$ |
| 3P4W | $\frac{U_1+U_2+U_3}{3}$ | $\frac{I_1+I_2+I_3}{3}$ | $P_1+P_2+P_3$ | $U_1I_1+U_2I_2+U_3I_3$ | $Q_1+Q_2+Q_3$ |
| 3V3A | $\frac{U_1+U_2+U_3}{3}$ | $\frac{I_1+I_2+I_3}{3}$ | $P_1+P_3$ | $\frac{\sqrt{3}}{3}(U_1I_1+U_2I_2+U_3I_3)$ | $Q_1+Q_3$ |

| Wiring System | λΣ | ΦΣ |
|---|---|---|
| 1P3W<br>3P3W<br>3P4W<br>3V3A | $\frac{P\Sigma}{S\Sigma}$ | $\cos^{-1}\lambda\Sigma$ |

# 4.2 Displaying Apparent Powers, Reactive Powers, and Power Factors

WTViewerFreePlus

## Procedure

### Displayed Function

Press the **FUNCTION** key for display A, B, or D to select VA (apparent power), var (reactive power), or PF (power factor).

Each time you press FUNCTION, the displayed function changes in the order shown below.

**Display**

A → V → A → W → VA → var → TIME ─┐ (returns to V)

B → V → A → W → PF → ° ─┐ (returns to V)

D → V → A → W → PF → VHz → AHz → THD V% → THD A% ─┐ (returns to V)

- The THD indicator is on the left side of the 7-segment LED display.
- Press SHIFT before pressing FUNCTION to change the displayed function in reverse order.

### Input Element (WT332E/WT333E only)

Press the **ELEMENT** key of the display that you selected the display function for (display A, B, or D), and then select an input element.

The procedure for selecting an input element is the same as the procedure in section 4.1.

The WT310E and WT310EH only have one input element, so there is no input element selection.

## Explanation

### Displayed Function

Select which measurement function to show on the display.

- VA: Apparent power S is displayed.
- var: Reactive power Q is displayed.
- PF: Power factor λ is displayed.

#### Maximum Displayed Value, Units, and Unit Prefixes

- Maximum displayed apparent power and reactive power: 99999 (when the number of displayed digits is set to 5)
- Power factor display range: –1.0000 to 1.0000 (when the number of displayed digits is set to 5)
- Units: VA for apparent power, var for reactive power, and no unit for power factors
- Unit prefix: m, k, or M

## Input Element (WT332E/WT333E only)

The elements that you can select vary depending on the model. Check the model when selecting elements.

- 1, 2, or 3: Display the measured values of element 1, 2, or 3.
- Σ: See section 4.1.

### Note

- A power factor of 1.0001 to 2.0000 is displayed as 1.0000. A power factor of 2.0001 or greater is displayed as an error (“Error”). A power factor of –2.0000 to –1.0001 is displayed as –1.0000. A power factor of –2.0001 or less is displayed as an error (“Error”).
- Even when the input signal is the same, the display may change if you change the measurement mode (RMS, VOLTAGE MEAN, or DC). For details on measurement modes, see section 2.1.
- When either the voltage or current falls to 0.5% or less (1% or less if the crest factor is set to 6 or 6A) of the measurement range, the power factor will be displayed as an error (“Error”).

# 4.3 Displaying Phase Angles and Frequencies

WTViewerFreePlus

## Procedure

### Displayed Function

Press the **FUNCTION** key for display B or D to select ° (phase angle), V Hz (voltage frequency), or A Hz (current frequency).
Each time you press FUNCTION, the displayed function changes in the order shown below.

**Display**

B → V → A → W → PF → ° →

D → V → A → W → PF → VHz → AHz → THD V% → THD A% →

- The THD indicator is on the left side of the 7-segment LED display.
- Press SHIFT before pressing FUNCTION to change the displayed function in reverse order.

### Input Element (WT332E/WT333E only)

Press the **ELEMENT** key of the display that you selected the display function for (display B or D), and then select an input element.
The procedure for selecting an input element is the same as the procedure in section 4.1.
The WT310E and WT310EH only have one input element, so there is no input element selection.

## Explanation

### Displayed Function

Select which measurement function to show on the display.

- °: Phase angle Φ is displayed.
- V Hz: Voltage frequency fU is displayed.
- A Hz: Current frequency fI is displayed.

#### Maximum Displayed Value, Units, and Unit Prefixes

- Phase angle display range: G180.0 to d180.0 (G is the lag and d is the lead)
- Maximum displayed frequency: 99999 (when the number of displayed digits is set to 5)
- Units: ° for phase angles and Hz for frequency
- Unit prefix: m or k (only for frequencies)

## Frequency Measurement Ranges

- The measurement range varies as shown below depending on the data update interval (see section 2.10).

| Data Update Interval | Measurement Range |
|---|---|
| 0.1 s | 20 Hz to 100 kHz |
| 0.25 s | 10 Hz to 100 kHz |
| 0.5 s | 5 Hz to 100 kHz |
| 1 s | 2.0 Hz to 100 kHz |
| 2 s | 1.0 Hz to 100 kHz |
| 5 s | 0.5 Hz to 100 kHz |
| 10 s | 0.2 Hz to 100 kHz |
| 20 s | 0.1 Hz to 100 kHz |
| Auto* | 0.1 Hz to 100 kHz |

* If the data update interval is set to Auto, the lowest measurable frequency is as follows depending on the timeout setting (see section 2.10).

| TImeout | Lower Frequency Limit |
|---|---|
| 1 s | 2.0 Hz |
| 5 s | 0.5 Hz |
| 10 s | 0.2 Hz |
| 20 s | 0.1 Hz |

- This instrument automatically switches between the following six measurement ranges: 1 Hz, 10 Hz, 100 Hz, 1 kHz, 10 kHz, and 100 kHz.
- The WT332E/WT333E simultaneously measures the voltage frequency and the current frequency of the element selected in display D.

## Input Element (WT332E/WT333E only)

The elements that you can select vary depending on the model. Check the model when selecting elements.

- 1, 2, or 3: Display the measured values of element 1, 2, or 3.
- Σ: For the display when the phase angle is being measured, see section 4.1. When the frequency is being measured, hyphens (------) are displayed instead of measured values.

### Note

**Phase Angle**

- Even when the input signal is the same, the display may change if you change the measurement mode (RMS, VOLTAGE MEAN, or DC). For details on measurement modes, see section 2.1.
- When either the voltage or current falls to 0.5% or less (1% or less if the crest factor is set to 6 or 6A) of the measurement range, the phase angle will be displayed as an error (“Error”).
- A proper distinction between phase lag and lead can only be made when both the voltage and current are sine waves and the ratios of the voltage and current input to the measurement range are not significantly different.
- When the power factor is greater than 1, the phase angle is displayed as follows.
  - When the power factor is between 1.0001 and 2.0000, the phase angle is displayed as 0.0.
  - When the power factor is between –1.0001 and –2.0000, the phase angle is displayed as 180.0.
  - When the power factor is greater than or equal to 2.0001 or less than or equal to –2.0001, the phase angle is displayed as “Error.”

**Frequency**

- The period cannot be detected if the AC amplitude is small. For information on the detectable frequency levels, see the conditions listed under “Accuracy” under “Frequency Measurement” in chapter 7, “Features,” in the Getting Started Guide, IM WT310E-02EN.
- This instrument measures the frequency by synchronizing with the cycle of the input signal. We recommend that you enable the frequency filter when measuring an inverted waveform or a waveform with a high noise level. However, depending on the signal’s frequency and level, the frequency may be displayed as “Error.” This is because the filter, which has a cutoff frequency of 500 Hz, may attenuate the signal to a level at which no input signal is recognized.
- Even when the frequency filter is disabled, the frequency may be displayed as “Error” if the frequency is greater than the measurement range and the internal circuit attenuates the signal to a level at which no input signal is recognized.

# 4.4 Displaying Peak Values

WTViewerFreePlus

## Procedure

### Displayed Function

Press the **FUNCTION** key for display C to select Vpk (voltage peak value), Apk (current peak value), or Wpk (power peak value).
Each time you press FUNCTION, the displayed function changes in the order shown below.

**Display**
C

→ V → A → W → Vpk(+) → Vpk(-) → Apk(+) → Apk(-) → Wpk(+) → Wpk(-)

MATH ← Ah±(-) ← Ah±(+) ← Ah ← Wh±(-) ← Wh±(+) ← Wh ←

- Vpk, Apk, Wpk, Wh±, and Ah± all illuminate twice. The first time is for the positive measurements and the second time is for the negative measurements.
- The MATH indicator is on the left side of the 7-segment LED display.
- Press SHIFT before pressing FUNCTION to change the displayed function in reverse order.

### Input Element (WT332E/WT333E only)

Press the **ELEMENT** key for display C to select which element to display.
The procedure for selecting an input element is the same as the procedure in section 4.1.
The WT310E and WT310EH only have one input element, so there is no input element selection.

## Explanation

### Displayed Function

Select which measurement function to show on the display.

- Vpk: The peak voltage is displayed. Select U+pk to display the highest voltage and U-pk to display the lowest voltage.
- Apk: The peak current is displayed. Select I+pk to display the highest current and I-pk to display the lowest current.
- Wpk: The peak power is displayed. Select P+pk to display the highest power and P-pk to display the lowest power.

#### Maximum Displayed Peak Value, Units, and Unit Prefixes

- Maximum displayed value: 99999 (when the number of displayed digits is set to 5)
- Units: V for the peak voltage, A for the peak current, and W for the peak power
- Unit prefix: m, k, or M

### Input Element (WT332E/WT333E only)

The elements that you can select vary depending on the model. Check the model when selecting elements.

- 1, 2, or 3: Display the measured values of element 1, 2, or 3.
- Σ: Hyphens (------) are displayed instead of measured values.

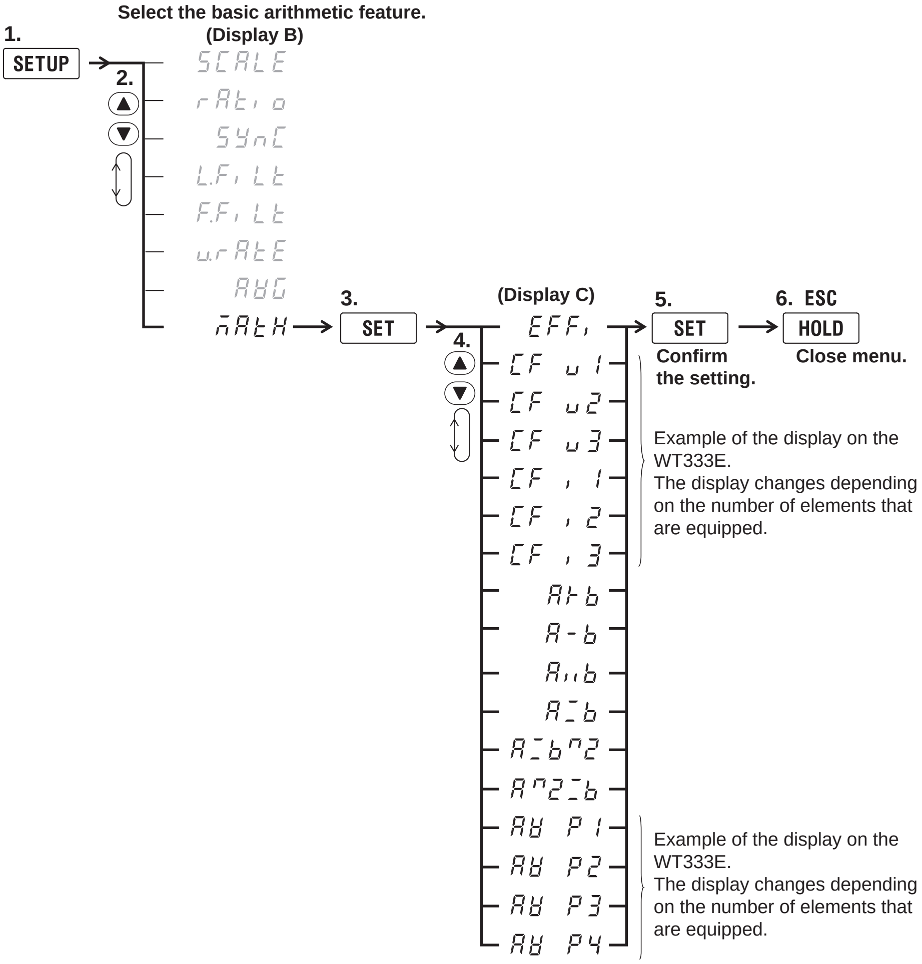
# 4.5 Displaying the Efficiency (WT332E/WT333E only), Crest Factors, the Results of Computations Using Basic Arithmetic, and Average Active Powers

**WTViewerFreePlus**

## Procedure

### Computation Functions

Follow the procedure indicated by the thick lines in the following menu.




### Displayed Function

Press the **FUNCTION** key for display C to select MATH (computation functions).

Each time you press FUNCTION, the displayed function changes in the order shown below.

**Display** C

V → A → W → Vpk(+) → Vpk(-) → Apk(+) → Apk(-) → Wpk(+) → Wpk(-) → Wh → Wh±(+) → Wh±(-) → Ah → Ah±(+) → Ah±(-) → MATH → V

- Vpk, Apk, Wpk, Wh±, and Ah± all illuminate twice. The first time is for the positive measurements and the second time is for the negative measurements.
- The MATH indicator is on the left side of the 7-segment LED display.
- Press SHIFT before pressing FUNCTION to change the displayed function in reverse order.

When the displayed function is set to MATH, there is no element indication.

Pressing ELEMENT has no effect.

## Explanation

## Computation Functions

There are four types of computation functions: efficiency (WT332E/WT333E only), crest factor, basic arithmetic, and average active power. The default setting is the crest factor function (CF u1) on the WT310E/WT310EH and the efficiency function (EFFi) on the WT332E/WT333E.

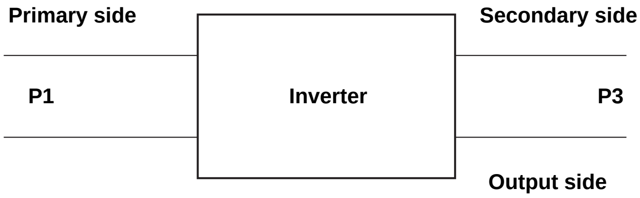
### Efficiency (EFFi; WT332E/WT333E only)

The efficiency of the DUT is computed.

#### Efficiency Equation

- WT332E

  The WT332E/WT333E computes the efficiency by taking the active power measured by element 1 (P1) as the active power applied to the primary side of the inverter and the active power measured by element 3 (P3) as the power consumed by the secondary side of the inverter.

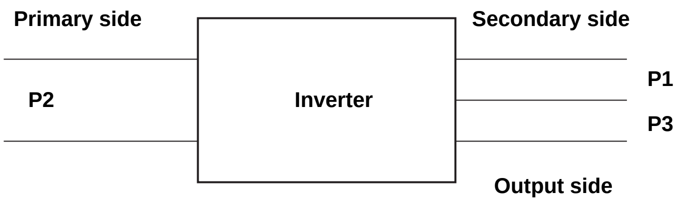



Equation

$$\text{Efficiency} = \frac{P3}{P1} \times 100\ (\%)$$

- WT333E

  The WT333E computes the efficiency by taking the active power measured by element 2 (P2) as the active power applied to the primary side of the inverter and the active power measured by elements 1 and 3 (P1 and P3) as the power consumed by the secondary side of the inverter.




Equation

$$\text{Efficiency} = \frac{P1+P3}{P2} \times 100\ (\%)$$

**Note**

If the denominator of the above equation is less than or equal to 0.0001% of the rated range, the efficiency will be displayed as an error (“Error”).

## Crest Factor (CF U and CF I)

This instrument determines the voltage or current crest factor by dividing the peak value by the rms value.

**Crest Factor Equations and Displayed Values**

- CF u1: The result of dividing the U1 peak by the U1 rms value is displayed.
- CF u2: The result of dividing the U2 peak by the U2 rms value is displayed (WT333E only).
- CF u3: The result of dividing the U3 peak by the U3 rms value is displayed (WT332E and WT333E).
- CF i1: The result of dividing the I1 peak by the I1 rms value is displayed.
- CF i2: The result of dividing the I2 peak by the I2 rms value is displayed (WT333E only).
- CF i3: The result of dividing the I3 peak by the I3 rms value is displayed (WT332E and WT333E).

### *Note*

- When the rms value falls to 0.5% or less (1% or less if the crest factor is set to 6 or 6A) of the rated range value, the crest factor will be displayed as an error (“Error”).
- You can compute the crest factor even when the measurement mode is VOLTAGE MEAN or DC.

## Basic Arithmetic

There are six different types of computation that you can perform (A + B, A – B, A × B, A ÷ B, $A^2$ ÷ B, A ÷ $B^2$).

The values of display A and display B are used in the computation, and the results of the computation are shown in display C.

A⊦b **: A + B**
A-b **: A – B**
A,,b **: A×B**
A⁼b **: A÷B**
A⁼b^2 **: A÷B²**
A^2⁼b **: A² ÷B**

### *Note*

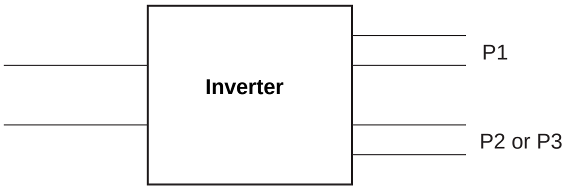
- The meanings of the displayed symbols are explained below.
  - ⊦ **: + (Addition)**
  - - **: − (Subtraction)**
  - ,, **: × (Multiplication)**
  - ⁼ **: ÷ (Division)**
  - ^ **: ^ (exponentiation)**
- When the function displayed in display A is the elapsed integration time (TIME), the computed result is displayed using the no data indication (------).
- In division, if the value of the display B function is less than or equal to 0.0001% of the rated value, the computed value will be displayed as an error (“Error”).

### Examples

A+B: The result of adding the values of display A and display B (total power) is displayed.

Computation example:

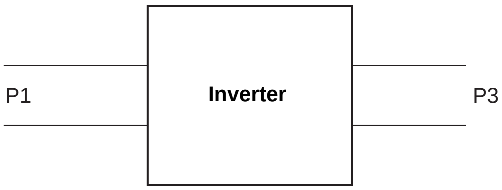
| Display A | Display B | Display C | Wiring System |
|---|---|---|---|
| P1 | P2 or P3 | P1+P2<br>or P1+P3 | Any |




A-B: The result of subtracting the value of display B from the value of display A (power loss) is displayed.

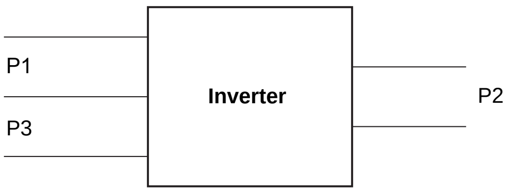
Computation example 1:

| Display A | Display B | Display C | Wiring System |
|---|---|---|---|
| P1 | P3 | P1–P3 | Any |



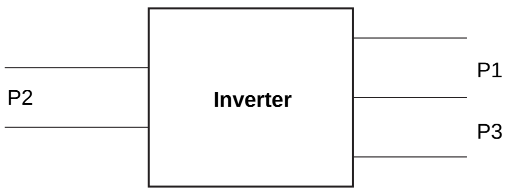

Computation example 2:

| Display A | Display B | Display C | Wiring System |
|---|---|---|---|
| PΣ(=P1+P3) | P2 | PΣ–P2 | 3P3W |




Computation example 3:

| Display A | Display B | Display C | Wiring System |
|---|---|---|---|
| P2 | PΣ(=P1+P3) | P2–PΣ | 3P3W |



A×B: The product of the values of display A and display B is displayed.

This feature is useful when you are displaying a function other than VA (apparent power S) in display A and you want to display apparent power S in display C.

Computation example:

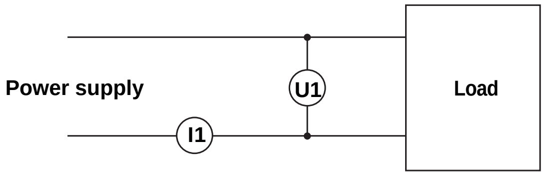
| Display A | Display B | Display C | Wiring System |
|---|---|---|---|
| **U1rms** | **I1rms** | **U1rms × I1rms** | Any |

A÷B: The result of dividing the value of display A by the value of display B is displayed.

When computing the absolute impedance value

Computation example 1:

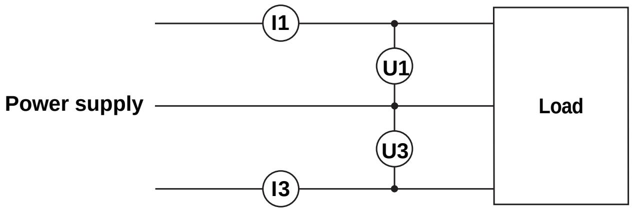
| Display A | Display B | Display C | Wiring System |
|---|---|---|---|
| U1rms | I1rms | $\lvert Z \rvert = \frac{U1rms}{I1rms}$ | Any |




When computing the line voltage ratio and line current ratio for three-phase wiring

Computation example 2:

| Display A | Display B | Display C | Wiring System |
|---|---|---|---|
| U1rms | U3rms | $\frac{U1rms}{U3rms}$ | 3P3W |
| I1rms | I3rms | $\frac{I1rms}{I3rms}$ | |

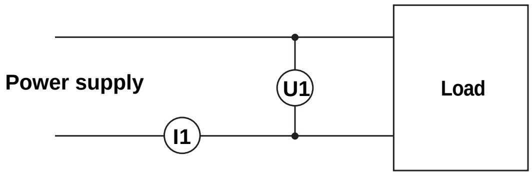



A÷B$^2$: The result of dividing the value of display A by the square of the value of display B is displayed.

When computing impedance (Z), resistance (R), or reactance (X)

Computation example:

| Display A | Display B | Display C | Wiring System |
|---|---|---|---|
| S1 (VA) | I1rms | $\lvert Z \rvert = \frac{S1}{(I1rms)^2}$ | Any |
| P1 (W) | I1rms | $\mathbf{R} = \frac{P1}{(I1rms)^2}$ | |
| Q1 (var) | I1rms | $\lvert X \rvert = \frac{Q1}{(I1rms)^2}$ | |

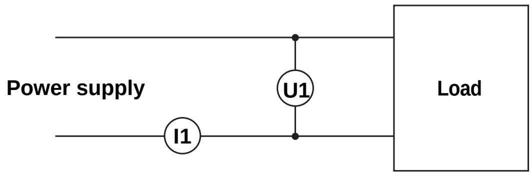


$A^2 \div B$: The result of dividing the square of the value of display A by the value of display B is displayed.

When computing resistance (R)

Computation example:

| Display A | Display B | Display C | Wiring System |
|---|---|---|---|
| U1rms | P1 | $\mathbf{R} = \frac{(U1rms)^2}{P1}$ | Any |




## Average Active Power during Integration (AV P)

The average active power within the integrated period is computed. This instrument determines the average active power by dividing the watt hour (integrated active power) by the integration time.

$$\textbf{Average active power during integration (W)} = \frac{\textbf{Watt hour (Wh)}}{\textbf{Elapsed integration time (h)}}$$

### Equations and Displayed Values for the Average Active Power during Integration

- AV P1: The result of dividing the watt hour of element 1 (WP1) by the elapsed integration time is displayed.
- AV P2: The result of dividing the watt hour of element 2 (WP2) by the elapsed integration time is displayed (WT333E only).
- AV P3: The result of dividing the watt hour of element 3 (WP3) by the elapsed integration time is displayed (WT332E and W333).
- AV P4: The result of dividing the watt hour of element Σ (WPΣ) by the elapsed integration time is displayed (WT332E and W333).
  - * Watt hour WPΣ varies depending on the wiring system. The equations for computing the value are the same as those listed in section 4.1 when “P” is replaced with “WP.”

### Note

This computation function is only valid during integration (during integration or after integration has been aborted). If you reset integration, the watt hour and elapsed integration time values become zero, and the no data indication (------) is displayed. For details about integration, see chapter 5.

## Displayed Function

When you select MATH, the results of the computation that you have specified (efficiency, crest factor, basic arithmetic, or average active power) are shown in display C.
Only the WT332E/WT333E can compute efficiency.

## Maximum Displayed Value, Units, and Unit Prefixes

**• Maximum Display (Display range)**

- Efficiency: 0.000 to 99.999 to 100.00 to 999.99 (%)
- Other computations (crest factor, basic arithmetic, and average active power): 99999

**• Units**

- Average active power: The unit is W, but it does not appear on the display.
- Efficiency: The unit is %, but it does not appear on the display.
- Crest factor and four arithmetic operation: No unit

**• Unit Prefixes**

- Basic arithmetic and average active power: m, k, or M
- Other computations (efficiency and crest factor): No prefix

When the displayed function is set to MATH, there is no element indication.
Pressing ELEMENT has no effect.

# 4.6 Setting the MAX Hold Feature

WTViewerFreePlus

## Procedure

Press **SHIFT+CURRENT** (MAX HOLD) to turn the MAX hold feature on and off.
Pressing SHIFT+CURRENT (MAX HOLD) turns the MAX hold feature on and off.


## Explanation

### MAX Hold

The maximum value that has occurred while the MAX hold feature has been enabled is held. If a value larger than the currently held value is measured, the larger value is held.
You can hold the following maximum values. The default setting is oFF.
U (voltage), I (current), P (active power), S (apparent power), Q (reactive power), U+pk and U-pk (peak voltage), I+pk and I-pk (peak current), and P+pk and P-pk (peak power)

- on: The MAX HOLD indicator illuminates, and the MAX hold feature is enabled.
- oFF: The MAX HOLD indicator turns off, and the MAX hold feature is disabled.

***Note***

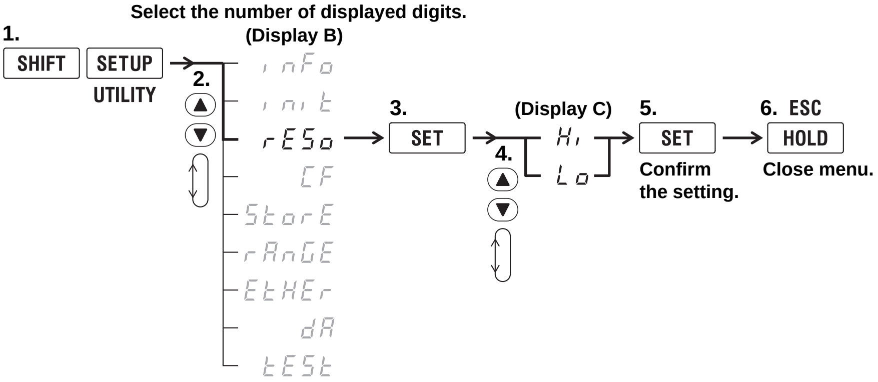
The D/A output, communication output, and other values reflect the held maximum values.

# 4.7 Setting the Number of Displayed Digits

WTViewerFreePlus

## Procedure

Follow the procedure indicated by the thick lines in the following menu.




## Explanation

### Number of Displayed Digits

You can select the maximum number of displayed digits for displayed functions other than the phase angle, integrated values, and the elapsed integration time. The default setting is Hi.

- Hi: 5 digits are displayed (99999).
- Lo: 4 digits are displayed (9999).

#### Note

- The actual number of displayed digits may be lower than the maximum number of displayed digits as a result of voltage and current range combinations and automatic digit increases.
- The displays of the phase angle, integrated value, and elapsed integration time are not affected by the displayed digit setting in this section. Please see the various sections that explain these items.

# 5.1 Integration Feature

You can integrate the active power (watt hour) and current (ampere hour).
During integration, you can display the integrated value (watt hour or ampere hour), the elapsed integration time, and other measured or computed values.
Also, you can display integrated values for individual polarities. This means that you can separately display the watt hour (ampere hour) consumed on the positive side and the watt hour (ampere hour is available only when the measurement mode is DC) returned to the power supply on the negative side.

## Integration Modes

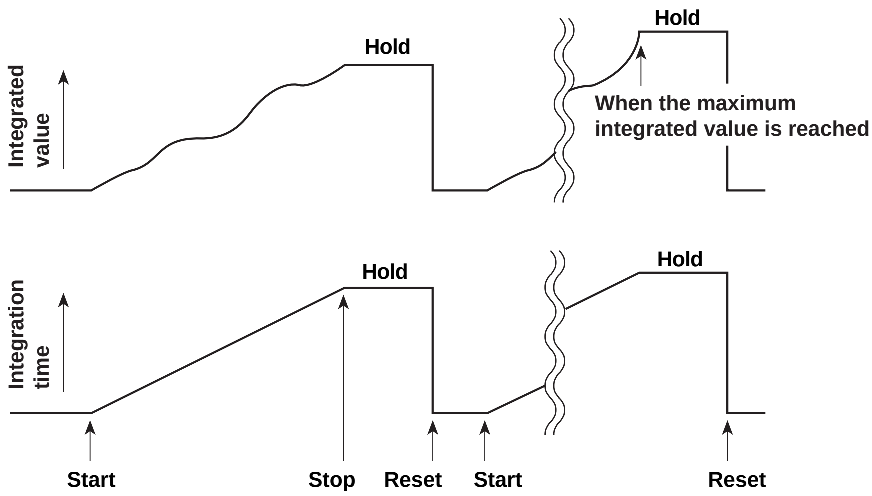
The integration feature has the following three modes.

| Integration Mode | Start | Stop | Repetition |
|---|---|---|---|
| Manual integration mode | Key operation | Key operation | --- |
| Standard integration mode | Key operation | Stopped by the timer | --- |
| Continuous (repetitive) integration mode | Key operation | Key operation | Repeats when the timer expires |

## Manual Integration Mode

When you set the integration mode to standard integration mode (nor) and set the integration timer to 00000:00:00, this instrument performs integration in manual integration mode. When you press START, integration starts, and it continues until you press STOP. However, if either of the conditions below is met, integration is stopped, and the integration time and integrated value are held.

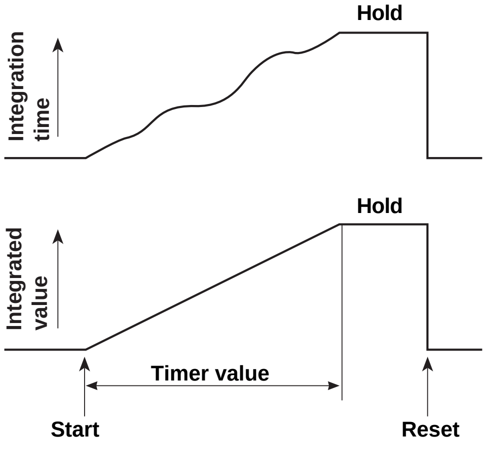
- The integration time reaches the maximum integration time (10000 hours).
- The integrated value reaches its maximum or minimum displayable value.



## Standard Integration Mode

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

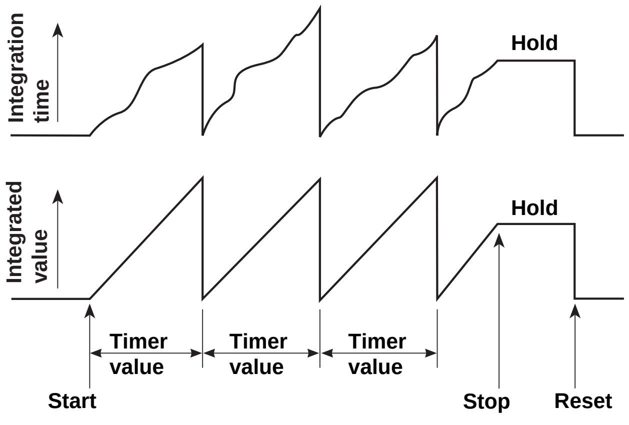
- The specified timer time elapses.
- You press STOP.
- The integrated value reaches its maximum or minimum displayable value.




## Continuous Integration Mode

You can set a relative integration time. Integration starts when you press START. When the specified integration timer time elapses, integration is automatically reset and restarted. Integration repeats until you press Stop. If either of the conditions below is met, integration is stopped, and the integration time and integrated value are held.

- You press STOP.
- The integrated value reaches its maximum or minimum displayable value.



## Integration Methods

The following expressions are used. The result is displayed using time conversion.

| | | |
|---|---|---|
| Power integration | | $\sum_{i=1}^{n} u_i \cdot i_i$ |
| Current integration | RMS | $\sum_{I=1}^{N} I_I$ |
| | DC | $\sum_{i=1}^{n} i_i$ |

$u_i$ and $i_i$ are the instantaneous voltage and current values.
n is the number of samples.
$I_I$ is the measured current for each data update interval.
N is the number of data updates.

In power integration and, when the measurement mode is set to DC, current integration, the instantaneous power or current values are integrated. When the measurement mode has been set to RMS, the current values measured at each data update interval (see section 2.10) are integrated.

### Note

If you stop integration, the integration process stops at the integrated value and elapsed integration time of the previous display update. The measured values between the previous display update and the execution of the integration stop are not integrated.

## Display Resolution during Integration

The display resolution of integrated values is normally 99999 counts. The display resolution can go up to 999999 counts when the unit is MWh or MAh.
When the integrated value becomes large and reaches 100000 counts, the decimal point is automatically moved. For example, when 0.0001 mWh is added to 9.9999 mWh, the display switches to 10.000 mWh.

## Displayed Integrated Value Functions

You can display integrated values for different polarities separately by choosing the appropriate functions to display.

| Displayed Function | Measurement Mode | Display Details |
|---|---|---|
| Wh | RMS, VOLTAGE MEAN, DC | Sum of positive and negative watt hours |
| Wh±[1] | RMS, VOLTAGE MEAN, DC | Positive watt hours |
| Wh±[1] | RMS, VOLTAGE MEAN, DC | Negative watt hours |
| Ah | RMS, VOLTAGE MEAN | Sum of ampere hours |
| | DC | Sum of positive and negative ampere hours |
| Ah±[2] | RMS, VOLTAGE MEAN | Total ampere hours (same as Ah) |
| | DC | Positive ampere hours |
| Ah±[2] | RMS, VOLTAGE MEAN | –0 is displayed |
| | DC | Negative ampere hours |

1 When Wh is the displayed function, the displayed function will be Wh± whether you press the FUNCTION key once or twice. When you press the function key once and switch to Wh±, the positive watt hour will be displayed. If you press the FUNCTION key once more, the negative watt hour for Wh± will be displayed. When the negative watt hour is being displayed, the displayed value is preceded by a minus sign.

2 When Ah is the displayed function, the displayed function will be Ah± whether you press the FUNCTION key once or twice. When you press the function key once and switch to Ah±, the positive ampere hour will be displayed. If you press the FUNCTION key once more, the negative ampere hour for Ah± will be displayed. When the negative watt hour is being displayed, the displayed value is preceded by a minus sign.

### *Note*

- When negative integrated values are displayed, the minimum display reading will become –99999 MWh/MAh because of the added minus character.
- During the period from when integration is started until it is reset, there are limits to the changes that you can make to other functions. For details, see section 5.4.

## Using an External Signal to Control Integration (Option)

On models with the D/A output option (/DA4 or /DA12), you can use the remote control feature to use an external signal to start, stop, and reset integration. For information about the remote control feature, see section 5.2 in the Getting Started Guide, IM WT310E-02EN.

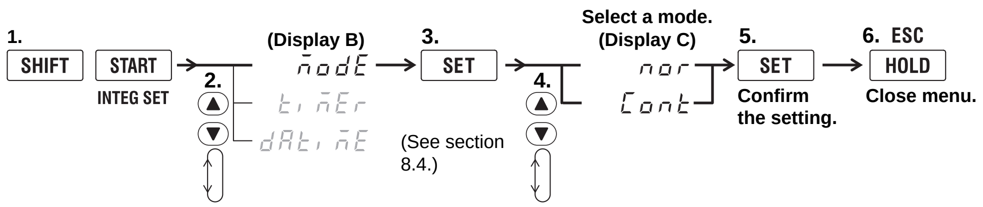
# 5.2 Setting the Integration Mode and Timer

WTViewerFreePlus

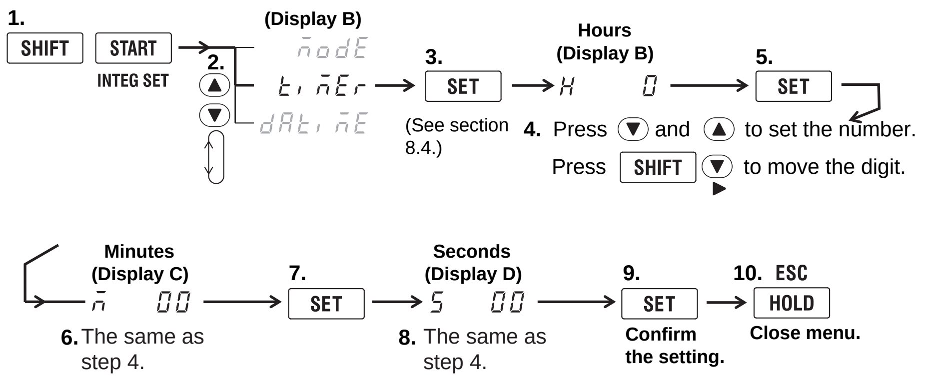
## Procedure

Follow the procedure indicated by the thick lines in the following menu.

### Integration Mode




### Integration Timer




## Explanation

### Integration Mode

You can select from the following options. The default setting is nor.

- nor: Select this setting for manual or standard integration mode.
  This instrument will automatically determine the appropriate mode in accordance with the integration timer setting.
  - When the integration timer is set to 0.00.00, the mode is set to manual integration mode.
  - When the integration timer is set to a value other than 0.00.00, the mode is set to standard integration mode.
- Cont: Select this setting to set the mode to continuous integration mode.

### Integration Timer

Set the integration time. You can set the integration time to a value between 0.00.00 (0 h, 0 min, 0 s) and 10000.00.00 (10000 h, 0 min, 0 s). The default setting is 0.00.00.

- 0.00.00: When the integration mode is set to nor, this instrument sets the mode to manual integration mode. When the integration mode is set to Cont, this instrument will display an error code when you try to start integration, and integration will not be performed.
- 0.00.01 to 10000.00.00: Set the integration time to a value within this range when the mode is standard integration mode or continuous integration mode. You can choose between standard integration mode and continuous integration mode in the integration mode menu.

# 5.3 Displaying Integrated Values

WTViewerFreePlus

## Procedure

### Displayed Function

Press the **FUNCTION** key for display A or C to select TIME (elapsed integration time), Wh/Wh± (integrated power), Ah/Ah± (current integration), or MATH (average active power during integration). Each time you press FUNCTION, the displayed function changes in the order shown below.

**Display**

A  V → A → W → VA → var → TIME → (back to V)

C  V → A → W → Vpk(+) → Vpk(-) → Apk(+) → Apk(-) → Wpk(+) → Wpk(-) → Wh → Wh±(+) → Wh±(-) → Ah → Ah±(+) → Ah±(-) → MATH → (back to V)

- Vpk, Apk, Wpk, Wh±, and Ah± all illuminate twice. The first time is for the positive measurements and the second time is for the negative measurements.
- The MATH indicator is on the left side of the 7-segment LED display.
- Press SHIFT before pressing FUNCTION to change the displayed function in reverse order.

### Input Element (WT332E/WT333E only)

Press the **ELEMENT** key for display C to select which element to display.
The procedure for selecting an input element is the same as the procedure in section 4.1.
The WT310E and WT310EH only have one input element, so there is no input element selection.

### Starting and Stopping Integration

1. Press **START**.
   The START key illuminates, and integration starts. The integrated value (or the average active power during integration) is shown on display C, and the elapsed integration time is shown on display A.

   START

2. Press **HOLD**.
   The HOLD key illuminates, and the displayed value is held.

   HOLD

3. Press **HOLD** when the measured values are being held.
   The HOLD key light turns off, the held state is released, and the display of the integration results is updated.

   HOLD

4. Press **SHIFT+HOLD** (SINGLE) when the measured values are being held.
   This instrument will perform a single measurement, update the display, and hold the new values.

   SHIFT  HOLD
   SINGLE

5. Press **STOP**.
   Integration stops. The START key light turns off, and the STOP key illuminates. The displayed integration value is held.

   STOP

*6.* To reset integration, press **SHIFT+STOP** (RESET).

The STOP key light will turn off, and displays A and C will show hyphens ("------").

SHIFT STOP
RESET

## Explanation

### Displayed Function

Select which measurement function to show on the display.

- TIME: The elapsed integration time is displayed.
- Wh: The sum of positive and negative watt hours WP is displayed.
- Wh±: The positive and negative watt hours are displayed. Positive watt hour is WP+, and negative watt hour is WP-.
- Ah: The total ampere hour q is displayed.
- Ah±: The total ampere hour is displayed or the positive and negative ampere hours are displayed. Positive ampere hour is q+, and negative ampere hour is q-.
- MATH: When the computation function is set to the average active power during integration, the average active power during integration is displayed.



### Maximum Displayed Value, Units, and Unit Prefixes

- Maximum display
  Elapsed integration time: 10000
  Integrated values: 99999 (999999 when the unit is MWh or MAh) or –99999 when a negative value is displayed.
- Units: Wh for the integrated power (watt hour) and Ah for the integrated current (ampere hour)
- Unit prefix: m, k, or M (for integrated values)

### Display and Resolution of the Elapsed Integration Time

The elapsed integration time can be displayed using up to 9 total digits for hours, minutes, and seconds. This instrument shows the elapsed integration time in display A. Because the maximum number of displayed digits in display A is 6, there are times when all the digits in the elapsed integration time cannot be displayed.

The number of digits in the displayed time varies as indicated below depending on the elapsed integration time.

| Elapsed Integration Time | Display A Indication | Display Resolution |
|---|---|---|
| 0 to 99 h, 59 m, 59 s | 0.00.00 to 99.59.59 | 1 s |
| 100 h to 9999 h, 59 m, 59 s | 100.00 to 9999.59 | 1 m |
| 10000 h | 10000 | 1 h |

#### *Note*

- For details about Wh, Wh±, Ah, and Ah±, see section 5.1.
- For details about the average active power during integration, see section 4.5.
- Regardless of the MAX hold feature, this instrument determines and displays the integrated value by summing the value that is measured at every data update interval.

## Input Element (WT332E/WT333E only)

The elements that you can select vary depending on the model. Check the model when selecting elements.

- 1, 2, or 3: Display the integrated results for element 1, 2, or 3.
- Σ: Display the sum of the integrated values of all equipped elements. The equation for computing the sum varies depending on the wiring system. The equations for computing the values are the same as those listed in section 4.1 when “P” is replaced with “WP” or “q.”

***Note***

When the displayed function in display A is TIME (elapsed integration time), there is no element indication for display A. Pressing the ELEMENT key for display A has no effect.

## Starting and Stopping Integration

### Starting Integration

When integration is started, the integration of the active power (watt hour) and the integration of the current (ampere hour) begin.

***Note***

The integration function cannot be used when the data update interval is set to Auto.

### Holding Displayed Values

- When values are held, their displays are not updated, but integration continues inside the instrument. Because the UPDATE indicator blinks whenever the internal data is updated, it will continue to blink. When the hold on the displayed values is released, the integration results (values and time) at the point in time when the hold is released will be displayed.
- For details on how START/STOP key operations relate to held values, see section 5.4.

### Stopping Integration

If you stop integration, the integration process stops at the integrated value and elapsed integration time of the previous display update. The measured values between the previous display update and the execution of the integration stop are not integrated.

### Resetting Integration

- When integration is reset, the integrated values are returned to what they were before integration started.
- The SHIFT+STOP (RESET) key is valid after integration has been stopped.
- For details on how START/STOP key operations relate to held values, see section 5.4.

### Display When There Is an Integration Overflow

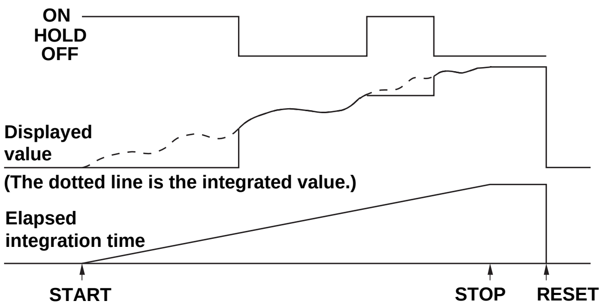
- When the integrated values reach their maximum value (999999 MWh/MAh) or minimum value (–99999MWh/MAh), integration stops and the display of the integration results at that point in time is held.
- When the elapsed integration time reaches the maximum integration time (10000 hours), integration is stopped and the display of the integration results at that point in time is held.
- When integration overflow occurs, both the START and STOP keys illuminate.

# 5.4 Notes about Using Integration

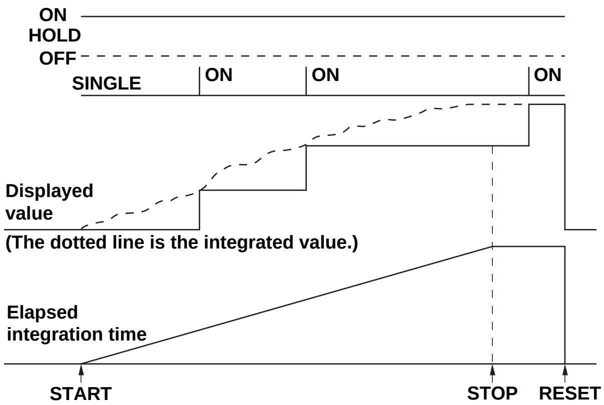
## Relationship between the Holding of Integration and START/STOP Key Operations

After you hold the display by pressing HOLD, the displayed integration results and communication output are held, but integration continues. The relationship between the holding of integration and START/STOP key operations is explained below.

- Starting integration when values are held
  The display and communication output do not change. If you release the hold on the displayed values or perform a single measurement (by pressing SHIFT+HOLD (SINGLE)), the integration results at that point in time are displayed and output through communication.

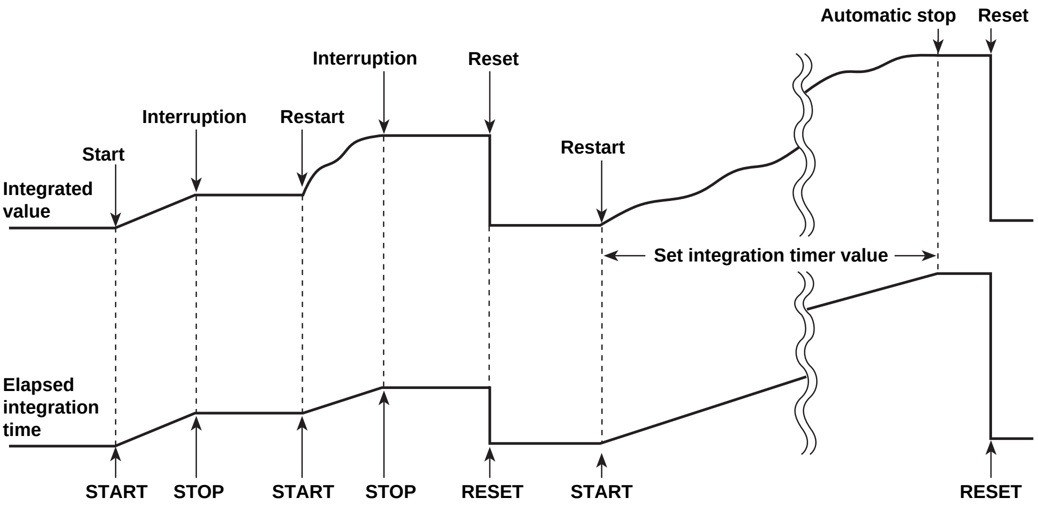



- Stopping integration when values are held
  Display and communication output values do not change from the held values. If you release the hold on the displayed values or perform a single measurement, the integration results at the time that you stopped integration are displayed and output through communication.



## Relationship between Resetting Integration and START/STOP Key Operations

The relationship is shown in the figure below.




## Data When a Power Failure Occurs during Integration

- Even if a power failure occurs during integration, the integrated results will be retained in memory. If the power is restored after a failure, this instrument will be in the following conditions.
  - Integration will be stopped.
  - Both the START and STOP keys will be illuminated.
  - Integration results up to the point when the power failure occurred will be displayed.
- After the power is restored, you cannot simply restart integration where you left off. Reset integration before starting it again.

## Integration Resume Function at Power Failure Recovery

When the integration resume function at power failure recovery is set to ON, the integration operation can be resumed if a power failure occurs and recovers while integration is in progress.

### Description

If this function is set to ON and a power failure occurs and then recovers while integration is in progress (the START key is illuminated) or while integration is paused (the STOP key is illuminated), this instrument behaves in the following manner.

- The integration result before the power failure is displayed, and this instrument enters a integration paused state (the STOP key is illuminated).
- Integration can be restarted with the START key or a command.
- The integration data after restarting is added to the results before the power failure.

### Turning the Function On

Turn the power on while holding down **SHIFT+FUNCTION A+VOLTAGE**.

A start message “WT300E/SYSTEM/START” appears, and then all the LEDs illuminate.
Hold down the keys until all the LEDs illuminate.
Then, “OPT.01/ON” appears.

### Turning the Function Off

Performing the above procedure when the function is on will turn it off.

In this case, “OPT.01/OFF” appears.

### Checking the On/Off State of the Function

From the menu select **UTILITY**(**SHIFT**+**SETUP**) →“**inFo**”→“**VEr.**”

For details how to select from the menu, see section 8.1.

If the function is on, display D shows “OPT.01.”

## Limitations on Changing Settings during Integration

During integration, the settings that you can change are limited as indicated below.

| | Integration Condition | | |
|---|---|---|---|
| | **Integration Reset** | **Integrating** | **Integration Paused** |
| **START key** | **Off** | **On** | **Off** |
| **STOP key** | **Off** | **Off** | **On** |
| **Function** | | | |
| Measurement mode | Yes | No | No |
| Wiring system (WT332E/WT333E only) | Yes | No | No |
| Measurement range | Yes | No[1] | No[1] |
| Scaling | Yes | No | No |
| Crest factor | Yes | No | No |
| Measurement synchronization source | Yes | No | No |
| Input filter | Yes | No | No |
| Data update interval | Yes | No | No |
| Averaging | Yes[2] | No | No |
| Hold | Yes | Yes | Yes |
| Single | Yes | Yes | Yes |
| Display function | Yes | Yes | Yes |
| Input element (WT332E/WT333E only) | Yes | Yes | Yes |
| MAX hold | Yes | Yes | Yes |
| Number of displayed digits | Yes | Yes | Yes |
| Integration | | | |
| Integration mode | Yes | No | No |
| Integration timer | Yes | No | No |
| Start | Yes | No | Yes |
| Stop | No | Yes | No |
| Reset | Yes | No | Yes |
| Harmonic measurement (option) | | | |
| Display on/off | Yes | Yes | Yes |
| PLL source | Yes | No | No |
| Measured harmonic order | Yes | No | No |
| Distortion factor equation | Yes | No | No |
| Storage | Yes | Yes | Yes |
| Zero-level compensation | Yes | No | No |

- Yes: Settings can be changed.
- No: Settings cannot be changed. An error code will be displayed if you attempt to change the settings.

1 Measurement ranges can be changed by the auto range feature, but you cannot change ranges manually.

2 When you start integration, averaging is disabled. Even after integration stops and is reset, averaging is not enabled again.

## Auto Range Feature and Range Skipping

If you start integration when the auto range feature is enabled, integration will take place with the auto range feature enabled.

- When the auto range feature is enabled, the measurement ranges for both the voltage and current will be automatically switched in accordance with the size of the input signal.
- For information about the conditions under which the range is automatically increased or decreased, see section 2.3.

Also, when the auto range feature is enabled, you can enable range skipping, in which measurement ranges that are not used are skipped, and this instrument switches between the measurement ranges that you have chosen to enable. For details, see section 2.6.

### *Note*

When an irregular pulse waveform is applied, a steady range may not be maintained. If this occurs, use a fixed range.

## Data Correction When the Auto Range Feature Switches the Range

Measurement does not take place while the range is being switched by the auto range feature. After the measurement range is determined, the first measured data for the period of time over which measurement did not take place is added to the integrated value.

- When the Range Is Increased
  Each time the range is increased, up to three of the first items of data measured after the determination of the measurement range is added to the integrated value immediately before the conditions for increasing the range were met.
- When the Range Is Decreased
  Each time the range is decreased, up to two of the first items of data measured after the determination of the measurement range is added to the integrated value immediately before the conditions for reducing the range were met.

## Checking Whether the Range Has Been Changed by the Auto Range Feature

During integration, when the measurement range is changed by the auto range feature, a hyphen is added to the measurement range information that is output through communication.

## Computation of the Integrated Value When the Measured Value Exceeds the Measurement Limit (for Fixed Ranges)

When the sampled instantaneous voltage or current value exceeds approximately 333% (approximately 666% when the crest factor is set to 6 or 6A) of the measurement range, the value is processed as if it were approximately 333% (approximately 666% when the crest factor is set to 6 or 6A) of the measurement range.

## Integration When the Applied Current Is Small

When the measurement mode is RMS or VOLTAGE MEAN and the applied current is less than or equal to 0.5% (1% when the crest factor is set to 6 or 6A) of the rated range, integration takes place as if the current value were zero.

## Valid Frequency Ranges for Integration

The sample rate is approximately 100 kHz. The voltage and current signal frequencies that are valid for integration are indicated below.

| Integrated Item | | Valid Frequency Range for Integration |
|---|---|---|
| Active power | | DC to 45 kHz |
| Current | When the measurement mode is RMS | DC or the lower frequency limit determined by the data update interval to approximately 45 kHz |
| | When the measurement mode is VOLTAGE MEAN | DC or the lower frequency limit determined by the data update interval to approximately 45 kHz |
| | When the measurement mode is DC | DC to 45 kHz |

# 6.1 Harmonic Measurement Feature

The previous chapters described normal voltage, current, and power measurements. This chapter describes the harmonic measurement feature.
The harmonic measurement feature can compute (1) the voltage, current, and active power for each harmonic up to the 50th harmonic, (2) the harmonic distortion factor of each harmonic, and (3) the phase angles of each harmonic relative to the fundamental wave (1st harmonic). It can also compute the rms voltage, rms current, and rms active power of the fundamental and harmonics as well as the distortion factor (THD).

## Displayed Items

This instrument displays the harmonic components of voltage, current, and active power. Depending on the display function setting, displays A, B, C, and D change as shown below.

**Display** A

→ **Display function off** → V → A → W ↩

Display function off: Shows the harmonic order (1 to 50).
Display function **V, A, W**: Shows all rms voltages, currents, and active powers (computed values) from the 1st to the 50th harmonic.

**Display** B

→ V → A → W → V% → A% → W% → V ° → A ° ↩

Display function
- **V** : Shows the measured voltage for the harmonic order shown in display A.
- **A** : Shows the measured current for the harmonic order shown in display A.
- **W** : Shows the measured active power for the harmonic order shown in display A.
- **V %** : Shows the harmonic distortion factor of voltage for the harmonic order shown in display A.
- **A %** : Shows the harmonic distortion factor of current for the harmonic order shown in display A.
- **W %** : Shows the harmonic distortion factor of active power for the harmonic order shown in display A.
- **V °** : • When display A is showing the 1st harmonic (fundamental)
  Shows the phase angle of the 1st harmonic current with respect to the fundamental voltage.
  • When display A is showing a harmonic between 2 and 50
  Shows the phase angle of the harmonic voltage with respect to the fundamental voltage.
- **A °** : • When display A is showing the fundamental
  Shows the phase angle of the fundamental current with respect to the 1st order voltage (same as V °).
  • When display A is showing a harmonic between 2 and 50
  Shows the phase angle of the harmonic current with respect to the fundamental current.

**Display** C

→ V → A → W ↩

Display function **V, A, W** : Shows all rms voltages, currents, and active powers (computed values) from the 1st to the 50th harmonic.

**Display** D

→ V → A → W → PF → VHz → AHz → THD V% → THD A% ↩

Display function
- **V, A, W** : Shows all rms voltages, currents, and active powers (computed values) from the 1st to the 50th harmonic.
- **PF** : Shows the power factor of the fundamental wave (1st harmonic).
- **VHz** : Shows the voltage frequency.
- **AHz** : Shows the current frequency.
- **THD V %** : Shows the total harmonic distortion of voltage.
- **THD A %** : Shows the total harmonic distortion of current.

## Auto Range Operation

The auto range operation when harmonic measurement data is displayed is the same as the operation during normal measurement. For details, see section 2.3.

**Note**

If the range changes repeatedly in auto range mode, PLL synchronization is lost, and resynchronization is repeated. Consequently, this instrument is unable to obtain correct measurements, and this may lead to further instability in the range setting. In such cases, set a fixed range appropriate for the measured values.

## Data Update Interval, Holding Measured Values, and Updating Display Data

Same as normal measurement.

## Error Display

### When the Fundamental Frequency of the PLL Source Is Outside the Measurement Range

The fundamental frequency range of the PLL source is 10 Hz to 1200 Hz. If the frequency is not within this range, all harmonic measurements will be displayed as no data (------).

**Note**

The measurement range of the harmonic frequency in harmonic measurement is different from the frequency measurement range of normal measurement. For details, see section 7.3 in the Getting Started Guide, IM WT310E-02EN.

### Over Range Indication

Harmonic measurements do not have over range indication (---oL-) or indication for measured values that are too small.

* See “Indications When the Measured Value Is Too Small” on page 1-12 in the Getting Started Guide, IM WT310E-02EN.

### Measurement Suspension/No Data Indication (Hyphens)

Hyphens are displayed in the following circumstances.

- When there is no analysis data to display during harmonic measurement data display
- Immediately after the harmonic measurement data display is turned on
- When PLL synchronization is lost and resynchronization is taking place
- Until the first measurement data is acquired after the settings are changed
- When the harmonic order of display A exceeds the upper limit of measured harmonic, which is determined by the fundamental frequency

## Averaging

If the averaging type is set to EP (exponential averaging), averaging is performed using the specified attenuation constant.

## Effects of Aliasing

This instrument does not have anti-aliasing filters. Aliasing errors occur in the following circumstances.

| Fundamental Frequency f (Hz) | Aliasing Occurs When |
|---|---|
| 10 ≤ f < 75 | 512th and higher harmonic components are present |
| 75 ≤ f < 150 | 256th and higher harmonic components are present |
| 150 ≤ f < 300 | 128th and higher harmonic components are present |
| 300 ≤ f < 600 | 64th and higher harmonic components are present |
| 600 ≤ f < 1200 | 32th and higher harmonic components are present |

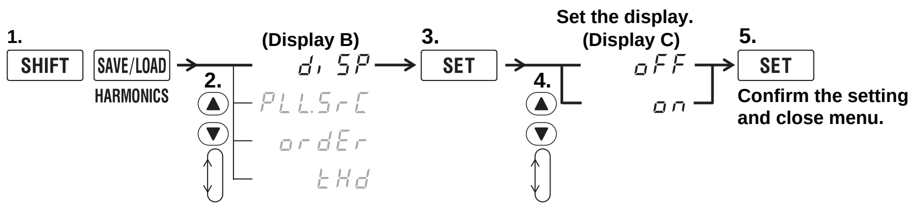
# 6.2 Displaying Harmonic Measurement Data

WTViewerFreePlus

## Procedure

### Turning the Harmonic Measurement Data Display On and Off

Follow the procedure indicated by the thick lines in the following menu.




### Display Function

Press **FUNCTION** to select harmonic measurement data.

Each time you press FUNCTION, the displayed function changes in the order shown below.

**Display A**: Display function off → V → A → W → (back to Display function off)

**Display B**: V → A → W → V% → A% → W% → V ° → A ° → (back to V)

**Display C**: V → A → W → (back to V)

**Display D**: V → A → W → PF → VHz → AHz → THD V% → THD A% → (back to V)

- THD is displayed on the left side of the 7-segment LED display.
- Press SHIFT before pressing FUNCTION to change the displayed function in reverse order.

### Source Element (WT332E/WT333E only)

Press **ELEMENT** to select which element to display.

Each time you press ELEMENT, the input element changes in the order shown below.

The WT310E and WT310EH only have one input element, so there is no input element selection.

**WT332E (2 input elements)**: 1 → 3 → (back to 1)

**WT333E (3 input elements)**: 1 → 2 → 3 → (back to 1)

## Explanation

### Turning the Harmonic Measurement Data Display On and Off

- on: The harmonic measurement data display is turned on, and the HARMONICS indicator illuminates.
- oFF: The harmonic measurement data display is turned off, and normal measurement data is displayed. The HARMONICS indicator turns off.

## Display Function

Select the measurement function that you want to display.

The following explanation is for when the upper limit of measured harmonic order is 50. If the upper limit is less than 50, computation is performed to the upper limit, and the results are displayed.

### Display A

- Display function off: Shows the harmonic order (1 to 50).
- V: Shows all rms voltages (computed values) from the 1st to the 50th harmonic. This is the same as display C described below.
- A: Shows all rms currents (computed values) from the 1st to the 50th harmonic. This is the same as display C described below.
- W: Shows all rms active powers (computed values) from the 1st to the 50th harmonic. This is the same as display C described below.

### Display B

- V: Shows the measured voltage for the harmonic shown in display A.
- A: Shows the measured current for the harmonic shown in display A.
- W: Shows the measured active power for the harmonic shown in display A.
- V%: Shows the harmonic distortion factor of voltage for the harmonic shown in display A. When the number of displayed digits is 5, the display range is 0.000 to 99.999 and 100.00 to 999.99%.
- A%: Shows the harmonic distortion factor of current for the harmonic shown in display A. When the number of displayed digits is 5, the display range is 0.000 to 99.999 and 100.00 to 999.99%.
- W%: Shows the harmonic distortion factor of active power for the harmonic shown in display A. When the number of displayed digits is 5, the display range is 0.000 to 99.999 and 100.00 to 999.99%.
- V°:
  - When display A is showing the 1st harmonic (fundamental)
    Shows the phase angle of the fundamental current with respect to the fundamental voltage. G appears in front of the value when the current lags the voltage; d appears when the current leads the voltage.
  - When display A is showing a harmonic between 2 and 50
    Shows the phase angle of the harmonic voltage with respect to the fundamental voltage. A minus sign (–) appears in front of the value when the harmonic lags the 1st harmonic. The display range is –180.0 to 180.0°.
- A°:
  - When display A is showing the 1st harmonic (fundamental)
    The same as V°.
  - When display A is showing a harmonic between 2 and 50
    Shows the phase angle of the harmonic current with respect to the fundamental current. A minus sign (–) appears in front of the value when the harmonic lags the 1st harmonic. The display range is –180.0 to 180.0°.

## Display C

- V: Shows all rms voltages (computed values) from the 1st to the 50th harmonic.
- A: Shows all rms currents (computed values) from the 1st to the 50th harmonic.
- W: Shows all rms active powers (computed values) from the 1st to the 50th harmonic.

**Equation**

$$V=\sqrt{\sum_{k=1}^{n}(Uk)^2}$$

$$A=\sqrt{\sum_{k=1}^{n}(Ik)^2}$$

$$W=\sum_{k=1}^{n}Pk$$

- Uk, Ik, Pk: 1st to the 50th harmonic components of voltage, current, and active power
- k: Measured harmonic order
- n: Upper limit of measured harmonic order. This value varies depending on the fundamental frequency of the PLL source.

## Display D

- V: Shows all rms voltages (computed values) from the 1st to the 50th harmonic. The same as display C.
- A: Shows all rms currents (computed values) from the 1st to the 50th harmonic. The same as display C.
- W: Shows all rms active powers (computed values) from the 1st to the 50th harmonic. The same as display C.
- PF: Shows the power factor of the fundamental wave (1st harmonic).
- VHz: Shows the voltage frequency.
- AHz: Shows the current frequency.
- THD V%: Shows the voltage distortion factor. There are two types of equations. For details, see section 6.3. The display range is 0.000 to 99.999 and 100.00 to 999.99%.
- THD A%: Shows the current distortion factor. There are two types of equations. For details, see section 6.3. The display range is 0.000 to 99.999 and 100.00 to 999.99%.

***Note***

- If you press the FUNCTION key of display A to set the display function to V, A, or W, display A shows the same measurement item as V, A, or W on display C or D.
- Unless specified otherwise in this section, the maximum display, display range, unit, unit prefix, and so on are the same as those of normal measurement.

## Source Element (WT332E/WT333E only)

Set the input element that you want to display harmonic measurement data of. The element types that you can select vary depending on the model. Check your model when selecting.

- 1/2/3: Shows the measured data of element 1, 2, or 3.

***Note***

If harmonic measurement data display is set to ON, the element display will not move to Σ even if you press ELEMENT.

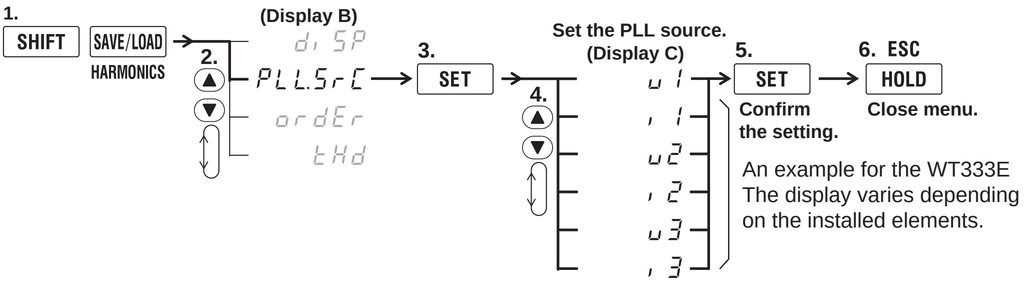
# 6.3 Setting the PLL Source, Measured Harmonic Order, and THD Equation

WTViewerFreePlus

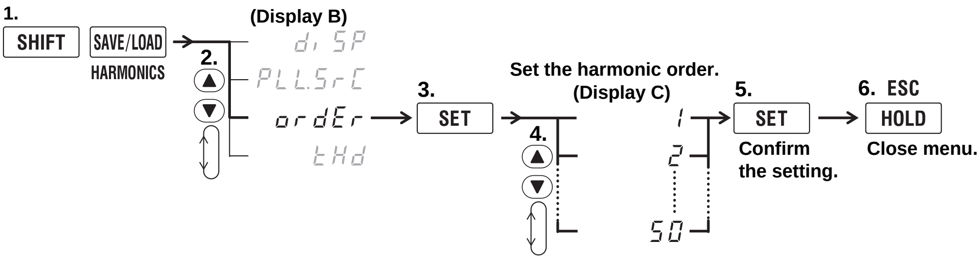
## Procedure

Follow the procedure indicated by the thick lines in the following menu.

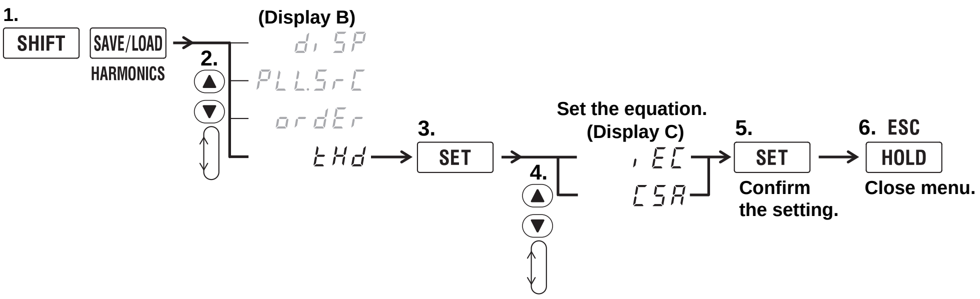
### PLL Source




### Measured Harmonic Order




### THD Equation




## Explanation

### PLL Source

Set the PLL (Phase Locked Loop; frequency synchronization) source, which is used to determine the fundamental frequency. The fundamental frequency is the reference for the measured harmonics of harmonic measurement. The default value is U1.

Be sure to specify a signal with the same period as the harmonic measurement source waveform. Selecting an input signal with small distortion and fluctuation for the PLL source will enable stable harmonic measurement.

- U1: The PLL source is set to the voltage of element 1.
- I1: The PLL source is set to the current of element 1.
- U2: The PLL source is set to the voltage of element 2 (WT333E only).
- I2: The PLL source is set to the current of element 2 (WT333E only).
- U3: The PLL source is set to the voltage of element 3 (WT332E and WT333E).
- I3: The PLL source is set to the current of element 3 (WT332E and WT333E).

***Note***

- If the fundamental frequency of the PLL source cannot be measured due to fluctuations or distortion, correct measurement results cannot be obtained. We suggest that you set the PLL source to the voltage, which has relatively smaller distortion than the current.
- If the fundamental frequency is 200 Hz or less and high frequency components are present, we suggest that you turn on the frequency filter (500 Hz cutoff frequency).
- If the amplitude of the PLL source input signal is small compared to the rated range, PLL synchronization may fail. Change the measurement range so that the amplitude level of the PLL source is 50% or higher than the rated range (100% or higher if the crest factor is set to 6 or 6A).

## Measured Harmonic Order

You can set the upper limit of measured harmonic order in the range of 2 to 50. However, the range varies depending on the fundamental (1st harmonic) frequency. This is because the upper limit of harmonics that are computed varies depending on the fundamental frequency. The default value is 50.

### Example

- Up to 50 when the fundamental frequency is 50 Hz
- Up to 4 when the fundamental frequency is 1.2 kHz

***Note***

- When a harmonic order exceeding the upper limit is specified, display B shows hyphens (-----).
- For details on the upper limit of measured harmonic order, see section 7.3 in the Getting Started Guide, IM WT310E-02EN.

## THD equation

Select the THD equation from below. The default value is iEC.

The following explanation is for when the upper limit of measured harmonic order is 50. If the upper limit is less than 50, computation is performed to the upper limit.

- iEC: Computes the ratio of the rms value of the 2nd to 50th harmonic component to that of the fundamental (1st order).
- CSA: Computes the ratio of the rms value of the 2nd to 50th harmonic component to that of the rms value of the 1st to 50th component.

### Equation

iEC

$$\left[\sqrt{\sum_{k=2}^{n}(Ck)^2}\right] / C_1 \times 100$$

CSA

$$\left[\sqrt{\sum_{k=2}^{n}(Ck)^2}\right] / \left[\sqrt{\sum_{k=1}^{n}(Ck)^2}\right] \times 100$$

- $C_1$: Fundamental (1st harmonic) component
- $C_k$: Fundamental or harmonic component
- k: Measured harmonic order
- n: Upper limit of measured harmonic order. This value varies depending on the fundamental frequency of the PLL source.

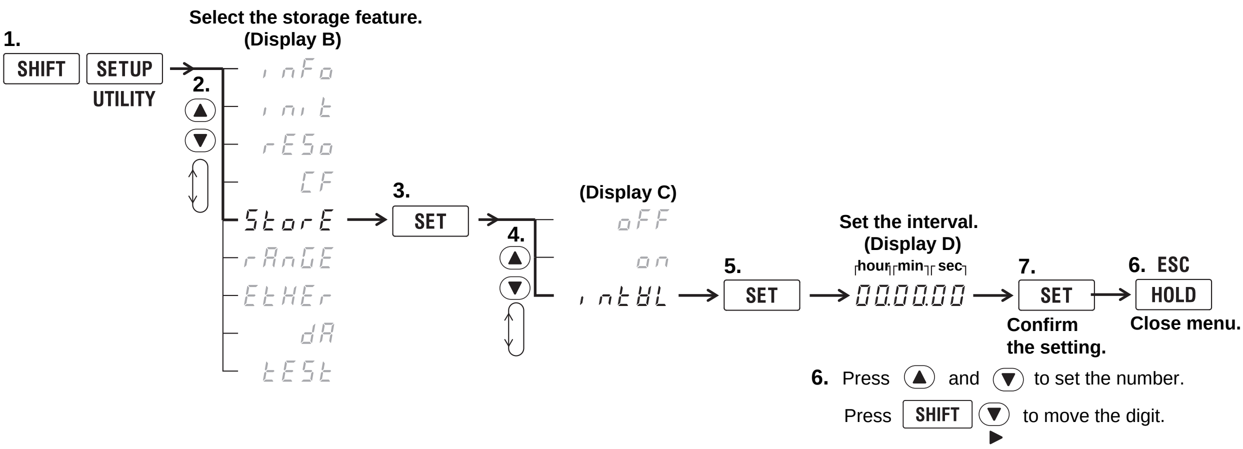
# 7.1 Storing Measured Data

WTViewerFreePlus

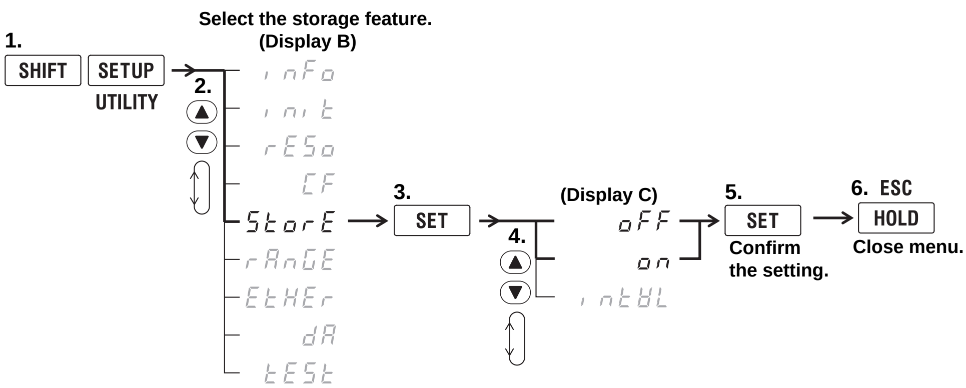
## Procedure

Follow the procedure indicated by the thick lines in the following menu.

### Storage Interval for Measured Data




### Turning Measured Data Storage On and Off




## Explanation

### Storing Measured Data

You can store measured data to the internal memory.

#### Stored Items

All measured data, computed data, integrated data, and frequencies (voltage and current) are stored. If the harmonic data display is set to ON (see section 6.2) on a model with the harmonic measurement option, all measured data, computed data, integrated data, and frequencies (voltage and current) including those of harmonic measurement are stored.

## Number of Blocks Stored

All data values that can be acquired within a single data update interval are stored as one block. The number of data values vary depending on the number of installed elements, so the number of blocks that can be stored varies depending on the product. The number of data blocks that can be stores in the internal memory is shown below.

| Model | Normal Measurement Data Only | Normal Measurement Data and Harmonic Measurement Data* |
|---|---|---|
| WT310E or WT310EH | 9000 blocks | 700 blocks |
| WT332E | 4000 blocks | 300 blocks |
| WT333E | 3000 blocks | 200 blocks |

* When the harmonic data display is set to ON on a model with the harmonic measurement option

## Stopping Storage

Storage stops in the following circumstances.

- When data has been stored to all blocks indicated above
- When the storage setting is set to oFF (while storage is in progress)

### Note

- Measured data that has been stored cannot be recalled on the screen of this instrument.
- Measured data that has been stored can be transmitted to a PC through the communication feature. You can view the data on the PC. For details, see the Communication Interface User’s Manual, IM WT310E-17EN.

## Storage Interval

Set the time interval for repeating the storage operation. The default value is00.00.00.

- Range: 00.00.00 (00 h, 00 min, 00 s) to 99.59.59 (99 h, 59 min, 59 s)

When set to 00.00.00, the storage interval is equal to the specified data update interval.

## Turning the Storage On and Off

After you set the storage interval, select whether to set the storage feature to ON or OFF. The default value is oFF.

- on: Storage starts, and the STORE indicator blinks at the pace at which storage is taking place.
- oFF: Storage stops, and the STORE indicator stops blinking.

### Note

- When you stop storage and restart it, the data in the memory will be overwritten.
- Stored data will be deleted if you:
  - Turn off the power.
  - Initialize the settings (section 5.2).
  - Load setup parameters (section 7.2).
- If the fundamental frequency is high and harmonic measured data does not exist up to the 50th harmonic, “no-data” values are stored for the non-existing harmonics.
- While storage is in progress, you cannot change measurement conditions except for the measurement range.
- If you press the HOLD key to hold the display while storage is in progress, the measurement operation and the storage interval time counter are held (paused), which causes the storage operation itself to be held. If integration is in progress, this instrument continues measurement and integration in the background.
- When the MAX hold feature (see section 4.6) is enabled, the displayed values for U (voltage), I (current), P (active power), S (apparent power), Q (reactive power), U+pk, U-pk (voltage peak), I+pk, I-pk (current peak), P+pk, and P-pk (power peak) will be the maximum held values. D/A output and communication output values will also be the maximum held values. In addition, stored measured data will be the maximum held values.
- While storage is in progress, do not change the MAX hold feature settings.
- If the data update interval is set to Auto, measured data cannot be saved.

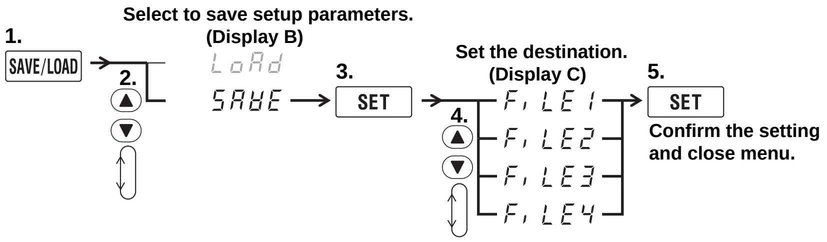
# 7.2 Saving and Loading Setup Parameters

WTViewerFreePlus

## Procedure

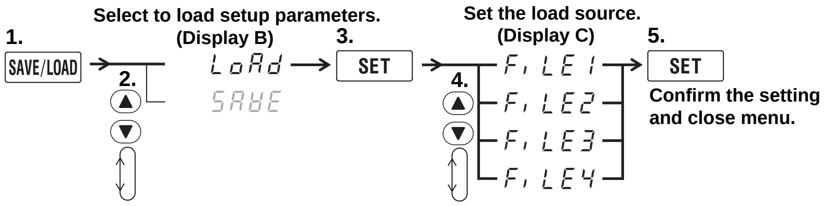
Follow the procedure indicated by the thick lines in the following menu.

### Saving Setup Parameters




If you select a file that contains previously saved setup parameters, display D shows “SAVEd.”
If you select a file that does not contain previously saved setup parameters, display D shows “FrEE.”

### Loading Setup Parameters




If you select a file that contains previously saved setup parameters, display D shows “SAVEd.”
If you select a file that does not contain previously saved setup parameters, display D shows “FrEE.”

## Explanation

### Saving Setup Parameters

You can save four sets of setup parameters to the internal memory. Set the save destination to FiLE1, FiLE2, FiLE3, or FiLE4. The current setup parameters shown below will be saved.

Measurement range, measurement mode, measurement synchronization source, scaling settings, averaging settings, input filter settings, MAX hold ON/OFF setting, computation settings, number of displayed digits, data update interval, crest factor, integration settings, harmonic settings, storage settings, communication settings, etc.

#### Note

- For files that contain previously saved data, display D shows “SAVEd.” Pressing the SET key in this condition will result in overwriting the previously saved setup parameters.
- Setup parameters are saved to a different internal memory than that of measured data.
- Saved setup parameters are retained by a lithium battery. For information on the service life of the lithium battery, see section 5.3 in the Getting Started Guide, IM WT310E-02EN.

### Loading Setup Parameters

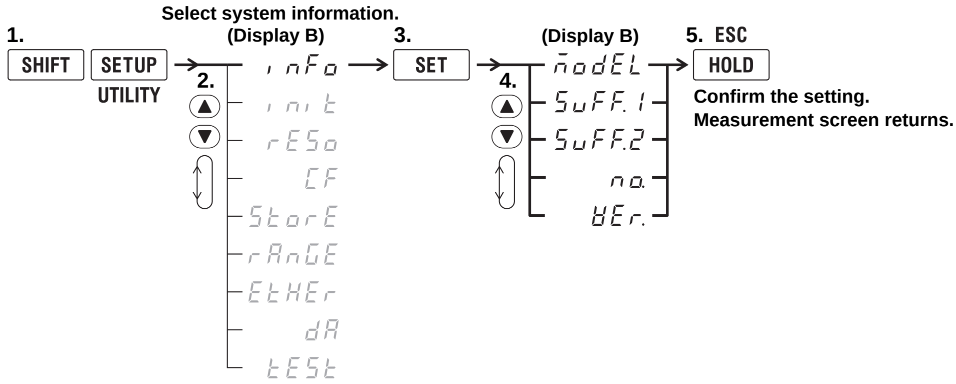
You can load setup parameters that have been saved to restore the settings. This instrument is configured according to the loaded setup parameters. After the settings are loaded, this instrument starts measuring.

# 8.1 Viewing System Information

WTViewerFreePlus

## Procedure

Follow the procedure indicated by the thick lines in the following menu.




## Explanation

### System Information

You can display the following information about this instrument.

| Item | Meaning |
|---|---|
| Model | Model |
| Suff.1 | Suffix code |
| Suff.2 | The rest of the suffix code |
| No. | Instrument number |
| Ver. | Firmware version |

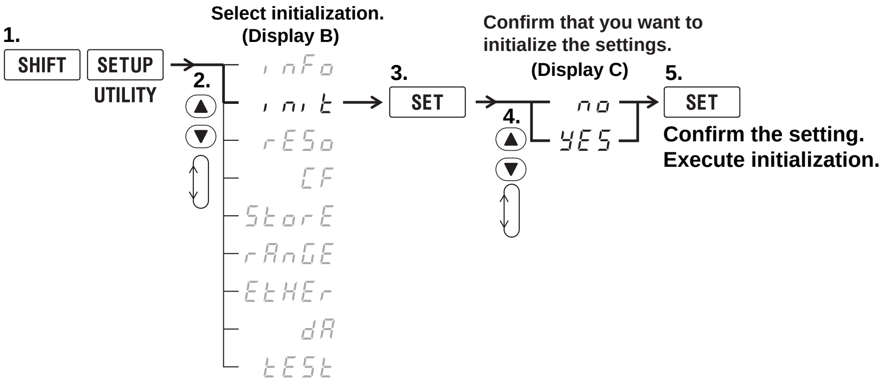
For details on models and suffix codes, see page ii in the Getting Started Guide, IM WT310E-02EN.

# 8.2 Initializing the Settings

WTViewerFreePlus

## Procedure

Follow the procedure indicated by the thick lines in the following menu.




## Explanation

### Initializing Setup Parameters

You can initialize the setup parameters to their factory defaults. This feature is useful when you want to cancel all of the settings that you have entered or when you want to redo measurement from scratch.
The default settings are shown below.

| Item | Default setting |
|---|---|
| Display A | Display function: V, element: 1 |
| Display B | Display function: A, element: 1 |
| Display C | Display function: W, element: 1 |
| Display D | Display function: PF, element: 1 |
| Number of displayed digits | Hi (5 digits) |
| Data update interval | 0.25 s |
| | When set to Auto: Synchronization source: WT310E/WT310EH: U1 |
| | When set to Auto: Synchronization source: WT332E/WT333E: I1 |
| | When set to Auto: Timeout: 1s |
| Line filter | OFF |
| Frequency filter | OFF |
| Measurement synchronization source | WT310E/WT310EH: VoLt (voltage) |
| | WT332E/WT333E: Curr (current) |
| Measurement range | Auto range |
| Measurement range skip | OFF |
| Measurement mode | RMS |
| Wiring system (WT332E/WT333E only) | 1P3W |
| Hold | OFF |
| MAX hold | OFF |
| Scaling | V:1.000, C: 1.000, F: 1.000 |
| | Scaling ON/OFF: OFF |
| External current sensor scaling constant | 10.00 |
| Averaging | Averaging type: Lin (moving average), averaging coefficient: 8 |
| | Averaging ON/OFF: OFF |
| Crest factor | 3 |
| MATH equation | WT310E/WT310EH: Voltage crest factor |
| | WT332E/WT333E: Efficiency |
| Frequency | Voltage frequency and current frequency of element 1 |
| Integration | Reset condition, integration mode: manual<br>Integration timer value: 0 hr, 00 min, 00 s |
| Harmonic measurement (option) | PLL source: U1, total harmonic distortion equation: iEC, maximum measured harmonic order: 50<br>Harmonic measurement data display ON/OFF: OFF |
| Storage | Interval: 0 hr, 00 min, 00 s, storage ON/OFF: OFF |
| D/A output (option) | Output items: default normal measurement items, rated integration time: 1 hr, 00 min, 00 s |

| Item | Default setting |
|---|---|
| GP-IB | Address: 1 |
| RS-232 | Handshaking method: 0, data format: 0, baud rate: 9600, terminator: Cr+Lf |
| Ethernet (option) | DHCP: ON<br>When DHCP is set to OFF<br>IP address: 192.168.0.100<br>Subnet mask: 255.255.255.0<br>Default gateway: 192.168.0.1 |
| Command mode | WT300E |

## Settings That Cannot Be Reset to Their Factory Default Values

- Communication (GP-IB, RS-232, Ethernet, and command mode) settings

## Data

- Stored measured data
  When you initialize the settings, stored measured data is lost.
- Setup parameters
  The setup parameters that are stored in internal memory are retained even if you initialize the settings.

### *Note*

Only initialize this instrument if you are sure that it is okay for all of the settings to be returned to their default values. You cannot undo an initialization. We recommend that you save the setup parameters before you initialize this instrument (see section 7.2).

## Initializing Using Communication Commands

Initialization of setup parameters executed through communication commands (*RST command) works in the same way as the initialization executed through the UTILITY key, as describe above.

# Initializing at Power-On

If you turn on the power while holding down SET, this instrument will start up with the default settings. Continue holding SET until after all the LEDs have lit and turned off (part 2 under “Power-on Messages” on page 2-10 in the Getting Started Guide, IM WT310E-02EN). All of the setup parameters, including the communication settings, will be initialized.

The message “CodE.3” will appear to indicate that the settings have been initialized. This is not a malfunction.

# 8.3 Performing Zero-Level Compensation

WTViewerFreePlus

## Procedure

**Press SHIFT+SET (CAL)** to execute zero-level compensation.

SHIFT SET
CAL

## Explanation

### Zero-Level Compensation

Zero-level compensation is the process of creating a zero-input condition using the internal circuit of this instrument and setting the level at that point to the zero input level. It must be performed to meet the specifications of this instrument (see chapter 7 in the Getting Started Guide, IM WT310E-02EN).
Zero-level compensation is automatically performed when you change the measurement range.

***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 7 in the Getting Started Guide, IM WT310E-02EN).
- If the measurement range remains the same for a long period of time, the zero level may change due to the changes in the instrument's environment. If this happens, we recommend that you execute zero-level compensation.

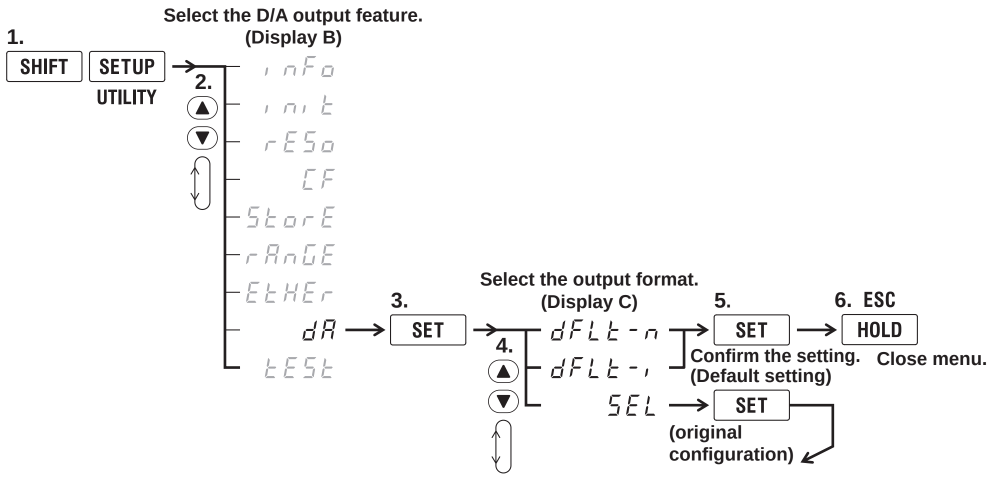
# 8.4 Configuring D/A Output Items (Option)

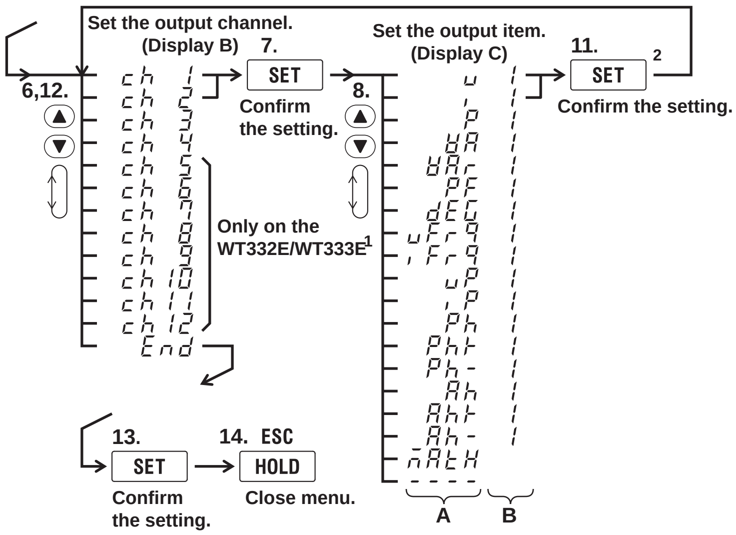
WTViewerFreePlus

## Procedure

Follow the procedure indicated by the thick lines in the following menu.

### D/A Output Format




**8.** Press ▼ and ▲ to set area A (the output function).

On the WT332E/WT333E, select the element in the following steps 9 and 10.

**9.** Press SHIFT ▼ (▶) to move to area B.

**10.** Press ▼ and ▲ to select an element[3] (you cannot select an element for MATH ).

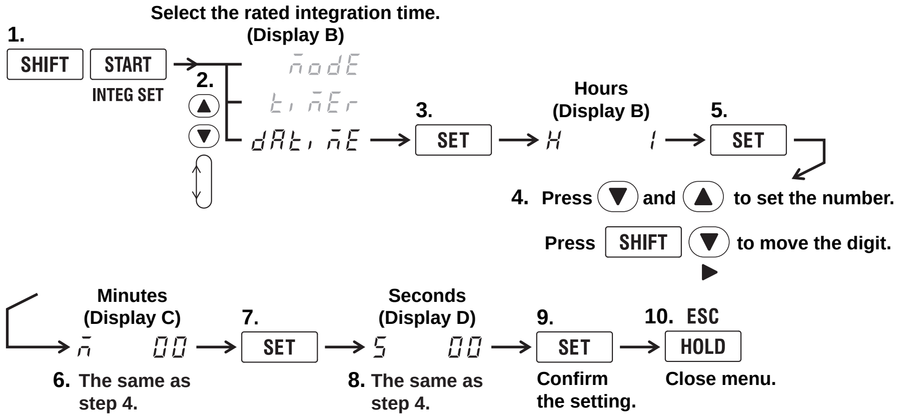
1 The number of channels varies depending on the specific option that is installed.
- /DA4 option on the WT310E/WT310EH: 4 channels
- /DA12 option on the WT332E/WT333E: 12 channels

2 When you press SET in step 11, the output channel shown in display B changes to the next channel. For example, ch1 changes to ch2.

3 The numbers (element numbers) that you can select vary depending on the model. For details, see “Explanation” in this section.

8 Other Features

## Rated Integration Time




## Explanation

## D/A Output

You can output voltage, current, active power, apparent power, reactive power, power factor, phase angle, frequency, voltage peak, current peak, and integrated values using a ±5 V FS DC analog voltage.

## Number of Channels

The number of channels varies depending on the specific option that is installed.

- /DA4 option on the WT310E/WT310EH: 4 channels
- /DA12 option on the WT332E/WT333E: 12 channels

## Output Format

You can select a preconfigured output format or configure your own original format.

### Using the Default Settings

Select one of the default settings to output preconfigured (default) items.

#### Default Values for Normal Measurement: dFLt-n

Select this setting to output normal measurement values. The output settings are as follows:

| | Suffix Code | /DA4 | /DA12 | |
|---|---|---|---|---|
| | Product Name | WT310E WT310EH | WT332E | WT333E |
| Output channel | ch1 | U1 | U1 | U1 |
| | ch2 | I1 | - | U2 |
| | ch3 | P1 | U3 | U3 |
| | ch4 | fU | UΣ | UΣ |
| | ch5 | 1 | I1 | I1 |
| | ch6 | | - | I2 |
| | ch7 | | I3 | I3 |
| | ch8 | | IΣ | IΣ |
| | ch9 | | P1 | P1 |
| | ch10 | | - | P2 |
| | ch11 | | P3 | P3 |
| | ch12 | | PΣ | PΣ |

1 These channels cannot be set.

2 The numbers are used to indicate input elements 1, 2, and 3.

#### Default Values for Integration: dFLt-i

Select this setting to output integrated values. The output settings are as follows:

| | Suffix code | /DA4 | /DA12 | |
|---|---|---|---|---|
| | Product Name | WT310E WT310EH | WT332E | WT333E |
| Output channel | ch1 | P1 | P1 | P1 |
| | ch2 | WP1 | - | P2 |
| | ch3 | q1 | P3 | P3 |
| | ch4 | fU | PΣ | PΣ |
| | ch5 | 1 | WP1 | WP1 |
| | ch6 | | - | WP2 |
| | ch7 | | WP3 | WP3 |
| | ch8 | | WPΣ | WPΣ |
| | ch9 | | q1 | q1 |
| | ch10 | | - | q2 |
| | ch11 | | q3 | q3 |
| | ch12 | | qΣ | qΣ |

1 These channels cannot be set.
2 The numbers are used to indicate input elements 1, 2, and 3.

## Configuring an Original Output Format

You can specify output items (output functions and elements) for each output channel.

#### Output Functions (Area A in step 8 in the procedural explanation for setting the D/A output format)

You can select from the following options.
u (voltage U), i (current I), P (active power P), VA (apparent power S),
VAr (reactive power Q), PF (power factor), dEG (phase angle Φ),
uFrq (voltage frequency fU), iFrq (current frequency fI),
uP (voltage peak Upk), iP (current peak Ipk),
Ph (total watt hour Wp), Ph+ (positive watt hour Wp+), Ph– (negative watt hour Wp–),
Ah (total ampere hour q), Ah+ (positive ampere hour* q+), Ah– (negative ampere hour* q–),
MATH (computation),
– – – – – (D/A output 0 V; no further elements can be set)

* For details on the positive ampere-hour, see “Display Function for Integrated Values” in section 5.1.

#### Elements (Area B in step 10 in the procedural explanation for setting the D/A output format)

| Product Name | Element |
|---|---|
| WT310E or WT310EH | 1 |
| WT332E | 1, 3, 4 |
| WT333E | 1, 2, 3, 4 |

Element number 4 represents Σ.

8

Other Features

## Rated Integration Time

In the D/A output of integrated values, this instrument assumes the integrated value that would be obtained if a rated value (same value as the measurement range) is continuously received over the specified duration to be 100% and assigns this value to 5 V.

The default setting is 1.00.00 (1 h, 00 min, 00 s).

- Range: 0.00.00 (00 h, 00 min, 00 s) to 10000.00.00 (10000 h, 00 min, 00 s)

If you set the rated integration time to 0.00.00, the D/A output value will be 0 V.

For the relationship between measured integrated D/A output and voltage, see "Relationship between Output Items and D/A Output Voltage."

### *Note*

- When the MAX hold feature (see section 4.6) is enabled, the maximum held values (MAX values) for the following items are displayed. The maximum held values (MAX values) are also output in D/A output.
  Voltage, current, active power, apparent power, peak voltage, peak current
- D/A output is performed for each output item with 100% (5 V) representing the application of the rated range value for voltage, current, and power.
- If a scaling coefficient such as a VT ratio, CT ratio, or power coefficient is applied to a voltage, current, or power value and scaling is enabled, this instrument produces 100% D/A output (5 V) when the scaled measured value is the same as the scaled rated value (measurement range × scaling factor).
- Even if the elements have different scaling constants, when you set the element to Σ, this instrument produces 100% D/A output (5 V) when scaled rated values are applied to the elements.
- The D/A output for all math functions except for those indicated below is 0 V.
  Efficiency, average active power during integration

## D/A Output Range Mode (Range Mode)

You can select the D/A output range mode from the following options. The default setting is Fixed.

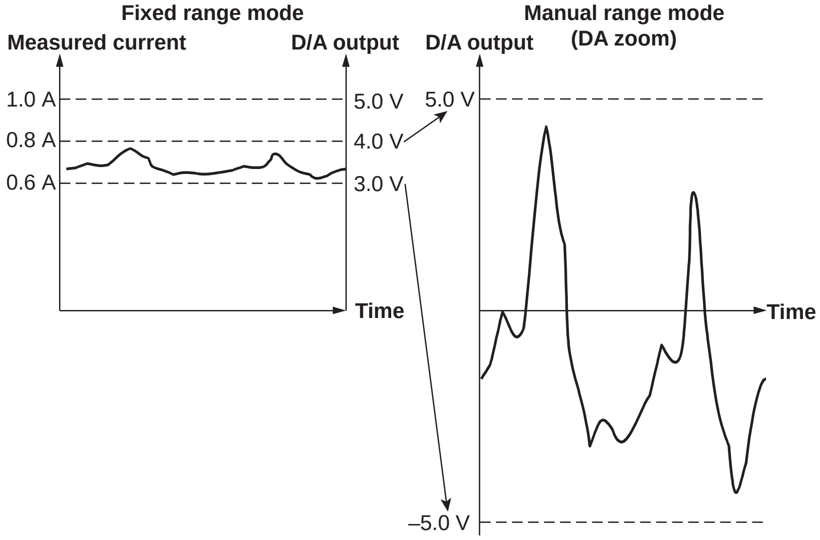
You can set this feature by sending communication commands through the communication interface. You cannot set this feature from the display menu of this instrument. For details, see the Communication Interface User's Manual, IM WT310E-17EN.

### Fixed (Fixed range mode)

When a measurement function's rated value is received, +5 V is output. For details, see "Relationship between Output Items and the D/A Output Voltage" on page 8-10.

### Manual (Manual range mode)

You can set which measurement function values result in a D/A output of -5 V, and which result in a D/A output of +5 V. By doing so, you can enlarge or reduce (zoom) the D/A output of each channel. For example, if you are measuring a current that fluctuates between 0.6 A and 0.8 A with a measurement range of 1 A, when the D/A output range mode is Fixed, the D/A output voltage will fluctuate between 3.0 V and 4.0 V. When you want to observe the fluctuations more closely, you can use the D/A zoom feature. If you set the D/A output range mode to Manual and set the minimum value to 0.6 and the maximum value to 0.8, this instrument will produce –5 V when the measured current value is 0.6 A and +5 V when the measured current value is 0.8 A.




## Compare (Comparator Mode)

By comparing with the comparator limits, this instrument outputs +5 V, 0 V, or –5 V. To replace the output with a relay contact output, like the WT210/WT230 comparator function, provide your own relay and relay driving circuit.

- Below the lower limit: –5 V output
- Greater than or equal to the lower limit and less than the upper limit: 0 V output
- Greater than or equal to the upper limit: +5 V output

## Maximum and Minimum Values in Manual Range Mode and Comparison Upper and Lower Limits in Comparator Mode

You can select a value between -9.999E+12 and 9.999E+12.

The default settings are shown below.

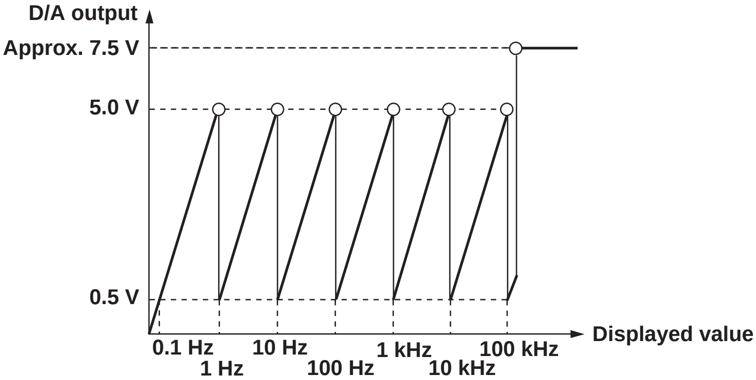
| | | |
|---|---|---|
| Manual Range Mode | Maximum Value | 100.0 |
| | Minimum Value | -100.0 |
| Comparator Mode | Comparison Upper Limit | 100.0 |
| | Comparison Lower Limit | -100.0 |

8

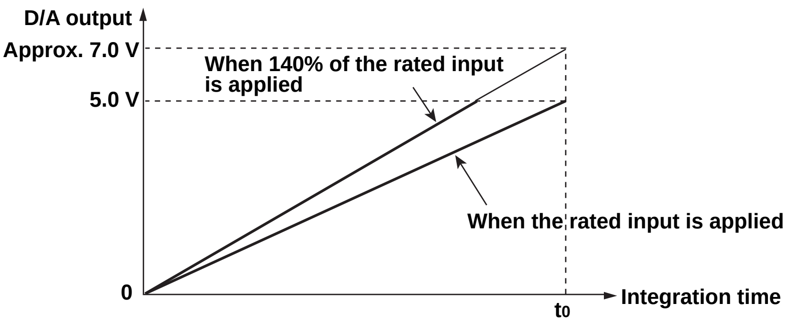
Other Features

# Relationship between Output Items and D/A Output Voltage

## Frequency



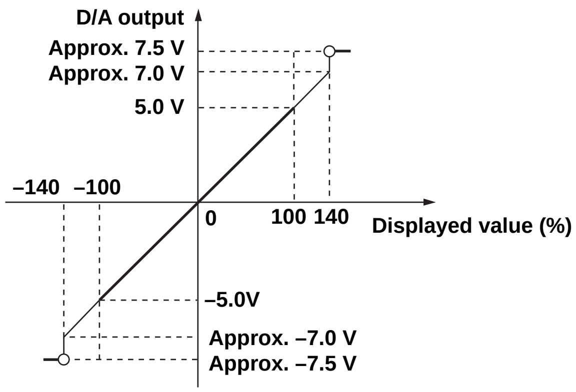

## Integrated Value




$t_0$: Rated integration time

## Other Items

| Displayed Value | Output |
|---|---|
| 140% | Approx. 7.0 V |
| 100% | 5.0 V |
| 0% | 0 V |
| –100% | –5.0 V |
| –140% | Approx. - 7.0 V |




- The range between +5 to +7 V and –5 to –7 V is not output for λ and Φ. When an error occurs, the output is approximately ±7.5 V.
- For the efficiency math function, +5 V represents 100%.
- For Upk and Ipk, ±5 V represents the application of 3 times the rated range value (6 times the rated range value when the crest factor is 6 or 6A).
- When the selected output function is "----" or there is no numerical data, the output is 0 V.

# 8.5 Enabling Key Protection

## Procedure

### Key Protection

**Press SHIFT+INTERFACE** (KEY PROTECT). The KEY PROTECT indicator illuminates, and all keys except for the power switch and KEY PROTECT are disabled.

SHIFT  INTERFACE
KEY PROTECT

### Disabling Key Protection

In the key protected condition, press **SHIFT+INTERFACE** (KEY PROTECT). The KEY PROTECT indicator turns off, and all keys are enabled.

SHIFT  INTERFACE
KEY PROTECT

## Explanation

### Key Protection

You can disable (lock) the front panel keys. The following switch and key are exceptions.

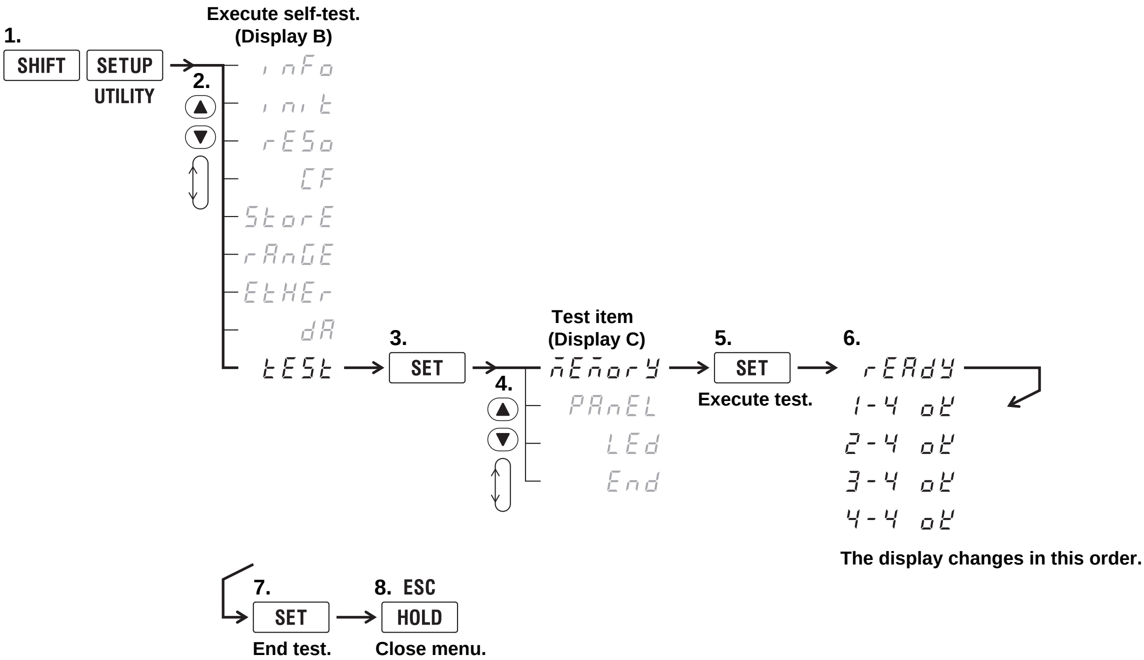
- Power switch
- KEY PROTECT (to disable key lock)

# 8.6 Carrying Out Self-Tests (Selftest)

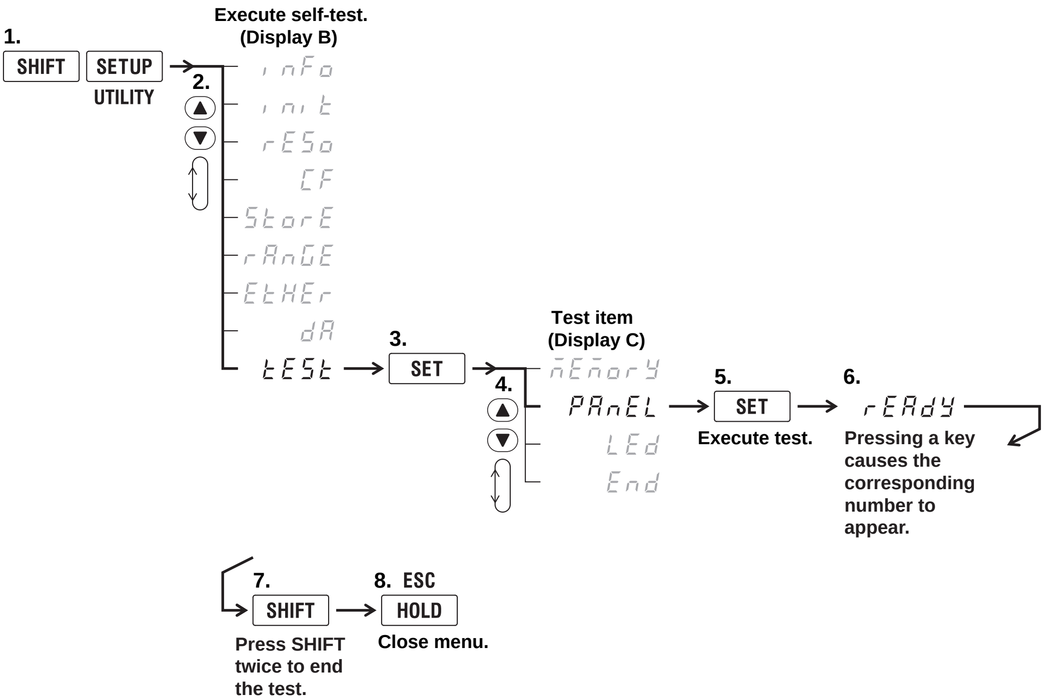
## Procedure

Follow the procedure indicated by the thick lines in the following menu.

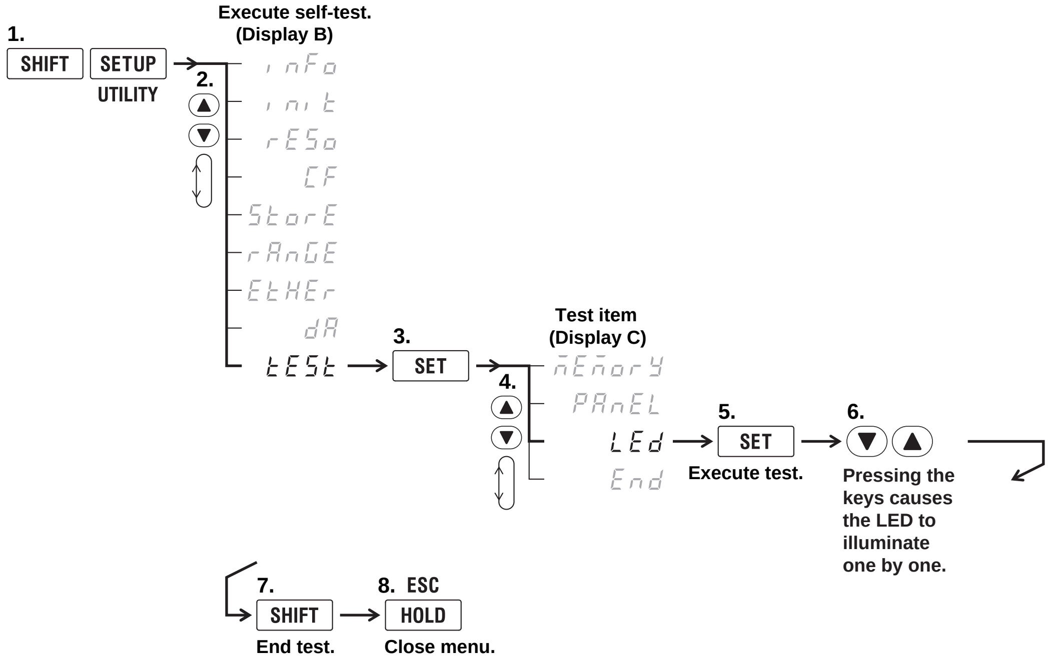
### Memory Test



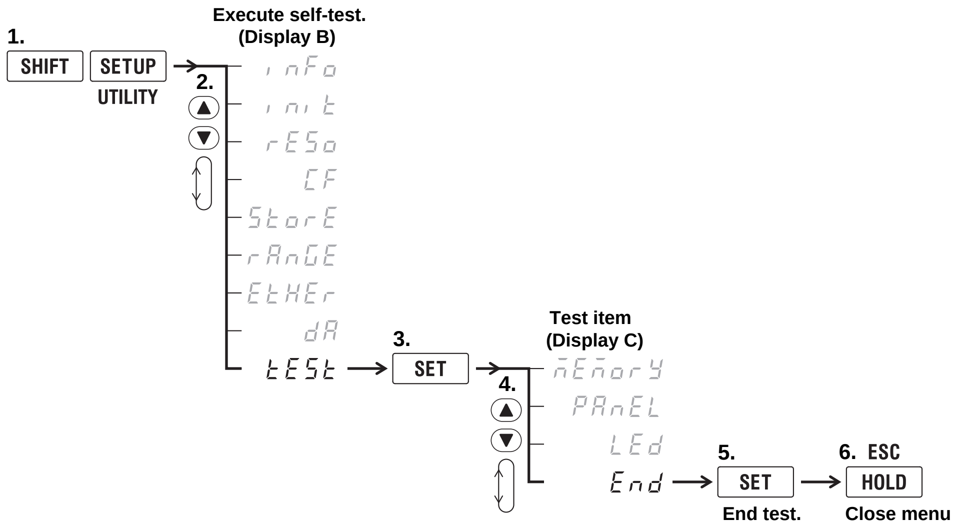

### Panel Key Test



## LED Test




## Ending a Test




8 Other Features

**Explanation**

## Self-test (Selftest)

You can test whether the memory, keys, and LEDs are operating properly.

### Memory Test (MEMorY)

The memory test checks the internal memory. The test is successful if the following messages appear in order.

- rEAdy
- 1-4 oK
- 2-4 oK
- 3-4 oK
- 4-4 oK

### Panel Key Test (PAnEL)

- The panel key test checks the front panel keys. The test is successful if the numbers corresponding to the pressed keys are displayed.
- To exit from the key test, press SHIFT twice.

### LED Test (LEd)

- The LED test checks the front panel indicators. The test is successful if you press the ▲ and ▼ arrow keys and the front panel LEDs turn on and off one by one.
- To exit from the LED test, press SHIFT.

### Ending the Self-Test (End)

The self-test ends.

## If an Error Occurs during a Self-Test

If any of the tests fail after trying them a few times, contact your nearest YOKOGAWA dealer.

# Appendix 1 Symbols and Determination of Measurement Functions

## Measurement Functions Used in Normal Measurement

(Table 1/2)

| Measurement Function | | Methods of Computation and Determination<br>For information about the symbols in the equations, see the notes on the next page. | | |
|---|---|---|---|---|
| Voltage U [V] | True rms value Urms<br>Rectified mean value calibrated to the rms value Umn<br>Simple average Udc | Urms | Umn | Udc |
| | | $\sqrt{AVG[u(n)^2]}$ | $\frac{\pi}{2\sqrt{2}} AVG[\lvert u(n) \rvert]$ | AVG[u(n)] |
| Current I [A] | True rms value Irms<br>Simple average Idc | Irms | | Idc |
| | | $\sqrt{AVG[i(n)^2]}$ | | AVG[i(n)] |
| Active power P [W] | | AVG[u(n) • i(n) ] | | |
| Apparent power S [VA] | | Select from Urms • Irms, Umn • Irms, and Udc • Idc. | | |
| Reactive power Q [var] | | $s \cdot \sqrt{S^2 - P^2}$<br>s is -1 for a lead phase and 1 for a lag phase | | |
| Power factor λ | | $\frac{P}{S}$ | | |
| Phase difference Φ [°] | | $\cos^{-1}\left(\frac{P}{S}\right)$<br>The phase angle displays lead (D) and lag (G). | | |
| Voltage frequency: fU (FreqU) [Hz]<br>Current frequency: fI (FreqI) [Hz] | | The voltage frequency (fU) and current frequency (fI) are measured by detecting the zero-crossing points.<br>Measures fU and fI for the element set in display D of the WT | | |
| Maximum voltage: U + pk [V] | | The maximum u(n) for every data update | | |
| Minimum voltage: U – pk [V] | | The minimum u(n) for every data update | | |
| Maximum current: I + pk [A] | | The maximum i(n) for every data update | | |
| Minimum current: I - pk [A] | | The minimum i(n) for every data update | | |
| Maximum power: P + pk [W] | | The maximum u(n) • i(n) for every data update | | |
| Minimum power: P – pk [W] | | The minimum u(n) • i(n) for every data update | | |
| Voltage crest factor: CfU<br>Current crest factor: CfI | | Voltage crest factor CfU = $\frac{Upk}{Urms}$<br>Upk= \|U+pk\| or \|U-pk\|, whichever is larger | Current crest factor CfI = $\frac{Ipk}{Irms}$<br>Ipk = \|I+pk\| or \|I-pk\|, whichever is larger | |

(Continued on next page)

(Table 2/2)

| | Measurement Function | | Methods of Computation and Determination<br>For information about the symbols in the equations see the notes. |
|---|---|---|---|
| Integration | Integration time [h:m:s] | Time | Time from integration start to integration stop |
| | Watt hours [Wh] | WP<br>WP+<br>WP– | $\left[\frac{1}{N}\sum_{n=1}^{N}\{u(n)\cdot i(n)\}\right]\cdot \text{Time}$<br>N is the integration time sampling count. The unit of Time is hours.<br>WP is the sum of positive and negative watt hours.<br>WP+ is the sum of the above equations for all iterations where u(n) • i(n) is positive.<br>WP– is the sum of the above equations for all iterations where u(n) • i(n) is negative. |
| | Ampere hours [Ah]<br>q<br>q+<br>q– | rms | $\frac{1}{N}\sum_{n=1}^{N} I(n)\cdot \text{Time}$<br>I(n) is the nth measured current value.<br>N is the number of data updates.<br>The unit of time is hours. |
| | | dc | $\frac{1}{N}\sum_{n=1}^{N} i(n)\cdot \text{Time}$<br>i(n) is the nth sampled data of the current signal.<br>N is the number of data samples.<br>The unit of time is hours.<br>q is the sum of i(n)'s positive and negative ampere hours.<br>q+ is the sum of the above equations for all iterations where i(n) is positive.<br>q– is the sum of the above equations for all iterations where i(n) is negative. |

<table>
<tr><td rowspan="14">Σ functions</td><td colspan="2">Wiring system</td><td>Single-phase, three-wire 1P3W</td><td>Three-phase, three-wire 3P3W</td><td>Three-voltage, three-current measurement 3V3A</td><td>Three-phase, four-wire 3P4W</td></tr>
<tr><td colspan="2">UΣ [V]</td><td colspan="2">(U1 + U3) / 2</td><td colspan="2">(U1 + U2 + U3) / 3</td></tr>
<tr><td colspan="2">IΣ [A]</td><td colspan="2">(I1 + I3) / 2</td><td colspan="2">(I1 + I2 + I3) / 3</td></tr>
<tr><td colspan="2">PΣ [W]</td><td colspan="3">P1 + P3</td><td>P1 + P2 + P3</td></tr>
<tr><td colspan="2">SΣ [VA]</td><td>S1 + S3</td><td>$\frac{\sqrt{3}}{2}$(S1 + S3)</td><td>$\frac{\sqrt{3}}{3}$(S1 + S2 + S3)</td><td>S1 + S2 + S3</td></tr>
<tr><td colspan="2">QΣ [var]</td><td colspan="3">Q1 + Q3</td><td>Q1 + Q2 + Q3</td></tr>
<tr><td rowspan="3">WPΣ [Wh]</td><td>WPΣ</td><td colspan="3">WP1 + WP3</td><td>WP1 + WP2 + WP3</td></tr>
<tr><td>WP+Σ</td><td colspan="3">WP+1 + WP+3</td><td>WP+1 + WP+2 + WP+3</td></tr>
<tr><td>WP–Σ</td><td colspan="3">WP–1 + WP–3</td><td>WP–1 + WP–2 + WP–3</td></tr>
<tr><td rowspan="3">qΣ [Ah]</td><td>qΣ</td><td colspan="3">q1 + q3</td><td>$q_1 + q_2 + q_3$</td></tr>
<tr><td>q+Σ</td><td colspan="3">q+1 + q+3</td><td>$q_{+1} + q_{+2} + q_{+3}$</td></tr>
<tr><td>q–Σ</td><td colspan="3">q–1 + q–3</td><td>$q_{-1} + q_{-2} + q_{-3}$</td></tr>
<tr><td colspan="2">λΣ</td><td colspan="4">$\frac{P\Sigma}{S\Sigma}$</td></tr>
<tr><td colspan="2">ΦΣ [°]</td><td colspan="4">$\cos^{-1}\left(\frac{P\Sigma}{S\Sigma}\right)$</td></tr>
</table>

## Note

- u(n) denotes instantaneous voltage.
- i(n) denotes 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 this instrument and the selected wiring system pattern.
- The numbers 1, 2, and 3 used in the equations for UΣ, IΣ, 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.

- On this instrument, S, Q, λ, and Φ are derived through the computation of the measured values of voltage, current, and active power. Therefore, for distorted signal input, the value obtained on this instrument may differ from that obtained on other instruments that use a different method.
- For Q, when the current leads the voltage, the Q value is displayed as a negative value; when the current lags the voltage, the Q value is displayed as a positive value. The value of QΣ may be negative, because it is calculated from the Q of each element with the signs included.

# Measurement Functions Used in Harmonic Measurement (Option)

(Table 1/2)

| Measurement Function | Methods of Computation and Determination: Harmonic order 1 (fundamental wave) | Harmonic order 2 to max (harmonics) | Rms value of all components (Total value) |
|---|---|---|---|
| Voltage U( ) [V] | $U(k) = \sqrt{Ur(k)^2 + Uj(k)^2}$ | | $U = \sqrt{\sum_{k=1}^{max} U(k)^2}$ |
| Current I( ) [A] | $I(k) = \sqrt{Ir(k)^2 + Ij(k)^2}$ | | $I = \sqrt{\sum_{k=1}^{max} I(k)^2}$ |
| Active power P( ) [W] | $P(k) = Ur(k) \cdot Ir(k) + Uj(k) \cdot Ij(k)$ | | $P = \sum_{k=1}^{max} P(k)$ |
| Power factor λ ( ) | $\lambda(1) = \frac{P(1)}{S(1)}$ | — | — |
| Phase difference ΦU( ) [°] | Phase difference between I(1) and U(1) | ΦU(k) = The phase difference between U(k) and U(1) | — |
| Phase difference ΦI( ) [°] | Same as above | ΦI(k) = The phase difference between I(k) and I(1) | — |
| PLL source frequency fU, fI [Hz] | Fundamental frequency of the voltage or current set as the PLL source | | |

(Continued on next page)

## Note

- k denotes a harmonic order, r denotes the real part, and j denotes the imaginary part.
- U(k), Ur(k), Uj(k), I(k), Ir(k), and Ij(k) are expressed using rms values.
- The upper limit of measured harmonic order is denoted by max. max is either an automatically determined value or the specified maximum measured harmonic order, whichever is smaller.
- Harmonic measurement functions are measured only for input elements, not Σ functions.

(Table 2/2)

| Measurement Function | Methods of Computation and Determination | |
|---|---|---|
| | When the Denominator of the THD Equation Is the Total Value (CSA) | When the Denominator of the THD Equation Is the Fundamental Wave (IEC) |
| Harmonic distortion factor of voltage Uhdf( ) [%] | $\frac{U(k)}{U(Total)^*} \cdot 100$ | $\frac{U(k)}{U(1)} \cdot 100$ |
| Harmonic distortion factor of current Ihdf( ) [%] | $\frac{I(k)}{I(Total)^*} \cdot 100$ | $\frac{I(k)}{I(1)} \cdot 100$ |
| Harmonic distortion factor of active power Phdf( ) [%] | $\frac{P(k)}{P(Total)^*} \cdot 100$ | $\frac{P(k)}{P(1)} \cdot 100$ |
| Total harmonic voltage distortion Uthd [%] | $\frac{\sqrt{\sum_{k=2}^{max} U(k)^2}}{U(Total)^*} \cdot 100$ | $\frac{\sqrt{\sum_{k=2}^{max} U(k)^2}}{U(1)} \cdot 100$ |
| Total harmonic current distortion Ithd [%] | $\frac{\sqrt{\sum_{k=2}^{max} I(k)^2}}{I(Total)^*} \cdot 100$ | $\frac{\sqrt{\sum_{k=2}^{max} I(k)^2}}{I(1)} \cdot 100$ |

* $U(Total) = \sqrt{\sum_{k=1}^{max} U(k)^2}$ , $I(Total) = \sqrt{\sum_{k=1}^{max} I(k)^2}$ , $P(Total) = \sum_{k=1}^{max} P(k)$

## Note

- k denotes a harmonic order.
- The upper limit of measured harmonic order is denoted by max. max is either an automatically determined value or the specified maximum measured harmonic order, whichever is smaller.

App

Appendix

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

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

## Power

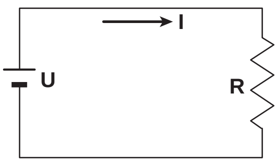
Electrical energy can be converted into other forms of energy and used. For example, it can be converted into the heat in an electric heater, the torque in a motor, or the light in a fluorescent or mercury lamp. In these kinds of examples, the work that electricity performs in a given period of time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

### DC Power

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

P = UI [W]

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

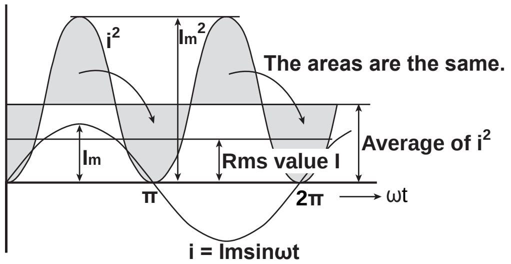



### Alternating Current

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

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

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




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

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

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

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

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

These relationships also apply to sinusoidal voltages.

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

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

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

## Vector Display of Alternating Current

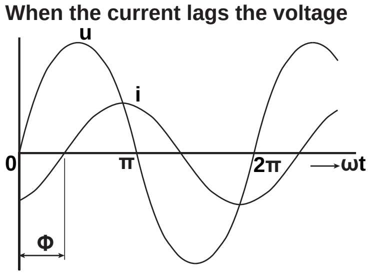
In general, instantaneous voltage and current values are expressed using the equations listed below.

Voltage: u = Umsinωt

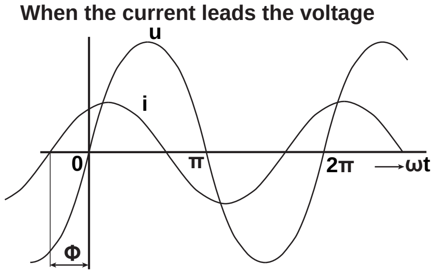
Current: i = Imsin(ωt – Φ)

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

**When the current lags the voltage**



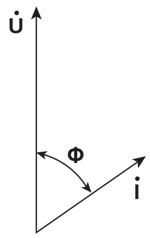

**When the current leads the voltage**



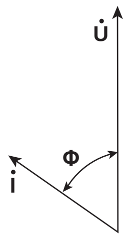

A vector display is used to clearly convey the magnitude and phase relationships between the voltage and current. A positive phase angle is represented by a counterclockwise angle with respect to the vertical axis.

Normally, a dot is placed above the symbol representing a quantity to explicitly indicate that it is a vector. The magnitude of a vector represents the rms value.

**When the current lags the voltage**




**When the current leads the voltage**

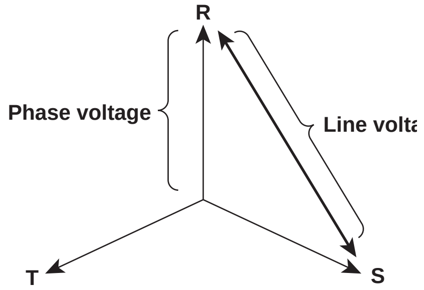


## Three-Phase AC Wiring

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

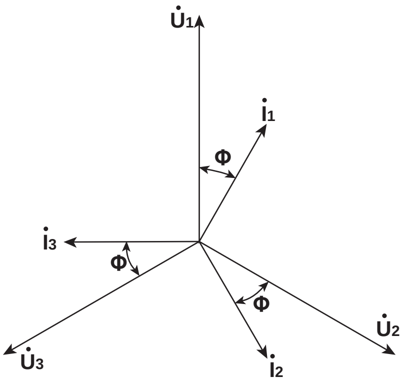

## Vector Display of Three-Phase Alternating Current

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




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

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



## AC Power

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

If the instantaneous voltage u = Umsinωt and the instantaneous current i = Imsin(ωt – Φ), 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.

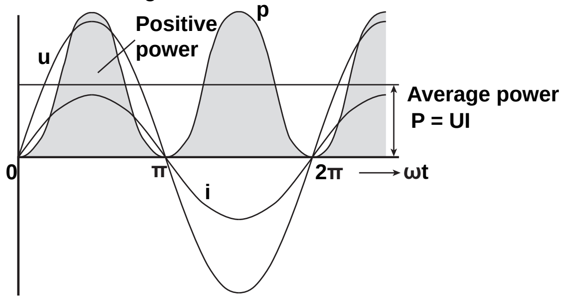
p is the sum of the time-independent term, UIcosΦ, and the AC component term of the voltage or current at twice the frequency, –UIcos(2ωt – Φ).

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

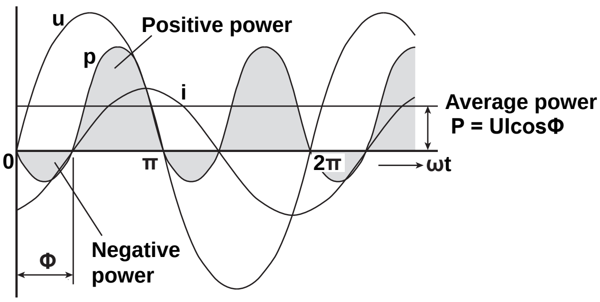
P = UIcosΦ [W]

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

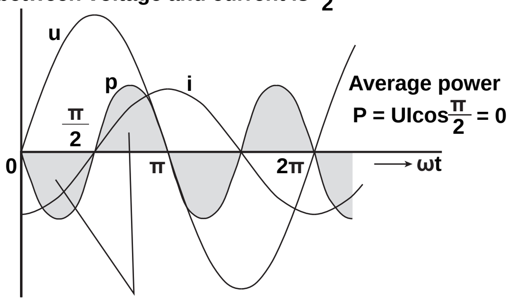
When the phase difference between voltage and current is 0




When the phase difference between voltage and current is Φ




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 [VA]

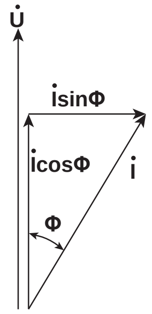
P = UIcosΦ [W]

cosΦ is called the power factor and is expressed as λ. It indicates the portion of the apparent power that becomes true power.

## Reactive Power

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

Q = UIsinΦ [var]




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

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

## Harmonics

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

### Terminology

The terminology related to harmonics is described below.

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

### Interference Caused by Harmonics

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

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

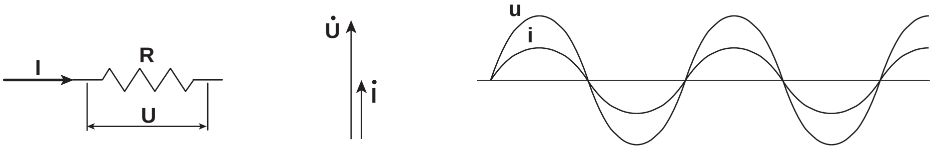
# AC RLC Circuits

## Resistance

The current i when an AC voltage whose instantaneous value u = Umsinωt 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.

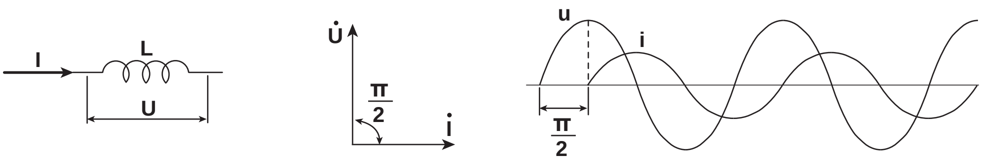



## Inductance

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

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

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

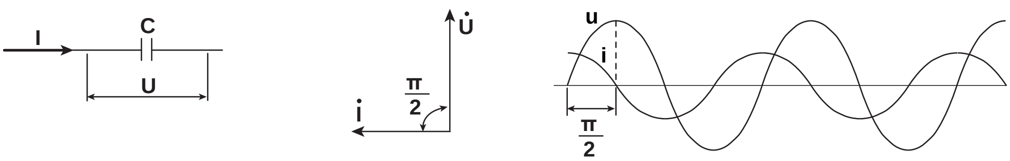



## Capacitance

The current i when an AC voltage whose instantaneous value u = Umsinωt is applied to capacitance C [F] is expressed by the equation below.

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

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



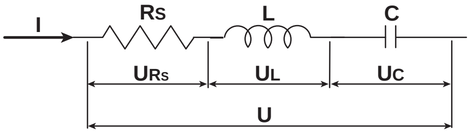
## Series RLC Circuits

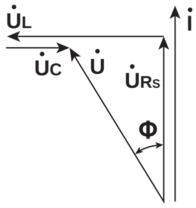
The equations below express the voltage relationships when resistance $R_S$ [Ω], inductance L [H], and capacitance C [F] are connected in series.

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

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

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




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

$$X_S = X_L - X_C$$

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

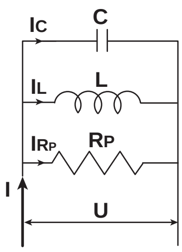
## Parallel RLC Circuits

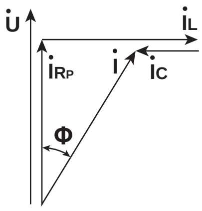
The equations below express the current relationships when resistance $R_P$ [Ω], inductance L [H], and capacitance C [F] are connected in parallel.

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

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

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




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

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

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

# Appendix 3 Power Range

- The table below shows actual voltage and current range combinations and the power ranges that result from them. The table shows the active power range (unit: W). The same ranges are set for apparent power (unit: VA) and reactive power (unit: var). Just read the unit as VA or var.
- The table is for when the number of displayed digits is five. If the number of displayed digits is 4, the least significant digit is removed from the values in the table. For information on how to set the number of displayed digits, see section 4.7.

## WT310E

### When the Crest Factor Is Set to 3

| Voltage Range | Current Range | | | | | |
|---|---|---|---|---|---|---|
| (V) | 500.00 mA | 1.0000 A | 2.0000 A | 5.0000 A | 10.000 A | 20.000 A |
| 15.000 | 7.5000 W | 15.000 W | 30.000 W | 75.000 W | 150.00 W | 300.00 W |
| 30.000 | 15.000 W | 30.000 W | 60.000 W | 150.00 W | 300.00 W | 600.00 W |
| 60.000 | 30.000 W | 60.000 W | 120.00 W | 300.00 W | 600.00 W | 1.2000 kW |
| 150.00 | 75.000 W | 150.00 W | 300.00 W | 750.00 W | 1.5000 kW | 3.0000 kW |
| 300.00 | 150.00 W | 300.00 W | 600.00 W | 1.5000 kW | 3.0000 kW | 6.0000 kW |
| 600.00 | 300.00 W | 600.00 W | 1.2000 kW | 3.0000 kW | 6.0000 kW | 12.000 kW |

| Voltage Range | Current Range | | | | | |
|---|---|---|---|---|---|---|
| (V) | 5.0000 mA | 10.000 mA | 20.000 mA | 50.000 mA | 100.00 mA | 200.00 mA |
| 15.000 | 75.000 mW | 150.00 mW | 300.00 mW | 750.00 mW | 1.5000 W | 3.0000 W |
| 30.000 | 150.00 mW | 300.00 mW | 600.00 mW | 1.5000 W | 3.0000 W | 6.0000 W |
| 60.000 | 300.00 mW | 600.00 mW | 1.2000 W | 3.0000 W | 6.0000 W | 12.000 W |
| 150.00 | 750.00 mW | 1.5000 W | 3.0000 W | 7.5000 W | 15.000 W | 30.000 W |
| 300.00 | 1.5000 W | 3.0000 W | 6.0000 W | 15.000 W | 30.000 W | 60.000 W |
| 600.00 | 3.0000 W | 6.0000 W | 12.000 W | 30.000 W | 60.000 W | 120.00 W |

### When the Crest Factor Is Set to 6 or 6A

| Voltage Range | Current Range | | | | | |
|---|---|---|---|---|---|---|
| (V) | 250.00 mA | 500.00 mA | 1.0000 A | 2.5000 A | 5.0000 A | 10.000 A |
| 7.5000 | 1.8750 W | 3.7500 W | 7.5000 W | 18.750 W | 37.500 W | 75.000 W |
| 15.000 | 3.7500 W | 7.5000 W | 15.000 W | 37.500 W | 75.000 W | 150.00 W |
| 30.000 | 7.5000 W | 15.000 W | 30.000 W | 75.000 W | 150.00 W | 300.00 W |
| 75.000 | 18.750 W | 37.500 W | 75.000 W | 187.50 W | 375.00 W | 750.00 W |
| 150.00 | 37.500 W | 75.000 W | 150.00 W | 375.00 W | 750.00 W | 1.5000 kW |
| 300.00 | 75.000 W | 150.00 W | 300.00 W | 750.00 W | 1.5000 kW | 3.0000 kW |

| Voltage Range | Current Range | | | | | |
|---|---|---|---|---|---|---|
| (V) | 2.5000 mA | 5.0000 mA | 10.000 mA | 25.000 mA | 50.000 mA | 100.00 mA |
| 7.5000 | 18.750 mW | 37.500 mW | 75.000 mW | 187.50 mW | 375.00 mW | 750.00 mW |
| 15.000 | 37.500 mW | 75.000 mW | 150.00 mW | 375.00 mW | 750.00 mW | 1.5000 W |
| 30.000 | 75.000 mW | 150.00 mW | 300.00 mW | 750.00 mW | 1.5000 W | 3.0000 W |
| 75.000 | 187.50 mW | 375.00 mW | 750.00 mW | 1.8750 W | 3.7500 W | 7.5000 W |
| 150.00 | 375.00 mW | 750.00 mW | 1.5000 W | 3.7500 W | 7.5000 W | 15.000 W |
| 300.00 | 750.00 mW | 1.5000 W | 3.0000 W | 7.5000 W | 15.000 W | 30.000 W |

# WT310EH

## When the Crest Factor Is Set to 3

| Voltage Range | Current Range | | | | | |
|---|---|---|---|---|---|---|
| **(V)** | **1.0000 A** | **2.0000 A** | **5.0000 A** | **10.000 A** | **20.000 A** | **40.000 A** |
| 15.000 | 15.000 W | 30.000 W | 75.000 W | 150.00 W | 300.00 W | 600.00 W |
| 30.000 | 30.000 W | 60.000 W | 150.00 W | 300.00 W | 600.00 W | 1.2000 kW |
| 60.000 | 60.000 W | 120.00 W | 300.00 W | 600.00 W | 1.2000 kW | 2.4000 kW |
| 150.00 | 150.00 W | 300.00 W | 750.00 W | 1.5000 kW | 3.0000 kW | 6.0000 kW |
| 300.00 | 300.00 W | 600.00 W | 1.5000 kW | 3.0000 kW | 6.0000 kW | 12.000 kW |
| 600.00 | 600.00 W | 1.2000 kW | 3.0000 kW | 6.0000 kW | 12.000 kW | 24.000 kW |

## When the Crest Factor Is Set to 6 or 6A

| Voltage Range | Current Range | | | | | |
|---|---|---|---|---|---|---|
| **(V)** | **500.00 mA** | **1.0000 A** | **2.5000 A** | **5.0000 A** | **10.000 A** | **20.000 A** |
| 7.5000 | 3.7500 W | 7.5000 W | 18.750 W | 37.500 W | 75.000 W | 150.00 W |
| 15.000 | 7.5000 W | 15.000 W | 37.500 W | 75.000 W | 150.00 W | 300.00 W |
| 30.000 | 15.000 W | 30.000 W | 75.000 W | 150.00 W | 300.00 W | 600.00 W |
| 75.000 | 37.500 W | 75.000 W | 187.50 W | 375.00 W | 750.00 W | 1.5000 kW |
| 150.00 | 75.000 W | 150.00 W | 375.00 W | 750.00 W | 1.5000 kW | 3.0000 kW |
| 300.00 | 150.00 W | 300.00 W | 750.00 W | 1.5000 kW | 3.0000 kW | 6.0000 kW |

## WT332E/WT333E

### When the Crest Factor Is Set to 3

| Wiring System | Voltage Range (V) | Current Range 500.00 mA | 1.0000 A | 2.0000 A | 5.0000 A | 10.000 A | 20.000 A |
|---|---|---|---|---|---|---|---|
| Single-phase, two-wire (1P2W) | 15.000 | 7.5000 W | 15.000 W | 30.000 W | 75.000 W | 150.00 W | 300.00 W |
| | 30.000 | 15.000 W | 30.000 W | 60.000 W | 150.00 W | 300.00 W | 600.00 W |
| | 60.000 | 30.000 W | 60.000 W | 120.00 W | 300.00 W | 600.00 W | 1.2000 kW |
| | 150.00 | 75.000 W | 150.00 W | 300.00 W | 750.00 W | 1.5000 kW | 3.0000 kW |
| | 300.00 | 150.00 W | 300.00 W | 600.00 W | 1.5000 kW | 3.0000 kW | 6.0000 kW |
| | 600.00 | 300.00 W | 600.00 W | 1.2000 kW | 3.0000 kW | 6.0000 kW | 12.000 kW |
| Single-phase, three-wire (1P3W), Three-phase, three-wire (3P3W), Three-voltage, three-current measurement method (3V3A) | 15.000 | 15.000 W | 30.000 W | 60.000 W | 150.00 W | 300.00 W | 600.00 W |
| | 30.000 | 30.000 W | 60.000 W | 120.00 W | 300.00 W | 600.00 W | 1.2000 kW |
| | 60.000 | 60.000 W | 120.00 W | 240.00 W | 600.00 W | 1.2000 kW | 2.4000 kW |
| | 150.00 | 150.00 W | 300.00 W | 600.00 W | 1.5000 kW | 3.0000 kW | 6.0000 kW |
| | 300.00 | 300.00 W | 600.00 W | 1.2000 kW | 3.0000 kW | 6.0000 kW | 12.000 kW |
| | 600.00 | 600.00 W | 1.2000 kW | 2.4000 kW | 6.0000 kW | 12.000 kW | 24.000 kW |
| Three-phase, four-wire (3P4W) | 15.000 | 22.500 W | 45.000 W | 90.000 W | 225.00 W | 450.00 W | 900.00 W |
| | 30.000 | 45.000 W | 90.000 W | 180.00 W | 450.00 W | 900.00 W | 1.8000 kW |
| | 60.000 | 90.000 W | 180.00 W | 360.00 W | 900.00 W | 1.8000 kW | 3.6000 kW |
| | 150.00 | 225.00 W | 450.00 W | 900.00 W | 2.2500 kW | 4.5000 kW | 9.0000 kW |
| | 300.00 | 450.00 W | 900.00 W | 1.8000 kW | 4.5000 kW | 9.0000 kW | 18.000 kW |
| | 600.00 | 900.00 W | 1.8000 kW | 3.6000 kW | 9.0000 kW | 18.000 kW | 36.000 kW |

### When the Crest Factor Is Set to 6 or 6A

| Wiring System | Voltage Range (V) | Current Range 250.00 mA | 500.00 mA | 1.0000 A | 2.5000 A | 5.0000 A | 10.000 A |
|---|---|---|---|---|---|---|---|
| Single-phase, two-wire (1P2W) | 7.5000 | 1.8750 W | 3.7500 W | 7.5000 W | 18.750 W | 37.500 W | 75.000 W |
| | 15.000 | 3.7500 W | 7.5000 W | 15.000 W | 37.500 W | 75.000 W | 150.00 W |
| | 30.000 | 7.5000 W | 15.000 W | 30.000 W | 75.000 W | 150.00 W | 300.00 W |
| | 75.000 | 18.750 W | 37.500 W | 75.000 W | 187.50 W | 375.00 W | 750.00 W |
| | 150.00 | 37.500 W | 75.000 W | 150.00 W | 375.00 W | 750.00 W | 1.5000 kW |
| | 300.00 | 75.000 W | 150.00 W | 300.00 W | 750.00 W | 1.5000 kW | 3.0000 kW |
| Single-phase, three-wire (1P3W), Three-phase, three-wire (3P3W), Three-voltage, three-current measurement method (3V3A) | 7.5000 | 3.7500 W | 7.5000 W | 15.000 W | 37.500 W | 75.000 W | 150.00 W |
| | 15.000 | 7.5000 W | 15.000 W | 30.000 W | 75.000 W | 150.00 W | 300.00 W |
| | 30.000 | 15.000 W | 30.000 W | 60.000 W | 150.00 W | 300.00 W | 600.00 W |
| | 75.000 | 37.500 W | 75.000 W | 150.00 W | 375.00 W | 750.00 W | 1.5000 kW |
| | 150.00 | 75.000 W | 150.00 W | 300.00 W | 750.00 W | 1.5000 kW | 3.0000 kW |
| | 300.00 | 150.00 W | 300.00 W | 600.00 W | 1.5000 kW | 3.0000 kW | 6.0000 kW |
| Three-phase, four-wire (3P4W) | 7.5000 | 5.6250 W | 11.250 W | 22.500 W | 56.250 W | 112.50 W | 225.00 W |
| | 15.000 | 11.250 W | 22.500 W | 45.000 W | 112.50 W | 225.00 W | 450.00 W |
| | 30.000 | 22.500 W | 45.000 W | 90.000 W | 225.00 W | 450.00 W | 900.00 W |
| | 75.000 | 56.250 W | 112.50 W | 225.00 W | 562.50 W | 1.1250 kW | 2.2500 kW |
| | 150.00 | 112.50 W | 225.00 W | 450.00 W | 1.1250 kW | 2.2500 kW | 4.5000 kW |
| | 300.00 | 225.00 W | 450.00 W | 900.00 W | 2.2500 kW | 4.5000 kW | 9.0000 kW |

# Appendix 4 Setting the Measurement Period

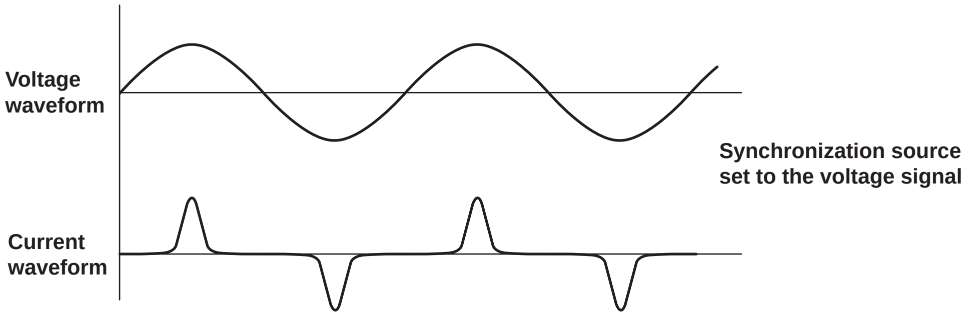
To make correct measurements on this instrument, you must set its measurement period properly.

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

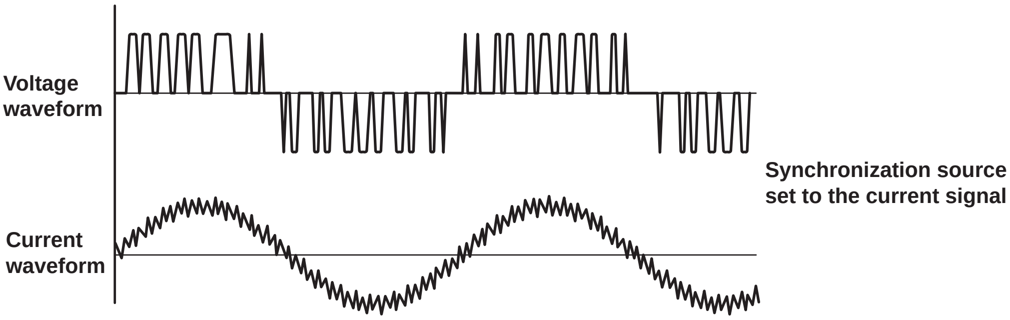
You can select the synchronization source signal from the options listed below.
Voltage (VoLt), Current (Curr), OFF
For example, if the synchronization source is set to current, an integer multiple of the period of the current becomes the measurement period. By averaging the sampled data in this measurement period, this instrument computes the measured values, such as U, I, and P.

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

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

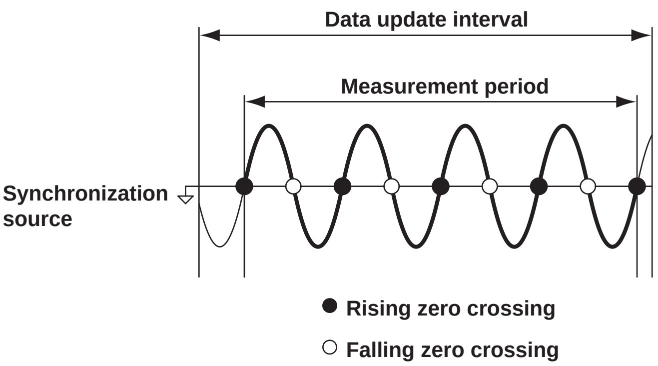


As another example, if an inverter is being measured and the current waveform distortion is smaller than the voltage waveform distortion, set the synchronization source to the current signal.



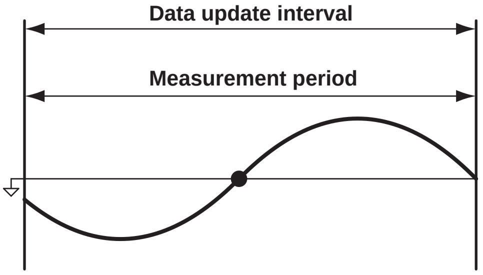

## Zero Crossing

- The rising (or falling) zero crossing is the time when the synchronization source passes through level zero (the center of the amplitude) on a rising (or falling) slope. The measurement period on this instrument is between the first rising (or falling) zero crossing and the last rising (or falling) zero crossing in the data update interval.
- This instrument determines the measurement period on the basis of the first rising or falling zero crossing within the data update interval.




## When the Period of the Synchronization Source Cannot Be Detected

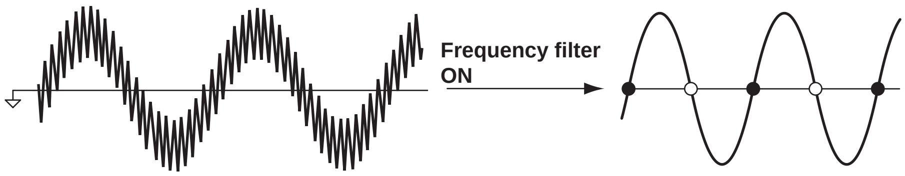
If the total number of rising and falling zero crossings on the input signal that has been set as the synchronization source is less than two within the data update interval, the period cannot be detected. Also, the period cannot be detected if the AC amplitude is small. For information on the detectable frequency levels, see the conditions listed under “Accuracy” under “Frequency Measurement” in section 7.4, “Features,” in the Getting Started Guide, IM WT310E-02EN.
If the synchronization is set to voltage and this instrument cannot detect the voltage period, it will detect and use the current period. If this instrument cannot detect the current period either, the entire data update interval is used to average the sampled data.
Likewise, if the synchronization is set to current and this instrument cannot detect the current period, it will detect and use the voltage period. If this instrument cannot detect the voltage period either, the measurement interval is the entire data update interval.



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

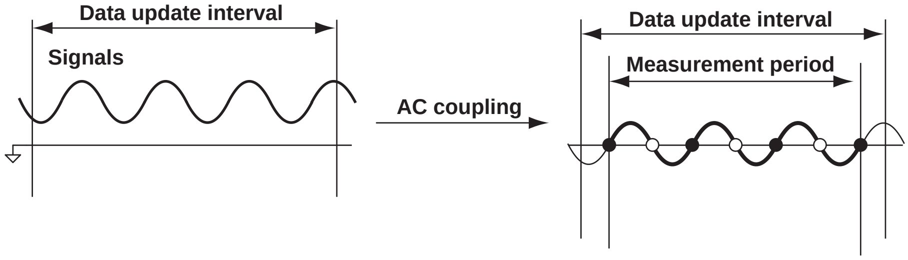
## When the Waveform of the Synchronization Source Is Distorted

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




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

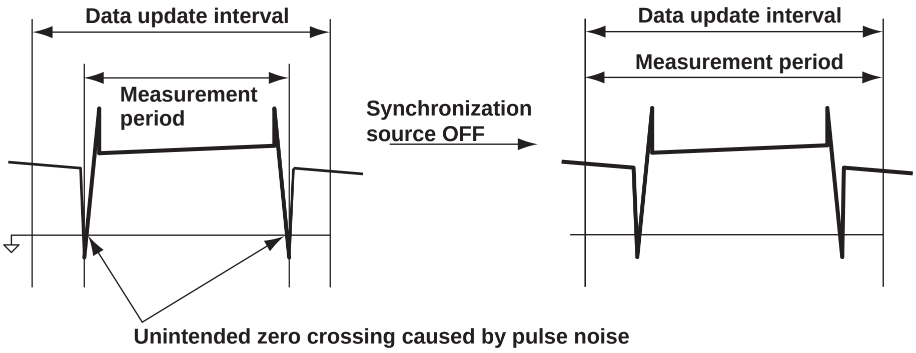
The measured values may be unstable if the period of the AC signal cannot be detected accurately. Change the synchronization source to a signal that allows for more stable detection of the period (switch from voltage to current or from current to voltage). The frequency detection circuit is AC coupled.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




## When Measuring a DC Signal

When there are ripples in the DC signal, if the level of the ripples is greater than or equal to the detection level of the frequency measurement circuit and the period can be detected accurately and stably, a more accurate DC measurement is possible. If a large AC signal is superposed on a DC signal, you can achieve a more stable measurement by detecting the AC signal period and averaging it.
In addition, if a small fluctuating pulse noise riding on the DC signal crosses level zero, that point is detected as a zero crossing. As a result, sampled data is averaged over an unintended period, and measured values such as voltage and current may be unstable. You can prevent these kinds of erroneous detections by setting the synchronization source to OFF. All of the sampled data in the data update interval is used to determine measured values. Set the synchronization source according to the signal under measurement and the measurement objective.

* See the conditions listed under "Accuracy" under "Frequency Measurement" in section 7.4, "Features," in the Getting Started Guide, IM WT310E-02EN.


Data update interval
Measurement period
Synchronization source OFF
Data update interval
Measurement period
Unintended zero crossing caused by pulse noise

# Appendix 5 Measurement Accuracy and Measurement Error

Instruments such as power meters have specifications for measurement accuracy or measurement errors. For example, on this instrument, the voltage and current accuracy in the range of 45 Hz to 66 Hz is ±(0.1% of reading + 0.05 % of range).

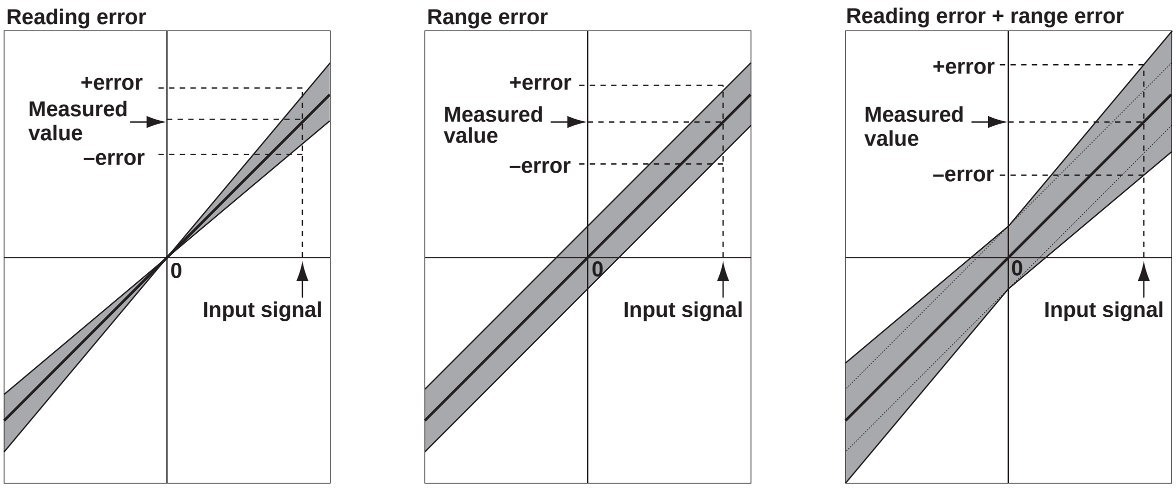
## Reading Error and Range Error

### Reading error: of reading

The error indicated by “of reading” is called reading error. The error is calculated on the basis of the measured reading. It is an error that is included at a given ratio of the measured values. The larger the measured value, larger the reading error that is included. The smaller the measured value, smaller the reading error that is included.

### Range error: of range

The error indicated by “of range” is called range error. The error is calculated on the basis of the measurement range that is used in measurement. It is an error that is included at a given magnitude in the measured values. The range error that is included is of the same magnitude regardless of whether the measured value is large or small.




To see how much error is included in the measured values, let us look at several computation examples for a 60 Hz sine wave input signal.

## Voltage and Current Measurement Error

### Example 1: Measuring 1 Arms Using the 1 A Measurement Range

When the measured value is 1.0000 [A], the reading error and range error are as follows:

- Reading error: 1.0000 [A]×0.1% = 0.001 [A]
- Range error: 1 [A]×0.05% = 0.0005 [A]

The error included in 1.0000 [A] is the sum of the reading and range errors, which is ±0.0015 [A]. This corresponds to 0.15% of the displayed value.

***Note***

Application of an input signal whose value is the same as the name of the measurement range is referred to as rated range input. And, such input signals are called rated range signals.

### Example 2: Measuring 1 Arms Using the 5 A Measurement Range

In this example, we measure the same input using the 5 A range. When the measured value is 1.0000 [A], the reading error and range error are as follows:
- Reading error: 1.0000 [A]×0.1% = 0.001 [A]
- Range error: 5 [A]×0.05% = 0.0025 [A]

The error included in 1.0000 [A] is the sum of the reading and range errors, which is ±0.0035 [A]. This corresponds to 0.35% of the measured value.
The error has increased even though the same current signal as example 1 was measured. As this example illustrates, using a measurement range that is unnecessarily large for an input signal results in larger measurement errors. It is import to measure using a measurement range that is appropriate for the input signal.

**Note**

If the input signal is not a sine wave and includes distortions and spikes, select a somewhat large measurement range that would not cause peak over-ranges to occur.

### Example 3: Measuring 0.5 Arms Using the 1 A Measurement Range

Next, we measure 0.5 A using the 1 A measurement range (the same as example 1). When the measured value is 0.5000 [A], the reading error and range error are as follows:
- Reading error: 0.5000 [A]×0.1% = 0.0005 [A]
- Range error: 1 [A]×0.05% = 0.0005 [A]

The error included in 0.5000 [A] is the sum of the reading and range errors, which is ±0.001 [A]. This corresponds to 0.2% of the measured value.
When we compare this result with that of example 1, we notice the following:
- The reading error has been reduced in accordance with the input amplitude.
- The range error has not changed.

As a result, the error is 0.2%, which is slightly larger than 0.15% of example 1. This is also because the measurement range is large relative to the input signal. In this case, we should use the 0.5 A measurement range.

## Measurement Error of Active Power

On this instrument, the power accuracy in the range of 45 Hz to 66 Hz is ±(0.1% of reading + 0.05 % of range).
Let us calculate the error for the following example.
- Voltage measurement range: 150 V, measured voltage: 100.00 V
- Current measurement range: 1A, measured current: 0.800 A
- Measured power: 80.00 W
- 60 Hz sine wave for both voltage and current
- Phase difference between the voltage and current signals = 0°

### Power Range

The power measurement range is defined as voltage measurement range × current measurement range. In this example, the power measurement range is 150 V×1 A = 150 W. We use this power measurement range to calculate the range error.

The reading error and range error included in the measured power (80.00 W) are as follows:
- Reading error: 80.00 [W]×0.1% = 0.08 [W]
- Range error: 150 [W]×0.05% = 0.075 [W]

The error included in 80.00 [W] is the sum of the reading and range errors, which is ±0.155 [W]. This corresponds to 0.19375% of the displayed value.

## Power Factor Influence (Power Factor Error)

The previous example was for when the phase difference between the voltage and current signals was 0°, or in other words, when the power factor was 1. Next, we will calculate the error for an example in which the power factor is not 1.

### When the Power Factor is 0

This is an example for when the phase difference is 90°, or in other words, when the power factor is 0. Theoretically, the active power is 0 W, apparent power is 80 VA, and the reactive power is 80 var. This assumes an ideal capacitive (C) load or an ideal inductive (L) load. For details, see appendix 2.

When the power factor ($\lambda$) = 0, the power error on this instrument is defined as follows:
±0.1% of S (S: apparent power) in the 45 Hz ≤ f ≤ 66 Hz range

When the measured apparent power is 80.00 [VA], the error in the measured power (0.00 W) is as follows:
80.00 × ±0.1% = ±0.08 [W]

### When the Power Factor Is Greater Than 0 but Less Than 1

As an example, let us calculate the error for when the power factor is 0.5, or in other words, when the phase difference between the voltage and current ($\Phi$) is 60°.

- Voltage measurement range: 150 V, measured voltage: 100.00 V
- Current measurement range: 1A, measured current: 0.800 A
- Power measurement range: 150 W, measured power: 40.00 W, measured apparent power: 80.00 VA, measured reactive power: 69.28 var

When $0 < \lambda < 1$, the power error on this instrument is defined as follows:
(Power reading) × [(power reading error %) + (power range error %) × (power range/indicated apparent power value) + {tan $\Phi$ × (influence when $\lambda$ = 0)%}],

If we substitute the above value into this equation, the power error becomes as follows:
40.00 [W] × [ 0.1% + 0.05% × (150/80.00) + {tan60° × (influence (%) when $\lambda$ = 0)}]
= 40.00 [W] × {0.1 + 0.05 × (150/80.00) + $\sqrt{3}$ × 0.1}%
= 0.1468 [W]

The error in the measured power (40.00 W) is ±0.1468 [W].

App

Appendix

# Error in Three-Phase Power

The error when measuring power of a three-phase, three-wire system using elements 1 and 3 of the WT332E/WT333E is explained with the next example.

- Voltage measurement range: 150 V, measured voltage: 100V for U1, U3, and UΣ
- Current measurement range: 1 A, measured current: 0.8 A for I1, I3, and IΣ
- Measured power: P1 = 69.28 W, P3 = 69.28W, PΣ = 138.56 W
- 60 Hz sine wave for both voltage and current
- Phase difference between the voltage and current signals = 0°
- Phase angle between phases = 60°

## Three-Phase Measurement Range

For the three-phase measurement range, refer to the table of Σ function equations on page App-2. This table shows the expressions that the WT332E/WT333E uses to internally calculate the measured values. This table also applies to how to think about the measurement range. In this example, we will apply the three-phase, three-wire (3P3W) column.

## Voltage and Current

Three-phase voltage (UΣ) measurement range = (U1 measurement range + U3 measurement range)/2 = (150 + 150)/2 = 150

Three-phase current (IΣ) measurement range = (I1 measurement range + I3 measurement range)/2 = (1 + 1)/2 = 1

The reading error and range error included in the measured three-phase voltage (UΣ; 100.00 V) are as follows:

- Reading error: 100.00 [V]×0.1% = 0.1 [V]
- Range error: 150 [V]×0.05% = 0.075 [V]

The error included in 100.00 [V] is the sum of the reading and range errors, which is ±0.175 [V]. This corresponds to 0.175% of the displayed value. Because the measured values of U1 and U3 are the same, UΣ also has the same error. The same calculation method applies for the currents.

## Power

Referring to the table of Σ function equations on page App-2, the power range is as follows:

Three-phase power (PΣ) measurement range
= P1 measurement range + P3 measurement range
= (U1 measurement range × I1 measurement range) + (U3 measurement range × I3 measurement range)
= (150 × 1) + (150 × 1)
= 300

The reading error and range error included in the measured three-phase power (PΣ; 138.56 W) are as follows:

- Reading error: 138.56 [W]×0.1% = 0.13856 [W]
- Range error: 300 [W]×0.05% = 0.15 [W]

The error included in 138.56 [W] is the sum of the reading and range errors, which is ±0.28856 [W]. This corresponds to approximately 0.208% of the displayed value.

## Note

**Accuracy and Precision**

Measurement accuracy refers to how close a measurement is to the true value. In other words, it indicates the deviation of a measured value from the true value. Measurement precision refers to how close measurements of the same quantity are to each other.

For example, let us consider the measured results of two voltmeters when 1.00 V is measured three times.

| | Voltmeter A | Voltmeter B |
|---|---|---|
| 1st measurement | 1.02 V | 1.04 V |
| 2nd measurement | 1.00 V | 1.05 V |
| 3rd measurement | 0.98 V | 1.06 V |

Voltmeter A measurements are closer to the true value (1.00 V). So we can say that voltmeter A is more accurate than voltmeter B.

On the other hand, the three voltmeter B measurements are closer to each other than those of voltmeter A. So we can say that voltmeter B is more precise than voltmeter A.

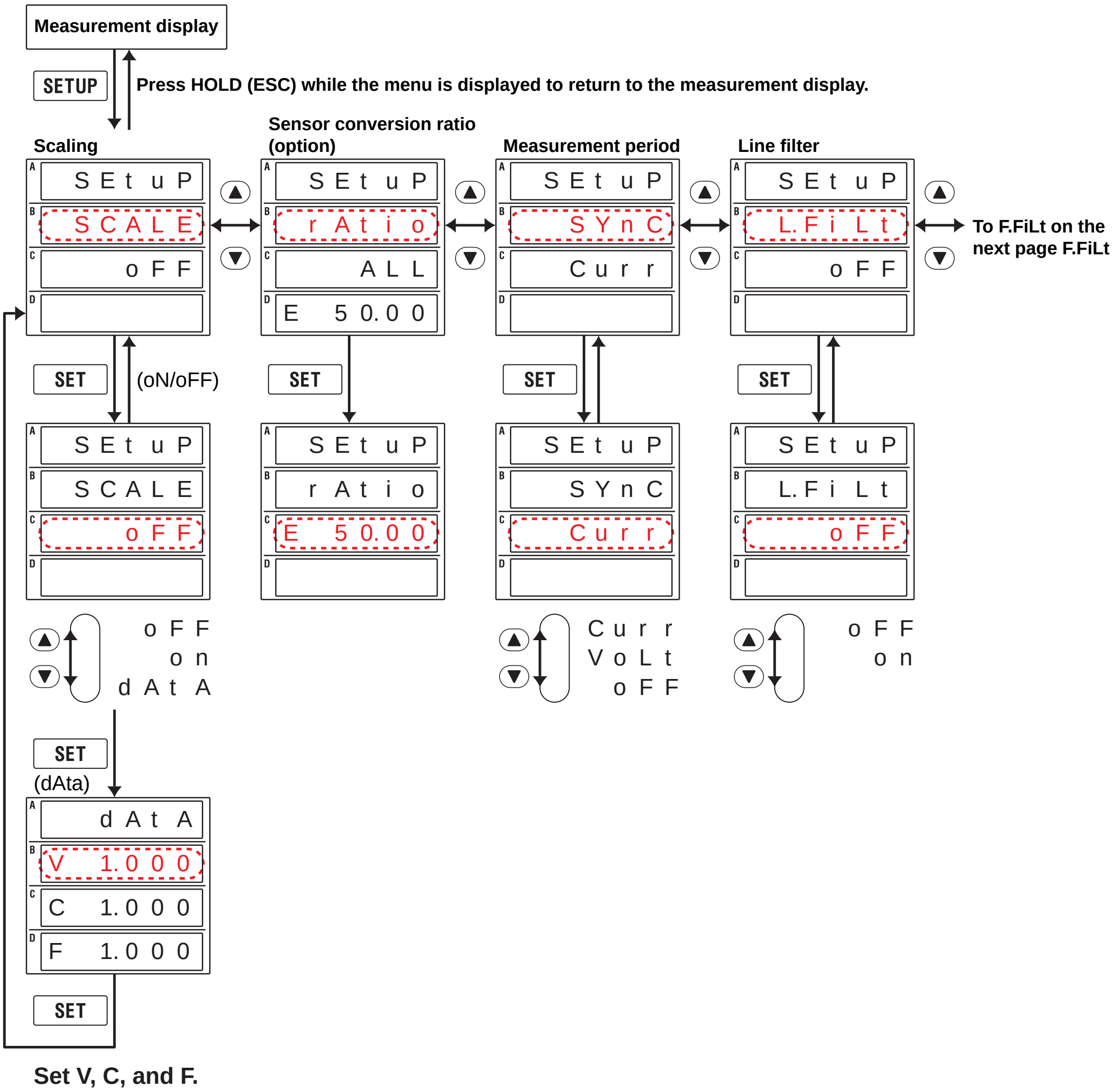
**Measurement Error**

A measurement error is the difference between the actual measurement and the true value.

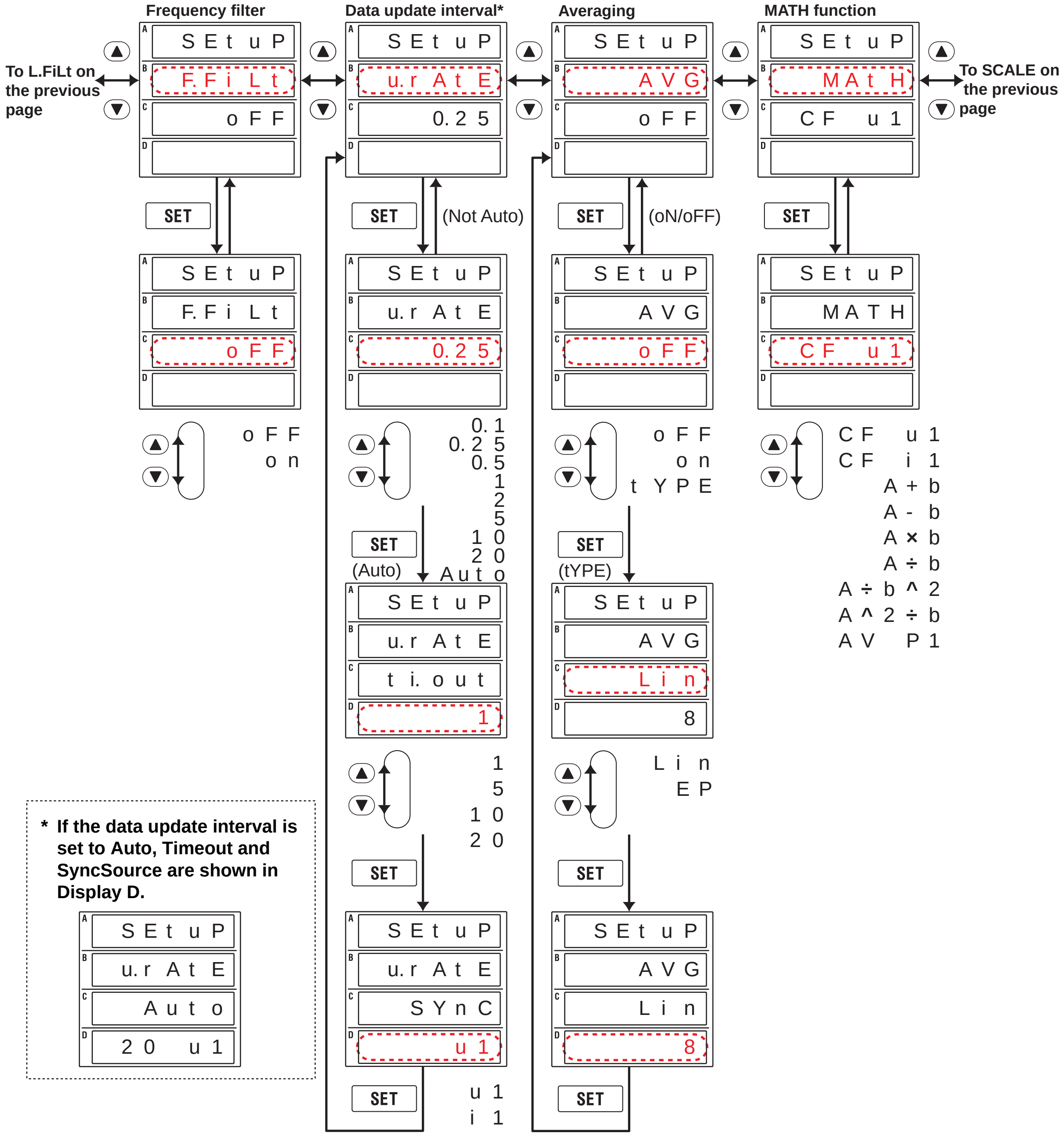
# Appendix 6 Menu Transition Diagram

This section shows the characters on the 7-segment LED using their corresponding alphabet and numbers.

## SETUP Menu (WT310E/WT310EH, 1/2)

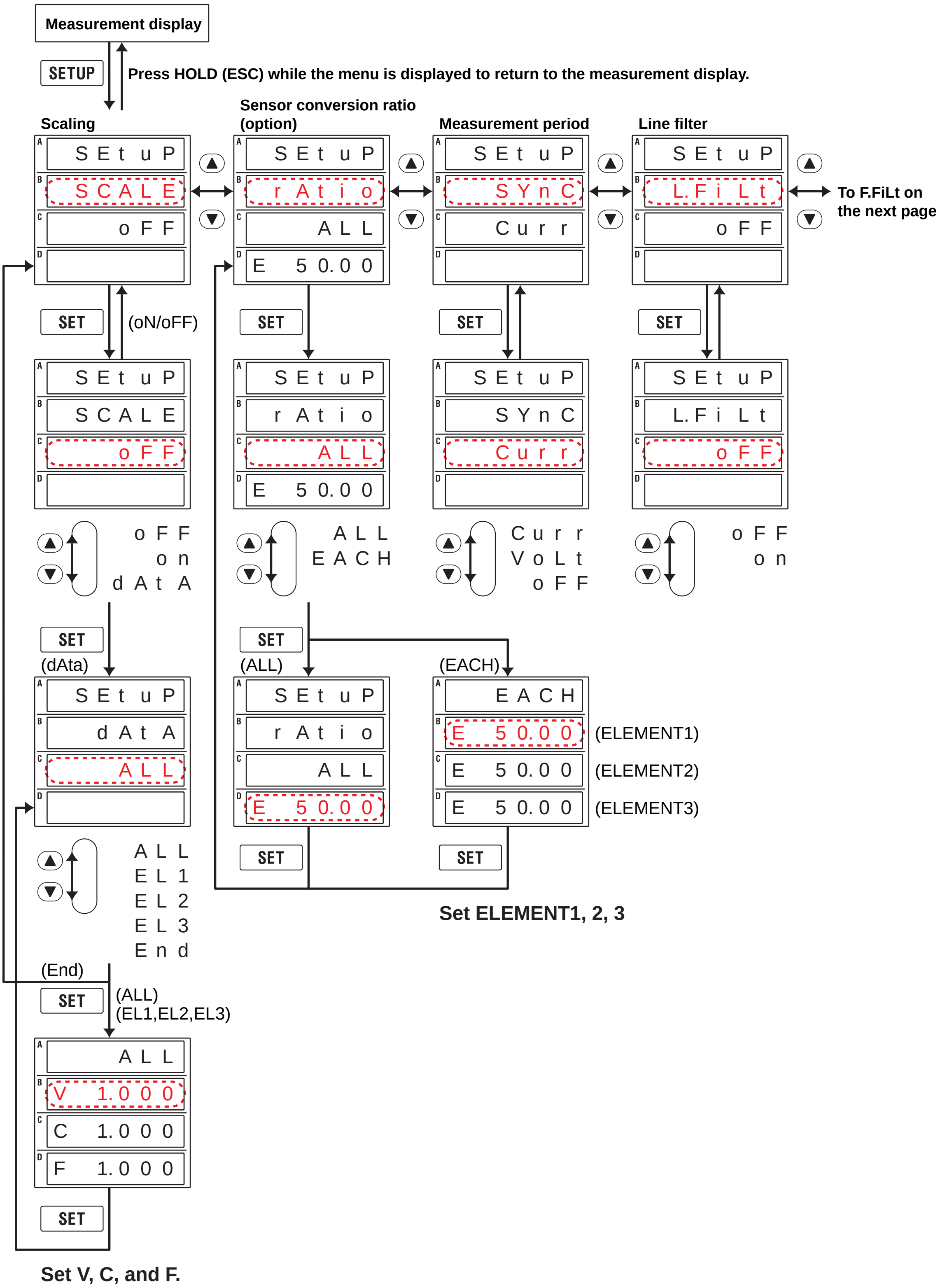


## SETUP Menu (WT310E/WT310EH, 2/2)

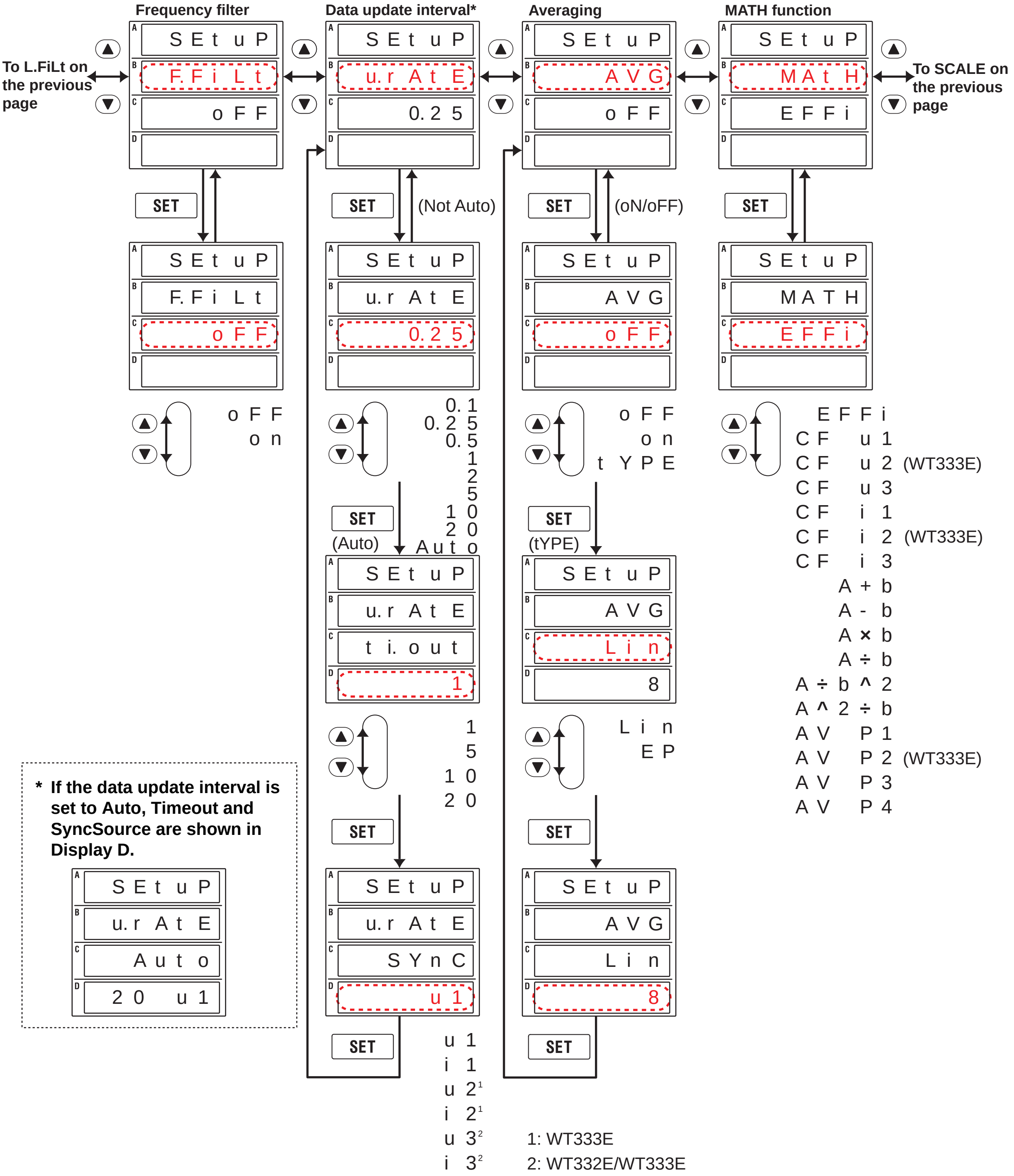



* If the data update interval is set to Auto, Timeout and SyncSource are shown in Display D.

## SETUP Menu (WT332E/WT333E, 1/2)



## SETUP Menu (WT332E/WT333E, 2/2)

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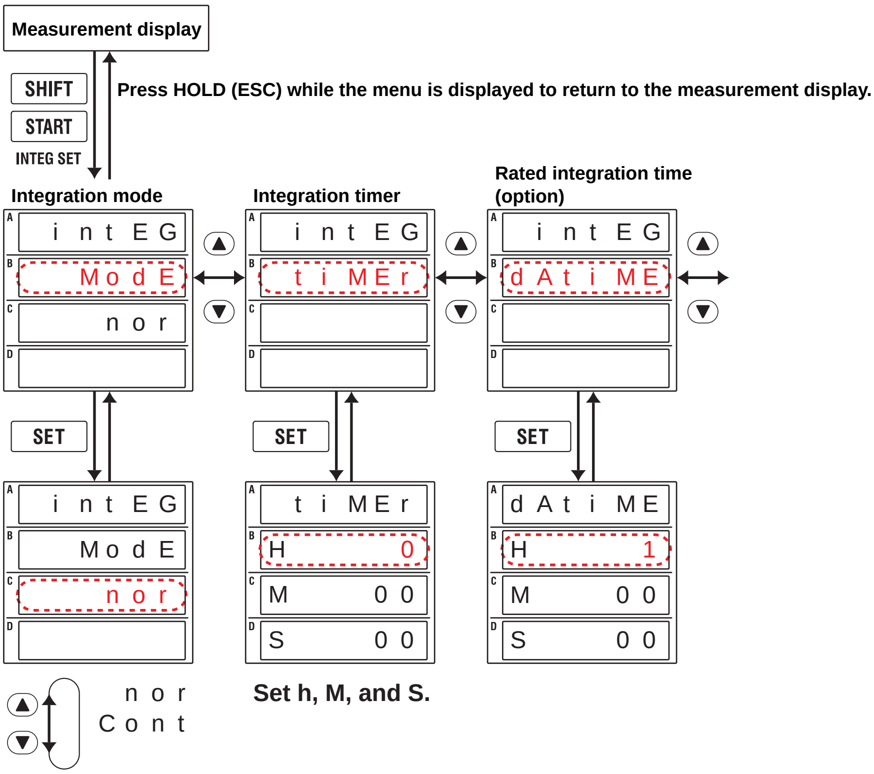
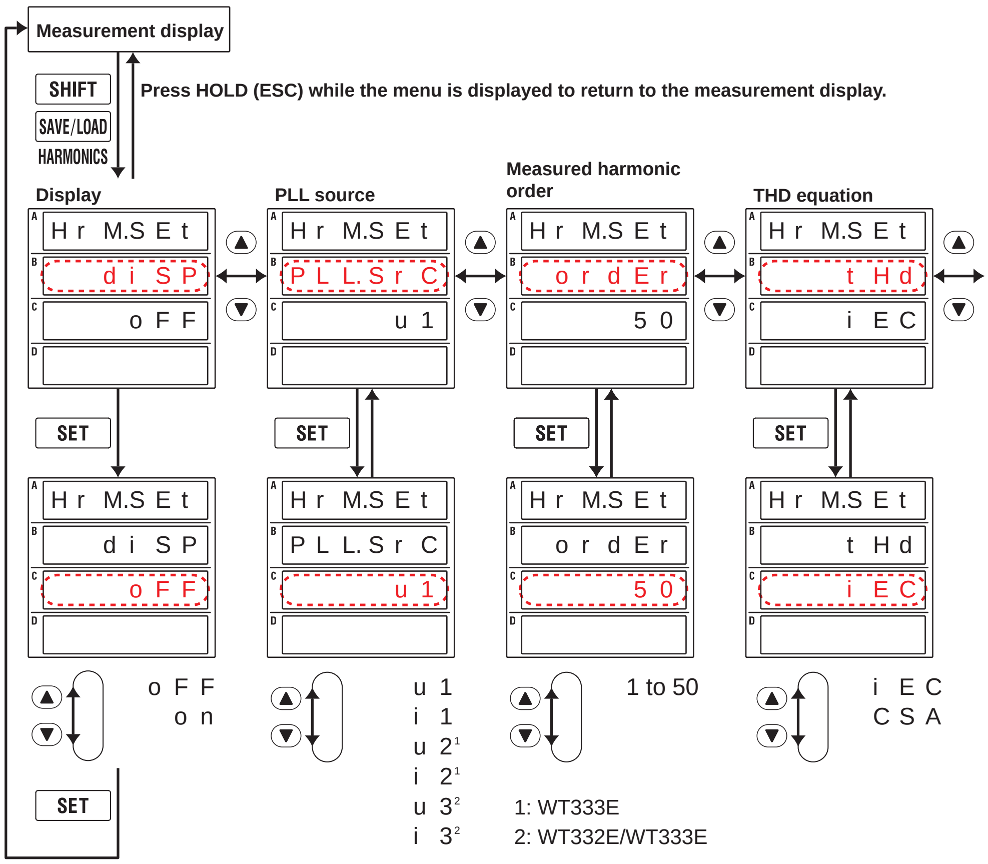
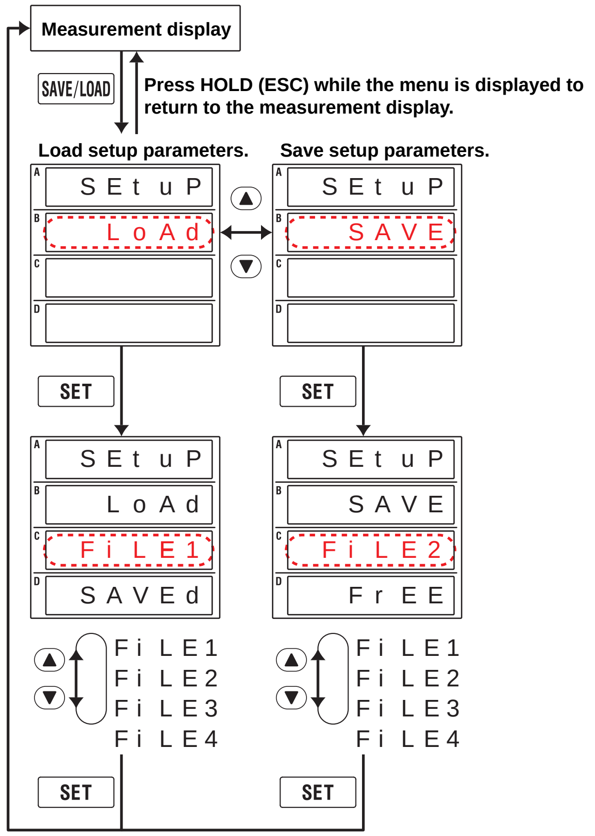
## INTEG SET Menu



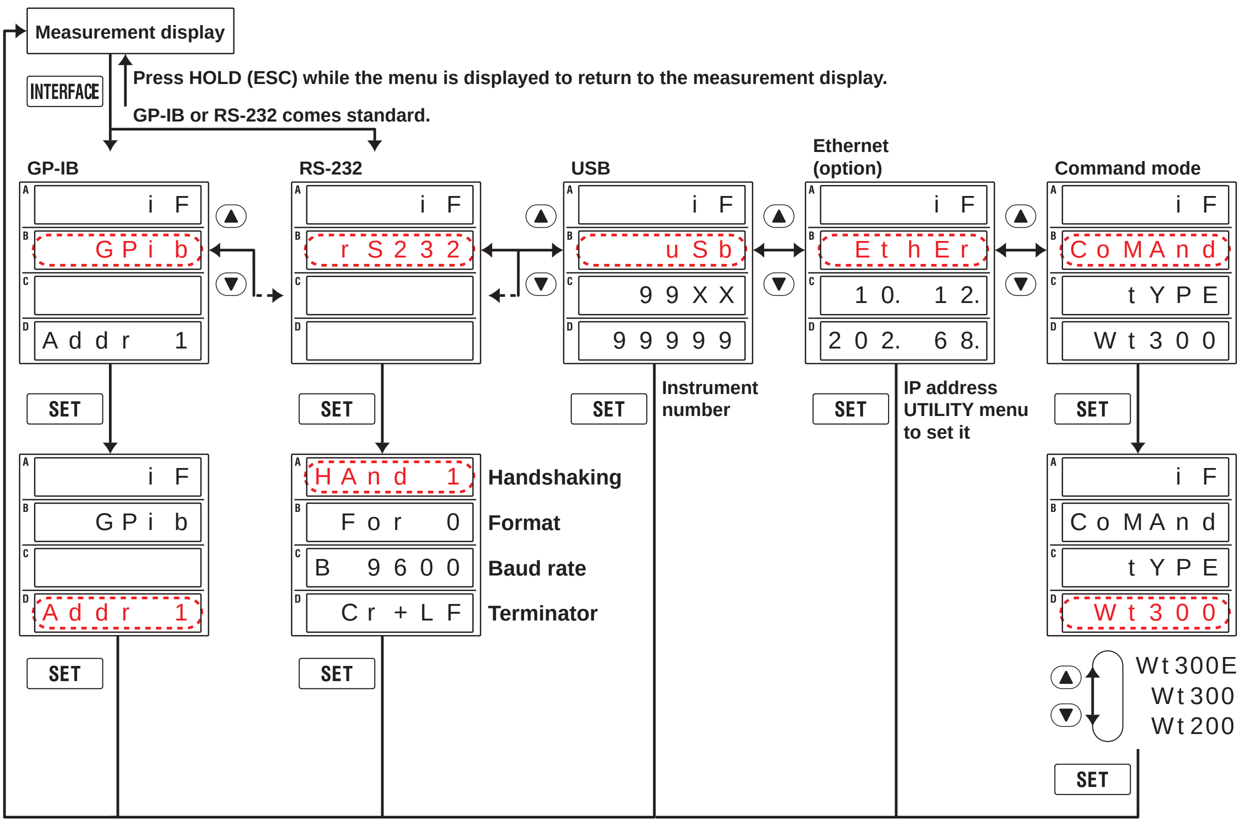

## HARMONICS Menu (Option)



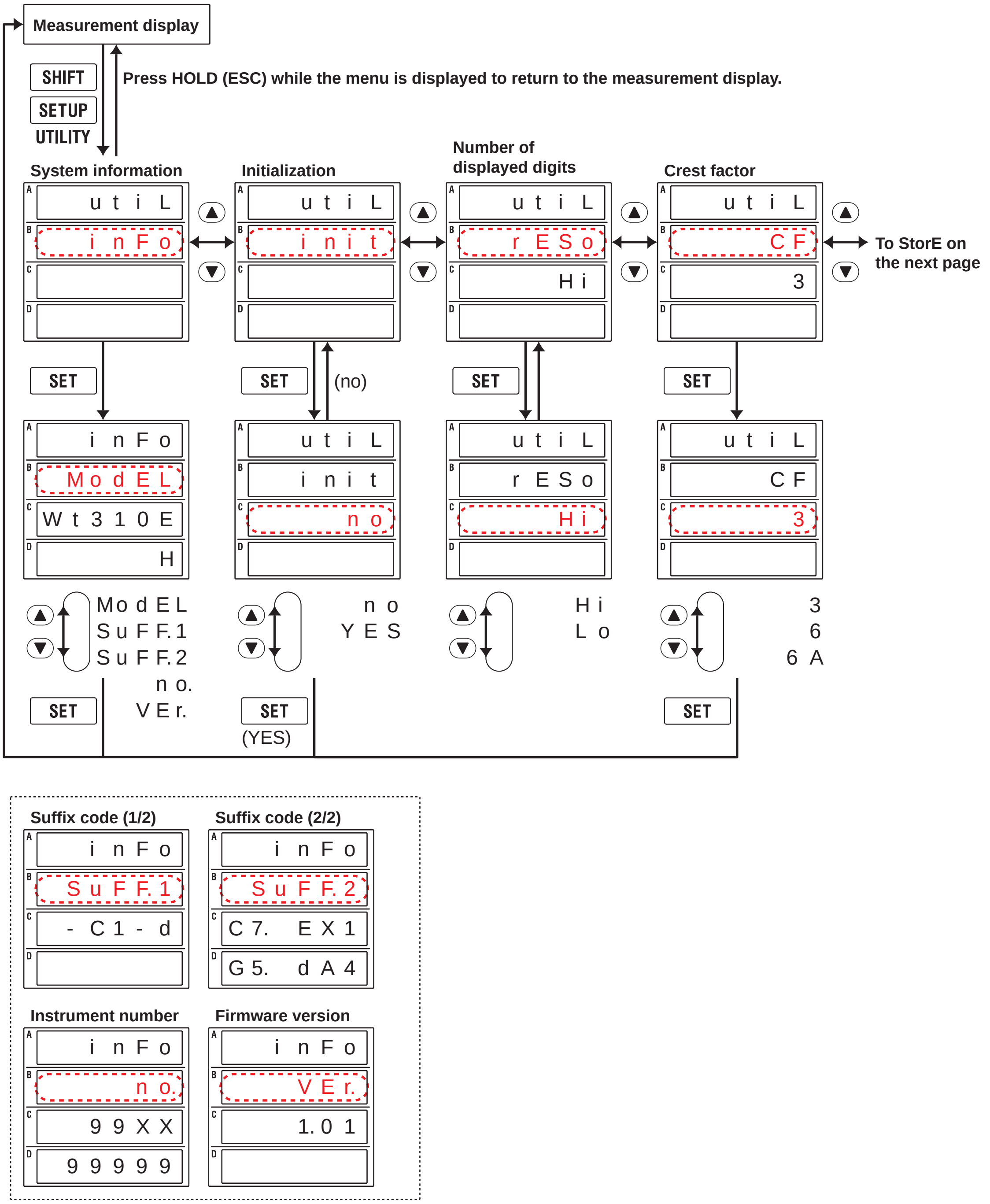
## SAVE/LOAD Menu



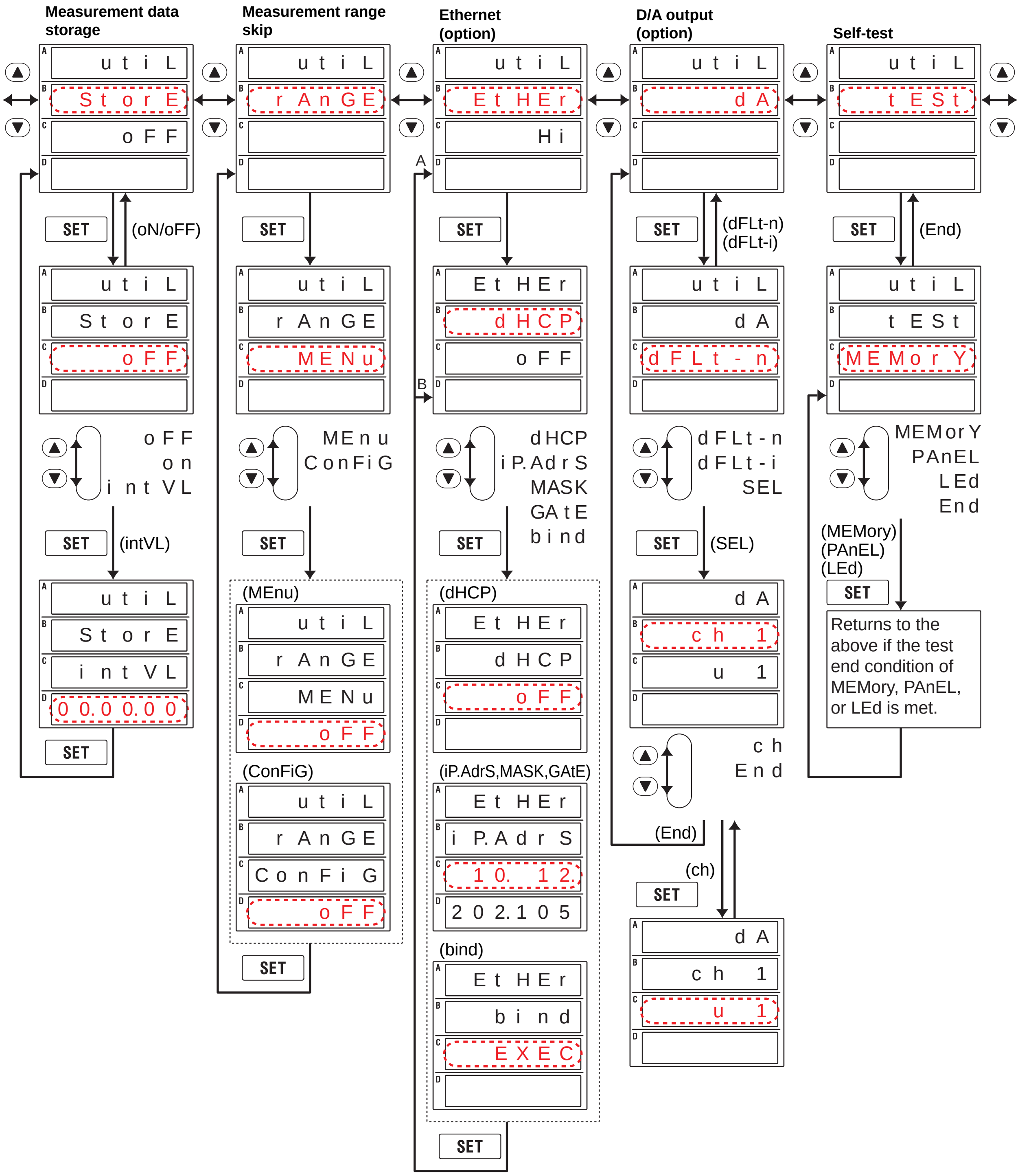

## INTERFACE Menu



## UTILITY Menu (1/2)



## UTILITY Menu (2/2)




A Press SET on the bind menu to return to A.
B Press SET on a menu other than the bind menu to return to B.



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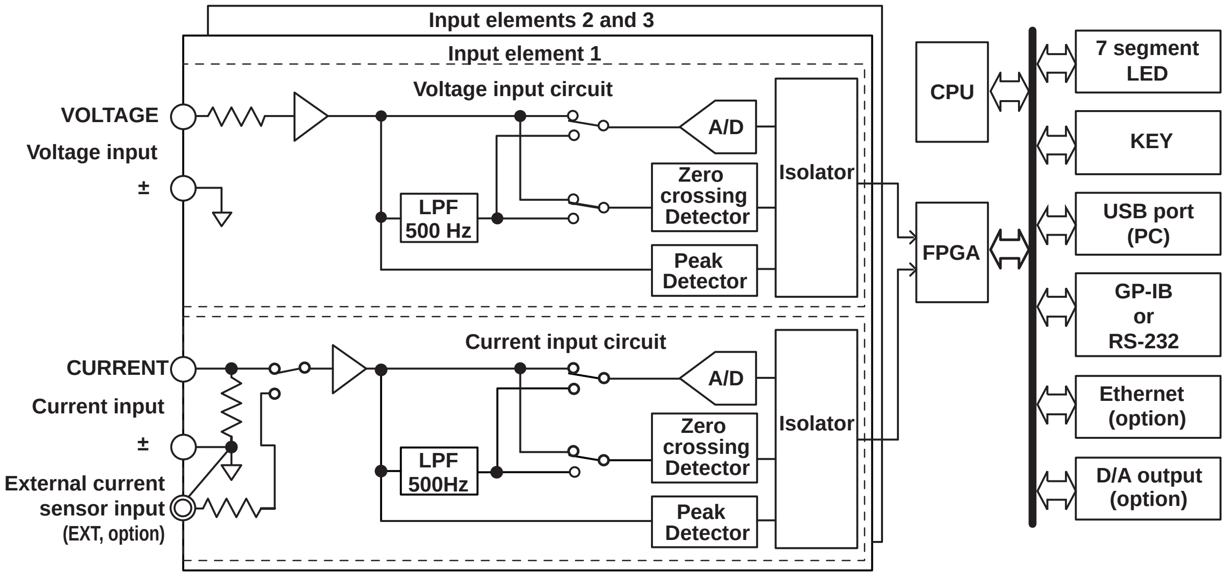
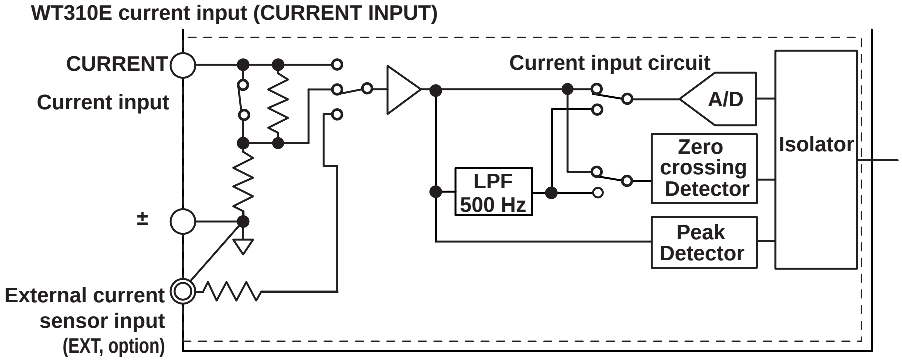
## Block Diagram




WT310E current input (CURRENT INPUT)




## 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 (VOLTAGE, ±) 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 (CURRENT, ±) and an external current sensor input terminal (EXT). Only one can be used at any given time. The voltage signal from the current sensor that is received at the external current sensor input terminal is normalized using the voltage divider and the operational amplifier (op-amp). It is then sent to a current A/D converter.

The current signal that is applied to the current input terminal is converted to a voltage signal by a shunt. Then, it is sent to the current A/D converter in the same fashion as the voltage signal from the current sensor.

The voltage signal that is applied to the voltage A/D converter and current A/D converter is converted to digital values at an interval of approximately 10 μs. These digital values are isolated by the isolator and passed to the FPGA. In the FPGA, the measured values are derived based on the digital values. The measured values are then transmitted to the CPU. Various computed values are determined from the measured values by the CPU. The measured values and computed values are displayed and transmitted (as D/A and communication output) as measurement functions of normal measurement.

The harmonic measurement functions (option) are derived in the following manner. The voltage signal sent to the A/D converter is converted to digital values at a sampling frequency that is determined by the PLL source signal. The CPU derives the measured value of each harmonic measurement item by performing an FFT on the converted digital values.

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