WT110/WT130
Digital Power Meter
USER'S MANUAL

YOKOGAWA
Yokogawa Electric Corporation

IM253401-01E
3rd Edition

Foreword

AThank you for purchasing the YOKOGAWA WT110 or WT130 Digital Power Meter. This User's Manual contains useful information regarding the instrument's functions and operating procedures, as well as precautions that should be observed during use. To ensure proper use of the instrument, please read this manual thoroughly before operating it. Keep the manual in a safe place for quick reference whenever a question arises.

Notes

- The peak measurement function and the MATH function described in this manual apply to WT110/WT130 with ROM version 2.01 or later.
- The contents of this manual are subject to change without prior notice.
- 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 dealer or YOKOGAWA sales office.
- Copying or reproduction of all or any part of the contents of this manual without YOKOGAWA's permission is strictly prohibited.

Revisions

First edition: September 1995
2nd edition: March 1997
3rd edition: March 1998

Disk No. BA12
3rd Edition:March 1998(YK)

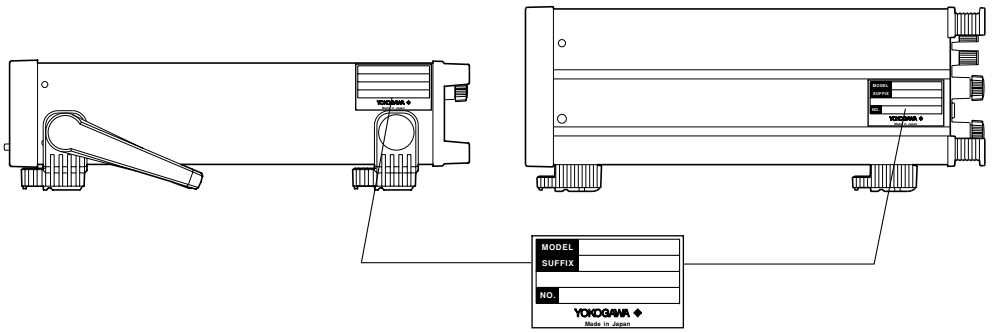
Checking the Contents of the Package

Unpack the box and check the contents before operating the instrument. In case the wrong instrument or accessories have been delivered, or if some accessories are not present, or if they seem abnormal, contact the dealer from which you purchased them.

WT110/WT130 Main Body

Check that the model code and suffix code given on the name plate located at the right side of the main body are according to your order.

WT110 (model code: 253401) **WT130 (model code: 253502, 253503)**



Model and Suffix codes

Model code	Suffix code	Specifications
253401		WT110 Single-phase model
253502		WT130 Three-phase, three-wire model
253503		WT130 Three-phase, four-wire model
Interface	-C1	GP-IB interface
	-C2	RS-232-C interface
Power voltage	-0	100-120V/220-240V
Power cord	-D	[Maximum rated voltage: 125V; Maximum rated current: 7A]
	-F	VDE Standard Power Cord (Part No.: A1009WD) [Maximum rated voltage: 250V; Maximum rated current: 10A]
	-J	BS Standard Power Cord (Part No.: A1023WD) [Maximum rated voltage: 250V; Maximum rated current: 5A]
	-R	SAA Standard Power Cord (Part No.: A1024WD) [Maximum rated voltage: 240V; Maximum rated current: 10A]
Options		
External sensor input function		/EX1 ... 2.5/5/10V range /EX2 ... 50/100/200mV range
Harmonic analysis function		/HRM .. –
External input/output function		/DA4 ... 4 channels D/A output (for 253401) /DA12 . 12 channels D/A output (for 253502/253503) /CMP .. Comparator 4 channels, D/A output 4 channels

Ex: WT130 Three-phase, three-wire model, GP-IB interface, with UL/CSA power cord, with external sensor input 50/100/200mV range, with harmonic analysis function, and 12 channels D/A output →253202-C1-0-D/EX2/HRM/DA12

NO. (instrument number)

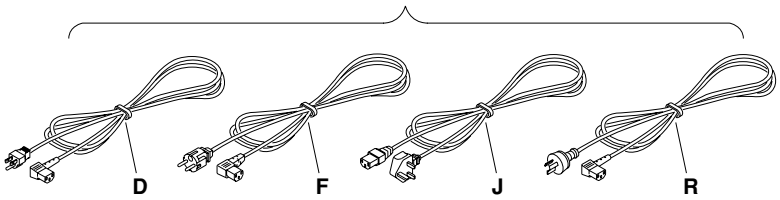
When contacting the dealer from which you purchased the instrument, please quote the instrument No.

Standard Accessories

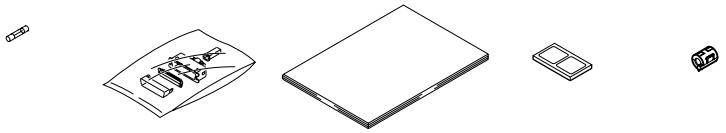
The following standard accessories are supplied with the instrument. Make sure that all items are present and undamaged.

Name	Part No.	Q'ty	Remarks
1 Power cord	see page 2	1	—
2 Power fuse	A1346EF	1	only for the three-phase model Time lag, 0.5A, 250V (located in the fuse holder) Not provided with the single-phase model
3 24-pin connector	A1004JD	1	For remote, D/A output (only provided with options /DA4, /DA12 or /CMP)
4 User's Manual	IM253401-01E	1	this manual
5 Rubber feed	A9088ZM	1 set	
6 Clamp filter (Ferrite core)	A1179MN	1	for WT110 only

1. One of the power cords is supplied according to the instrument's suffix code



2. **3.** **4.** **5.** **6.**



Optional Equipment

The following optional equipment is available. Upon receiving any optional equipment, make sure that all the items ordered have been supplied and they are in good condition.
If you have any questions regarding optional equipment, or if you wish to place an order, contact the dealer from whom you purchased the instrument.

Name	Parts No.	Minimum Q'ty	Remarks
Digital printer	740921	1	ESC/P compatible, RS-232-C/Centronics

Note

It is recommended that the packing box be kept in a safe place. The box can be used for transporting the instrument.

Safety Precautions

This instrument is a IEC safety class I instrument (provided with terminal for protective grounding).
The following general safety precautions must be observed during all phases of operation, service and repair of this instrument. If this instrument is used in a manner not sepecified in this manual, the protection provided by this instrument may be impaired.
Also,YOKOGAWA Electric Corporation assumes no liability for the customer’s failure to comply with these requirements.

The fullowing symbols are used on this instrument.


To avoid injury, death of personnel or damage to the instrument, the operator must refer to an explanation in the User's Manual or Service Manual.


Danger, risk of electric shock


Alternating current

ON(power)


OFF(power)


In-position of a bistable push control


Out-position of a bistable push control


Ground

WARNING

Do not Operate in an Explosive Atmosphere

Do not operate the instrument in the presence of flammable liquids or vapors.

Operation of any electrical instrument in such an environment constitutes a safety hazard.

Protective Grounding

Make sure to connect the protective grounding to prevent an electric shock before turning ON the power.

Necessity of Protective Grounding

Never cut off the internal or external protective grounding wire or disconnect the wiring of protective grounding terminal. Doing so poses a potential shock hazard.

Defect of Protective Grounding

Do not operate the instrument when protective grounding or fuse might be defective.

Power Cord and Plug

To prevent an electric shock or fire, be sure to use the power cord supplied by YOKOGAWA. The main power plug must be plugged in an outlet with protective grounding terminal. Do no invalidate protection by using an extension cord without protective grounding.

Power Supply

Ensure the source voltage matches the voltage of the power supply before turning ON the power.

External Connection

To ground securely, connect the protective grounding before connecting to measurement or control unit.

Fuse

To prevent a fire, make sure to use fuses with specified standard (current, voltage, type). Before replacing the fuse, turn OFF the power and disconnect the power source. Do not use a different fuse or short-circuit the fuse holder.

Do not Remove any Covers

There are some areas with high voltage. Do not remove any cover if the power supply is connected. The cover should be removed by qualified personnel only.

How to Use this Manual

This User's Manual consists of 15 chapters, an Appendix and an Index as described below.

Chapter 1	**What this Instrument Can Do** Explains the flow of the measurement input signals and gives an outline of the functions.
Chapter 2	**Nomenclature, Keys and Displays** Gives the name of each part and each key, and describes how to use it. This chapter also gives the displays in case of overrange/error during measurement.
Chapter 3	**Before Operation** Describes points to watch during use and describes how to install the instrument, wire the measuring circuits, connect the power cord and switch the power ON/OFF.
Chapter 4	**Setting Measurement Conditions** Explains settings such as measurement mode, filter ON/OFF, measurement range, scaling in case of external PT/CT or external sensor (such as shunt or clamp), averaging and measurement conditions.
Chapter 5	**Measuring/Displaying Voltage, Current, and Active Power and Frequency** Explains the procedures for measuring and displaying voltage, current and active power.
Chapter 6	**Computing/Displaying Apparent Power, Reactive Power, Power Factor and Phase Angle.** Explains the procedures for measuring and displaying apparent power, reactive power, power factor and phase angle.
Chapter 7	**Integrating** Explains the procedures for integration of active power and current.
Chapter 8	**Using the Harmonic Analysis Function (option)** Explains the procedures when using the harmonic analysis function.
Chapter 9	**Storing/Recalling** Explains the procedures when storing or recalling measured data or setting parameters from the internal memory.
Chapter 10	**Using External In/Output** Explains the procedures for remote control, D/A output (option), external plotter/ printer output and comparator (option).
Chapter 11	**GP-IB Interface** Explains the procedures for controlling the instrument by personal computer and for sending measurement/computed data to a personal computer using the GP-IB interface.
Chapter 12	**RS-232-C Interface** Explains the procedures for controlling the instrument by personal computer/ controller and for sending measurement/computed data to a personal computer/ controller using the RS-232-C interface.
Chapter 13	**Other Useful Functions** Explains the procedures such as backing up set-up information and initializing settings.
Chapter 14	**Adjustment, Calibration and Trouble-Shooting** Explains the procedures for calibration, adjustment, the way to verify trouble, the contents of error messages and the way to replace the fuse.
Chapter 15	**Specifications** Describes the specifications of the instrument.
Appendix	Describes communication commands and sample programs.
Index	Gives the index in alphabetic order.

Conventions Used in this Manual

Symbols Used

The following symbol marks are used throughout this manual to attract the operator's attention.

To avoid injury or death of personnel, or damage to the instrument, the operator must refer to the User's Manual. In the User's Manual, these symbols appear on the pages to which the operator must refer.

WARNING Describes precautions that should be observed to prevent the danger of serious injury or death to the user.

CAUTION Describes precautions that should be observed to prevent the danger of minor or moderate injury to the user, or the damage to the property.

Note Provides information that is important for proper operation of the instrument.

Displayed Characters on the 7-Segment LED

In order to display all numbers and alphabetic characters on the 7-segment LED, some of them are displayed in a slightly altered format. For details, refer to section 1.3.

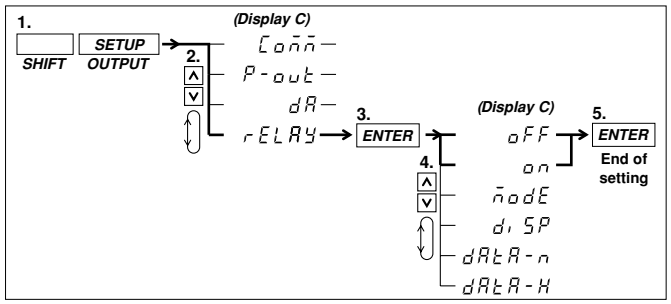
Markings used for Descriptions of Operations

Relevant Keys Indicates the relevant panel keys and indicators to carry out the operation.

Operating Procedure The procedure is explained by a flow diagram. For the meaning of each operation, refer to the example below. The operating procedures are given with the assumption that you are not familiar with the operation. Thus, it may not be necessary to carry out all the steps when changing settings.

Explanation Describes settings and restrictions relating to the operation.

An example of an Operating Procedure



The items in this figure are obtained by the following setting procedures. The blinking part of the display can be set.

1. After pressing the SHIFT key and the SHIFT indicator is lit, press the SETUP (OUTPUT) key. The output setting menu will appear on display C.
2. Select rELAY using the up/down keys.
   Pressing either key, 4 selectable items will be displayed consecutively.
3. Verify the setting by pressing the ENTER key.
   The setting menu corresponding to the item selected at step 2 will appear at display C.
4. Select oFF or on using the up/down keys.
   Pressing either key, 6 selectable items will be displayed consecutively.
5. Verify the setting by pressing the ENTER key.

Contents

Chapter 14 Adjustment, Calibration and Trouble-Shooting

Chapter 15 Specifications

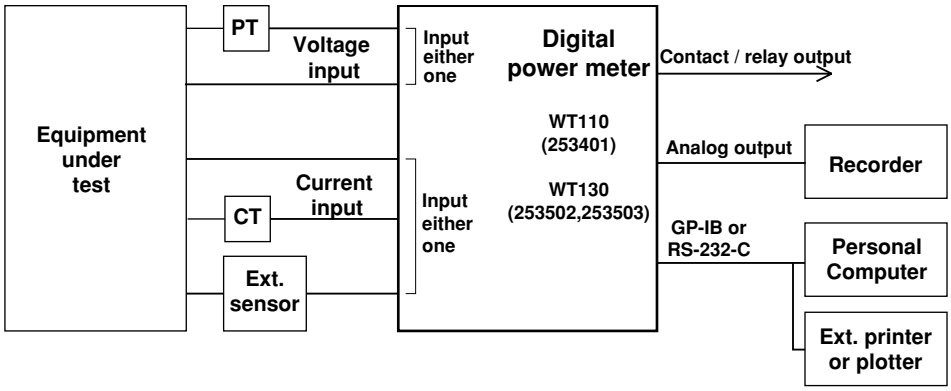
Appendix 1 Communication Commands (before the IEEE488.2-1987 Standard)

Appendix 2 Communication Commands (according to the IEEE488.2-1987 Standard)

Index

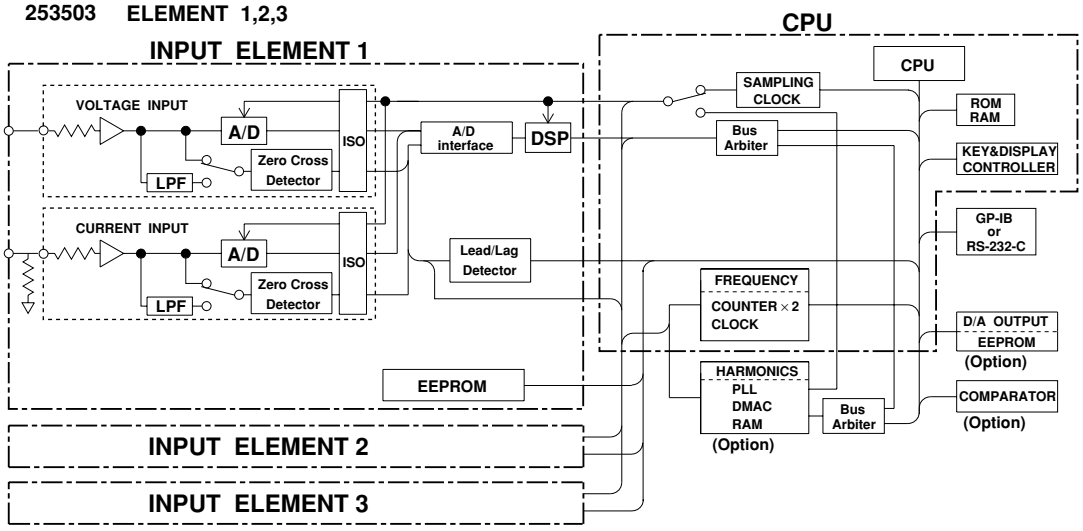
1.1 System Configuration and Block Diagram

System Configuration



Block Diagram

Model	INPUT Section
253401	ELEMENT 1
253502	ELEMENT 1,3
253503	ELEMENT 1,2,3



This instrument consists of various sections: input (voltage input and current input circuits), DSP, CPU, display and interface section.

In the voltage input circuit, the input voltage is formalized by a voltage divider and operational amplifier, then sent to the A/D converter.

In the current input circuit, one shunt resistor is used to form a closed circuit. The voltage between both ends of the shunt resistor is amplified and formalized by an operational amplifier and then sent to the A/D converter. This method enables switching of the current range without opening the current measurement circuit, so the current range can be switched while electricitiy is supplied to the circuit. This also enables remote control via communications outputs.

The output from the A/D converter in the current input and voltage input circuits is sent to the DSP (Digital Signal Processor) via a photo-isolator, which is used to provide insulation between the current input circuit (or voltage circuit) and the DSP. One DSP is provided for each input element (current/voltage). For example, a total of 3 DSP's are used for the three-phase, four-wire model (model 253503). The DSP performs averaging of voltage, current and active power for each sampled data sent from the A/D converter. After processing of a certain number of sets of data has been completed, computation of apparent power, reactive power, power factor and phase angle starts.

Computation results are then sent from the DSP to the CPU, where computation such as range conversion, sigma computation and scaling is carried out. Control of display and outputs is also performed by the CPU.

1.2 Functions

Input Functions

Voltage and Current Input Sections

A voltage or current supplied to each input terminal is normalized then sent to the A/D converter, where the voltage or current is converted into digital signals. The digital signals are then sent via photo-isolator to a 16-bits high-speed DSP (Digital Signal Processor) or CPU, where computation of the measured value is carried out.

Frequency Measuring Range

Measurement of DC voltage, current and power as well as AC voltage and current in the frequency range 10Hz to 50kHz.

Filter

This instrument carries out various measurements after synchronizing the frequency of the input signals. Therefore, correct measurements are necessary. Thus, a filter is being applied to the frequency measurement circuit to eliminate noise of waveforms, such as inverted and distortion waveforms.

Wiring Method

The input units for voltage or current measurement are located on the rear panel of this instrument. These units are called input elements. The number of input elements depends on the model, and the possible wiring methods are as follows. The wiring method demonstrates the circuit configuration to measure voltage, current and power and this circuit configuration varies by phase and number of electrical wires.

model	number of elements	wiring method
253401	1	single-phase, two-wire (1Φ2W)
253502	2	single-phase, two-wire (1Φ2W); single-phase, three-wire (1Φ3W); three-phase, three-wire (3Φ3W)
253503	3	single-phase, two-wire (1Φ2W); single-phase, three-wire (1Φ3W); three-phase, three-wire (3Φ3W); three-phase, four-wire (3Φ4W); three-voltage, three-current (3V3A)

Display Functions

This function enables display of measured/computed values using three red high-intensity 7-segment LED displays. A total of three values can be displayed at once.

Computing Functions

Apparent Power, Reactive Power, Power Factor and Phase Angle

Based on the measurement values of voltage, current and active power, the values of apparent power, reactive power, power factor and phase angle can be computed.

Scaling Function

When performing voltage or current measurements with an external PT, CT, shunt, external sensor (clamp) or such connected, you can set a scaling factor to the primary/secondary ratio. This is called scaling. This function enables display of the measured values of voltage, current, active power, reactive power, integrated current and integrated power factor in terms of primary-side values.

Averaging Function

This function is used to perform exponential or moving averaging on the measured values before displaying them in cases where the measured values are not stable.

Four Arithmetic Operation Function (Applies to WT110/WT130 with ROM Version 2.01 or later)

Results from six types of arithmetic operations can be displayed. (A+B, A-B, A∗B, A/B, A2/B, A/B2)

Crest Factor Computing Function (Applies to WT110/WT130 with ROM Version 2.01 or later)

Crest factor is determined by peak value/RMS value. Crest factor of the voltage and current are computed and displayed on models that have the peak measurement function.

Peak Measurement Function (Applies to WT110/WT130 with ROM Version 2.01 or later)

This function measures the peak value of the voltage and current. Crest factor (peak value/RMS value) can also be computed and displayed.

Integrator Functions

This function enables integration of active power and current. All measurement values (and computed values) can be displayed, even when integration is in progress, except for the integrated values (watt hour and ampere hour) and elapsed integration time. Since also integrated values of negative polarity can be displayed, the consumed watt hour (ampere hour) value of the positive side and the watt hour value returning to the power supply of the negative side can be displayed seperately.

Frequency Measurement Function

This function enables measurement of the frequency of input voltage and current. Measuring range is from 10Hz to 50kHz (however, depending on the internal timing of the instrument, measurement might be carried out in the range from 4Hz to 10Hz also).

Harmonic Analysis Function (option)

This function enables computation of voltage, current, active power and so forth of up to the 50th order, the relative harmonic content of harmonic orders and the phase angle of each order compared to the fundamental (first order). This is for one selected input element. Furthermore, the total rms value (fundamental + harmonic) of the voltage, current and active power, and the harmonic distortion factor (THD) can be calculated.

Storage/Recalling of Measured data and Setting Parameters

This function enables the storage of measured data and setting parameters into the internal memory. Furthermore, after recalling measured data or setting parameters, these data can be displayed or output by communication interface.

D/A Output Function (option)

This function enables output of measured values of voltage, current, active power, apparent power, reactive power, power factor and phase angle as a DC analog signal with full scale of ±5V. Output items up to 12 output channels (253401: 4 channels) can be selected.

Comparator Function (option)

This function compares the measured values of voltage, current, active power, apparent power, reactive power, power factor and phase angle and such with preset limit values. When the measured values cross those preset limits, a contact output relay will be activated. Output items up to 4 channels can be set.

Remote Control Functions (option)

External Input

This instrument can be controlled using the following TTL-level, low pulse, logic signals.

EXT HOLD (when options /DA4, /DA12, /CMP are installed)

Holds updating of the displayed values or releases the hold status.

EXT TRIG (when options /DA4, /DA12, /CMP are installed)

Updates the displayed values in hold mode.

EXT START (when options /DA4, /DA12 are installed)

Starts integration.

EXT STOP (when options /DA4, /DA12 are installed)

Stops integration.

EXT RESET (when options /DA4, /DA12 are installed)

Resets the integration results.

External Output

This instrument can output the following TTL-level, low pulse, logic signals.

EXT BUSY (when options /DA4, /DA12 are installed)

Outputs continuously from integration start through integration stop.

Communication Functions

Either a GP-IB or RS-232-C interface is provided as standard according to the custormer's preference. Measured/computed data of up to 14 channels can be output. It is also possible to control this instrument from the personal computer.

Output Function to an External Plotter / Printer

Measured/computed data can be printed on an external plotter or printer using the GP-IB or RS-232-C interface.

Other Useful Functions

Backup Function of Set-up Parameters

This instrument backs up the set-up parameters (including computed values) in case power is cut off accidentally as a result of a power failure or for any other reason.

Initializing Set-up Parameters

This function enables you to reset the set-up parameters to initial (factory) settings.

1.3 Digital Numbers/Characters, and Initial Menus

Digital Numbers/Characters

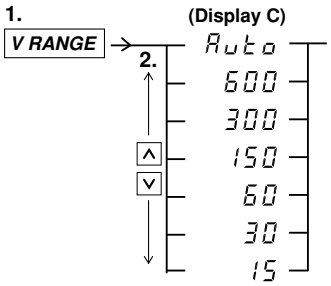
This instrument is equipped with a 7-segment LED which imposes some restrictions on the usable characters. The numbers/characters are styled as follows.

0 → 0	A → A	K → K	U → U
1 → 1	B → b	L → L	V → V
2 → 2	C → C Small c → c	M → m	W → W
3 → 3	D → d	N → n	X → X
4 → 4	E → E	O → o	Y → Y
5 → 5	F → F	P → P	Z → Z
6 → 6	G → G	Q → q	+ → +
7 → 7	H → H Small h → h	R → r	− → -
8 → 8	I → I	S → S	× → x
9 → 9	J → J	T → t	÷ → /

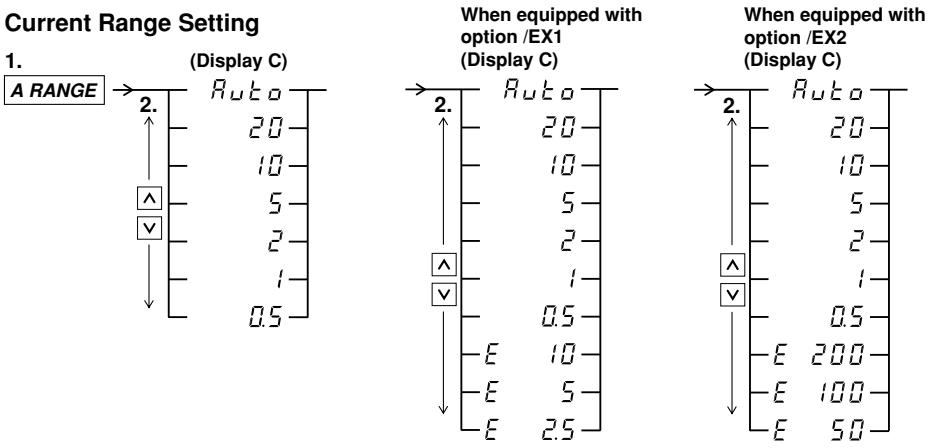
Initial Menus

Every function of this instrument can be set using the menus on the display. The initial displays which appear when the operation keys are pressed, are shown below.

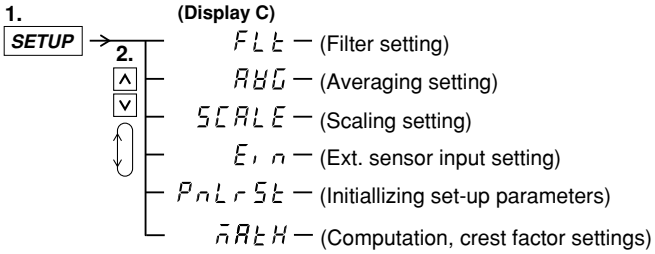
• Voltage Range Setting



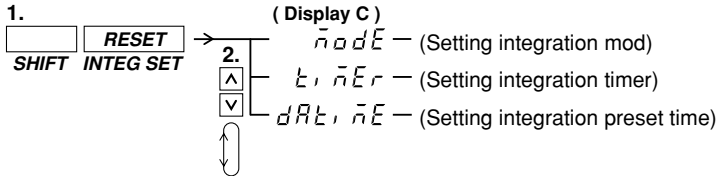
• Current Range Setting



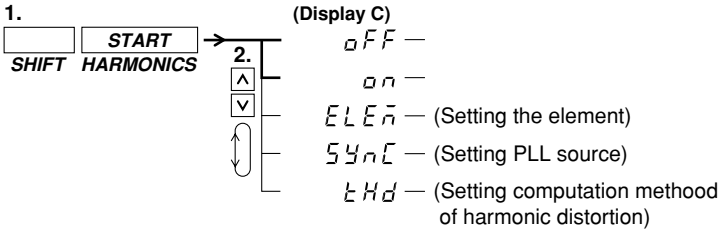
• Filter/Scaling/Averaging/Ext. Sensor Input/Initializing Set-up Parameters



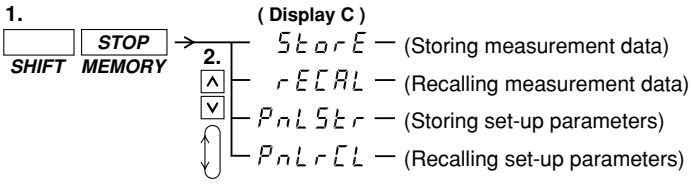
• **Integration Setting**



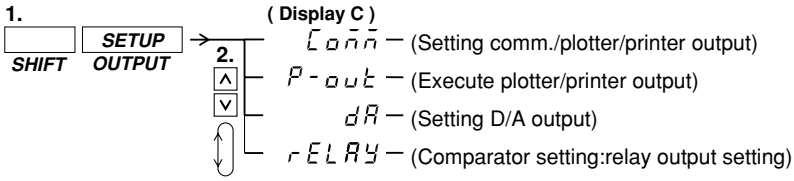
• **Turning the Harmonic Analysis Function ON/OFF**



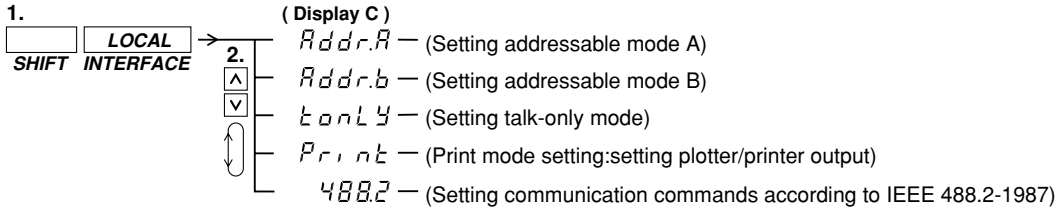
• **Storing/Recalling to/from Internal Memory**



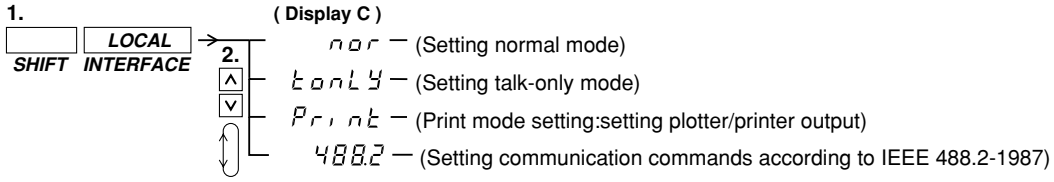
• **Setting Output**



• **Setting Communication Interface (GP-IB)**



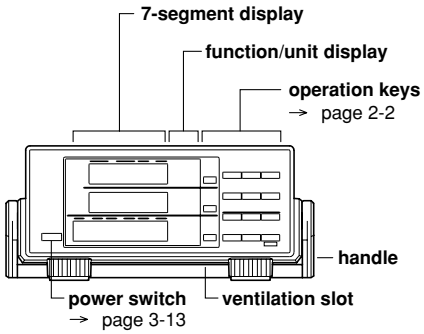
• **Setting Communication Interface (RS-232-C)**



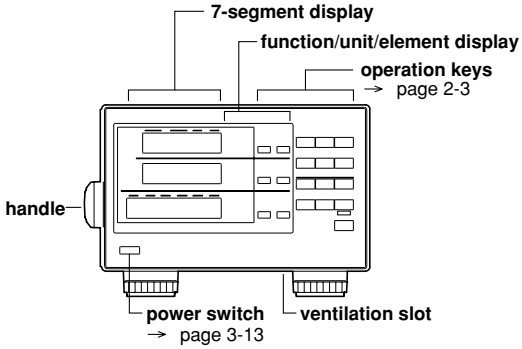
2.1 Front Panel, Rear Panel and Top View

Front Panel

WT110 (253401)

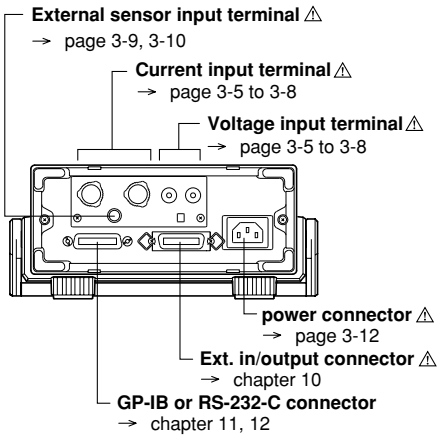


WT130 (253502, 253503)

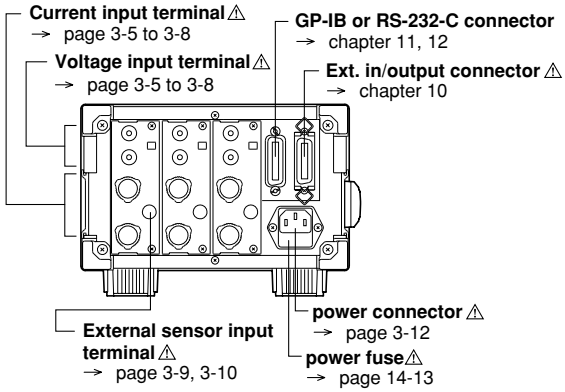


Rear Panel

WT110 (253401)

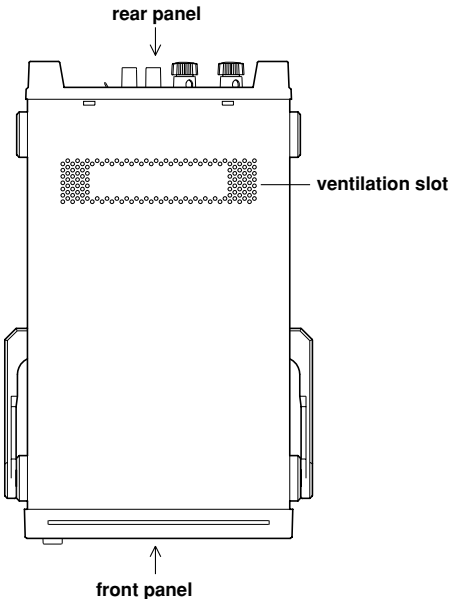


WT130 (253502, 253503)

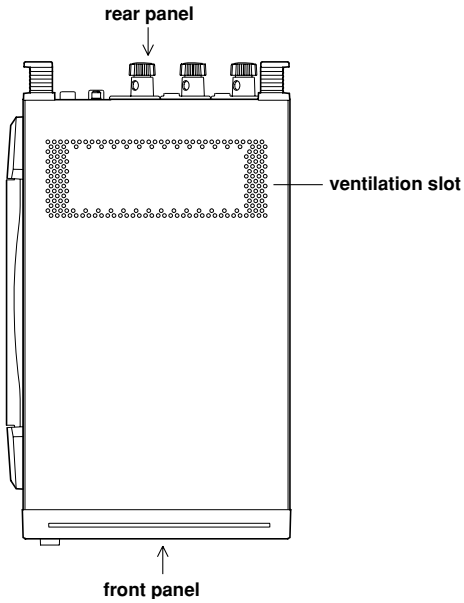


Top View

WT110 (253401)

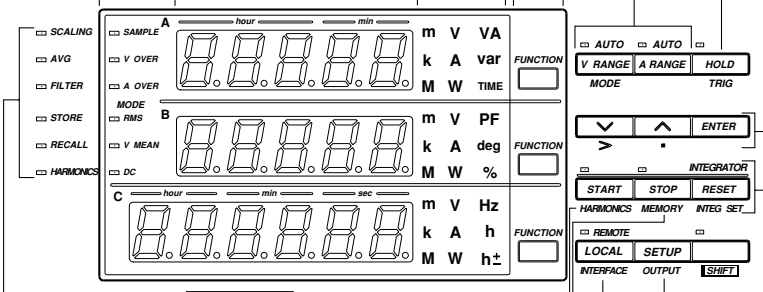


WT130 (253502, 253503)



2.2 Operation Keys and Function/Element Display

WT110 (253401): Operation keys and function display



Indicators for operation conditions

Shows sampling, voltage/current overrange and measurement mode

V RANGE

Shows the voltage range setting menu (page 4-4)

A RANGE

Shows the current range setting menu (page 4-4, 4-8)

SHIFT ***V RANGE MODE***

Switches between modes (page 4-1)

AUTO indicator

Lights up when range is AUTO

FUNCTION

Sets the displayed function (Ch. 5, 6)

Function/unit display

SHIFT ***START HARMONICS***

Shows the setting menu for harmonics ON/OFF, PLL source, and element selection (Ch. 8)

SHIFT ***STOP MEMORY***

Shows the setting menu for storing/recalling measurement data and set-up information (Ch. 9)

LOCAL

When the REMOTE indicator is lit, the remote function will be canceled. When the REMOTE indicator is not lit, the setting menu for communication/printing will appear

SHIFT ***LOCAL INTERFACE***

Shows the setting menu for communication/printing (Ch. 11, 12)

SHIFT ***SETUP OUTPUT***

Shows the setting menu for communication output items, D/A output, plotter /printer output and comparator output (Ch. 10 to 12)

SETUP

For settings such as initializing settings, filter, average, scaling, computing and ext. sensor input (Ch. 4)

Indicators for operating functions

When a function is set and in operation, this indicator will light up

HOLD

Keeps the displayed value, and the HOLD indicator will light up. Pressing once again will result in canceling HOLD

SHIFT ***HOLD TRIG***

When in the HOLD situation this results in updating the displayed value

∨

For decreasing the voltage/current range, and for setting of functions/values

∧

For increasing the voltage/current range, and for setting of functions/values

ENTER

For verifying the set range/function/value

SHIFT ∨ **>**

Moves the cursor of a value from left to right

SHIFT ∧ **▪**

Moves the decimal point from left to right

START

Starts integration

STOP

Stops integration

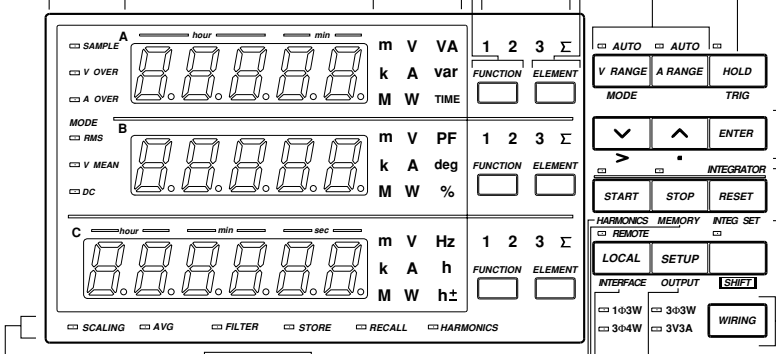
RESET

Integration value and elapsed time of integration are set to zero(0)

SHIFT ***RESET INTEG SET***

Shows the setting menu for integration mode/time, and rated integration time (Ch. 7)

WT130 (253502, 253503): Operation keys and function / element display



Indicators for operation conditions
Shows sampling, voltage/current overrange and measurement mode

V RANGE
Shows the voltage range setting menu (page 4-4)

A RANGE
Shows the current range setting menu (page 4-4, 4-8)

SHIFT ***V RANGE*** ***MODE***
Switches between modes (page 4-1)

AUTO indicator
Lights up when range is AUTO

ELEMENT
Sets the input element for measurement/integration. The corresponding indicator will light up (Ch. 5, 6)

FUNCTION
Sets the displayed function (Ch. 5, 6)

Function/unit display

HOLD
Keeps the displayed value, and the HOLD indicator will light up. Pressing once again will result in canceling HOLD

SHIFT ***HOLD*** ***TRIG***
When in the HOLD situation this results in updating the displayed value

∨
For decreasing the voltage/current range, and for setting of functions/values

∧
For increasing the voltage/current range, and for setting of functions/values

ENTER
For verifying the set range/function/value

SHIFT ∨ **>**
Moves the cursor of a value from left to right

SHIFT ∧ **▪**
Moves the decimal point from left to right

START
Starts integration

STOP
Stops integration

RESET
Integration value and elapsed time of integration are set to zero(0)

SHIFT ***RESET*** ***INTEG SET***
Shows the setting menu for integration mode/time, and rated integration time (Ch.7)

WIRING
Sets the connection format matching the connection to the voltage/current input terminals at the rear (page 3-15)

SHIFT ***START*** ***HARMONICS***
Shows the setting menu for harmonics ON/OFF, PLL source, and element selection (Ch. 8)

SHIFT ***STOP*** ***MEMORY***
Shows the setting menu for storing/recalling measurement data and set-up information (Ch. 9)

LOCAL
When the REMOTE indicator is lit, the remote function will be canceled. When the REMOTE indicator is not lit, the setting menu for communication/printing will appear

SHIFT ***LOCAL*** ***INTERFACE***
Shows the setting menu for communication/printing (Ch. 11, 12)

SHIFT ***SETUP*** ***OUTPUT***
Shows the setting menu for communication output items, D/A output, plotter / printer output and comparator output (Ch. 10 to 12)

SETUP
For settings such as initializing settings, filter, average, scaling and ext. sensor input (Ch. 4)

Indicators for operating functions
When a function is set and in operation, this indicator will light up

2.3 Displays in case of Overrange / Error during Measurement

Overrange display

Overrange occurs when the measured voltage or current exceeds 140% of the rated measurement range. In that case the range will automatically be increased, however up to 140% of the maximum range. When this level is exceeded, the overrange display wil appear, which looks as follows.

Computation over display

When the computed value becomes too high during the computation process, the following display will appear.

Peak over display

When the sampled data (instantaneous voltage or instantaneous current) exceed approx. 300% of the measurement range, the “V over” or “A over” indicators at the front panel will light up.

▭ *V OVER*

▭ *A OVER*

Note

The “V over” and “A over” indicators at the front panel will light up in case of overrange or peak-over of any signal which is input to the elements.

Display in case the measurement value is too small

In case either the measured voltage or measured current drops below 0.5% of the measurement range, the display will indicate as follows. This is only in case the measurement mode is RMS or V MEAN.

Function	Display
V(voltage) A(current) var(reactive power)	displays zero
PF(power factor)	PFErr
deg(phase angle)	dEGEr

Interruption during measurement

If the measurement range, or function/element is changed and the contents of the display changes, the display will indicate as follows.

3.1 Usage Precautions

Safety Precautions

Before using the instrument for the first time, make sure you have read the safety precautions on page 4 and 5.

Do not remove the case from the instrument.
Some areas in the instrument use high voltages, which are extremely dangerous.
When the instrument needs internal inspection or adjustment, contact your nearest YOKOGAWA representative. Addresses may be found on the back cover of this manual.

If you notice smoke or unusual odors coming from the instrument, immediately turn OFF the power and unplug the power cord. Also turn OFF the power to all the objects being measured that are connected to the input terminals. If such an irregularity occurs, contact your nearest YOKOGAWA representative. Addresses may be found on the back cover of this manual.

Do not place anything on the power cord and keep it away from any heat generating articles. When unplugging the power cord from the power outlet, always hold the plug and pull it, never pull the cord itself. If the power cord becomes damaged, contact your nearest YOKOGAWA representative. Addresses may be found on the back cover of this manual.

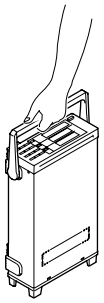
General Handling Precautions

Never place anything on top of the instrument, especially objects containing water. Entry of water into the instrument may result in breakdowns.

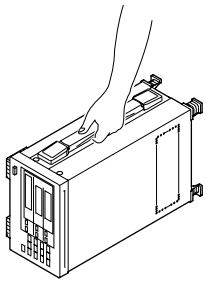
When Moving the Instrument

First turn off the power of the objects to be measured and disconnect the connected cables such as for measurement and communication. Then turn off the power switch and unplug the power cord from the power outlet. Always carry the instrument by the handles as shown below.

WT110 (253401)



WT130 (253502, 253503)



To prevent internal temperature rise, do not block the vent holes in the instrument case.

Keep input terminals away from electrically charged articles as they may damage internal circuits.

Do not allow volatile chemicals to come into contact with the case or operation panel. Also do not leave any rubber or vinyl products in contact with them for prolonged periods. The operation panel is made of thermoplastic resin, so take care not to allow any heated articles such as a soldering iron to come in contact with it.

For cleaning the case and the operation panel, unplug the power cord first, then gently wipe with a dry, soft and clean cloth. Do not use chemicals such as benzene or thinner, since these may cause discoloration or damage.

If the instrument will not be used for a long period, unplug the power cord from the AC outlet.

3.2 Installing the Instrument

Installation Conditions

The instrument must be installed in a place where the following conditions are met.

Ambient temperature and humidity

Ambient temperature: 5 to 40˚C

Ambient humidity: 20 to 80% RH (no condensation)

Horizontal position

The instrument must be installed horizontally. A non-horizontal or inclining position can impede proper measurement of the instrument.

Well-ventilated location

Vent holes are provided on the top and bottom of the instrument. To prevent rise in internal temperature, do not block these vent holes.

In case you removed the feet for rack-mounting the instrument, make sure to keep a space of at least 20mm as not to block the vent holes.

Never install the instrument in any of the following places

- In direct sunlight or near heat sources;
- Near noise sources such as high voltage equipment or power lines ;
- Where an excessive amount of soot, steam, dust or corrosive gases is present;
- Where the level of mechanical vibration is high;
- Near magnetic field sources;
- In an unstable place.

Note

- To ensure high measurement accuracy, the instrument should only be used under the following conditions.
  Ambient temperature: 23 ± 5˚C
  Ambient humidity: 30 to 75% RH (no condensation)
  When using the instrument in the temperature ranges of 5 to 18 or 28 to 40˚C, add the temperature coefficient to the accuracy as specified in chapter 15 “Specifications”.
- If the ambient humidity of the installation site is 30% or below, use an anti-static mat to prevent generation of static electricity.
- Internal condensation may occur if the instrument is moved to another place where both ambient temperature and humidity are higher, or if the room temperature changes rapidly. In such cases acclimatize the instrument to the new environment for at least one hour before starting operation.

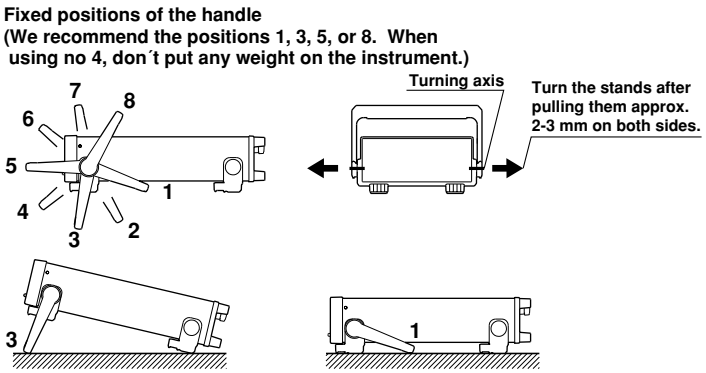
Installation Position

Desktop

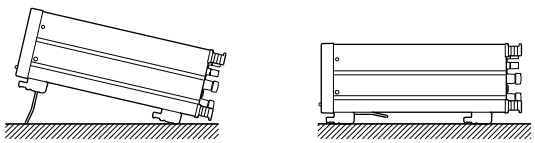
Place the instrument in a horizontal position or tilted using the stand, as shown below.

• WT110 (253401)

When installing using the handle, verify that the handle is in a fixed position. While pulling the handle approx. 2 to 3mm from the turning axes on both side, slowly turn the handle until it slips into the fixed position.



• WT130 (253502, 253503)



Rack mount

To install the instrument in a rack, use one of the following optional rack mount kits.

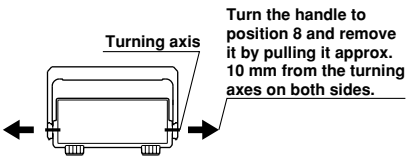
- **Rack mount kit (option)**

Specifications	Kit	Specifications	Kit
WT110 EIA standard	751533-E2	WT130 EIA standard	751533-E3
WT110 JIS standard	751533-J2	WT130 JIS standard	751533-J3
WT110 EIA standard	751534-E2	WT130 EIA standard	751534-E3
WT110 JIS standard	751534-J2	WT130 JIS standard	751534-J3

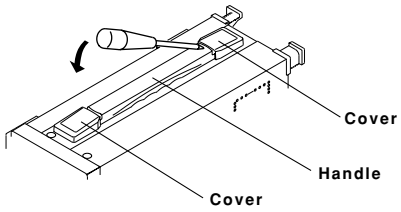
- **Mounting procedure**

1. Remove the handle. For the WT110, turn the handle to position 8 (refer to the picture on the previous page) and remove the handle by pulling it approx. 10mm from the turning axes on both sides. For the WT130, remove the handle by first removing the covers of the handle, and then unfastening the screws.

WT110 (253401)



WT130 (253502, 253503)



For more detailed information regarding the rack mount procedure, refer to the instruction manual accompanied with the rack mount kit.

2. Remove the feet from the instrument.
3. Remove the seals covering the mounting holes from the front side of the instrument.
4. Mount the rack mount brackets.
5. Mount the instrument in the rack.

Note

When mounting the instrument in a rack, make sure not to block the vent holes. Refer to page 3-2.

3.3 Wiring Precautions

WARNING

- To prevent hazards, make sure to apply a ground protection before connecting the object being measured.
- Always turn OFF the power to the object being measured before connecting it to the instrument. Never connect or disconnect the measurement lead wires from the object while power is being supplied to it, otherwise a serious accident may result.
- When the power switch is ON, never apply a voltage or current exceeding the level specified in the table below to the voltage input or current input terminal. When the power switch is OFF, turn off the power of the instrument under measurement as well.
  For details regarding the other terminals, such as the external input terminal, refer to chapter 15 “Specifications”.

Max allowable input	Voltage input	Current input
Instantaneous max (for 1s)	The peak value is 2000V or the RMS value is 1500V, whichever is less	The peak value is 150A or the RMS value is 40A, whichever is less
Continuous	The peak value is 1500V or the RMS value is 1000V, whichever is less	The peak value is 100A or the RMS value is 30A, whichever is less

- In case you are using an external potential transformer (PT) or current transformer (CT), use one which has a sufficient withstand voltage against the voltage to be measured (a withstand voltage of 2E + 1000V is recommended, where E is the measurement voltage.) Also be sure not to allow the secondary side of the CT to go open-circuit while power is supplied, otherwise an extremely dangerous high voltage will be generated on the secondary side of the CT.
- If the instrument is used in a rack, provide a power switch so that power to the instrument can be shut off from the front of the rack in an emergency.
- For safety reasons, make sure that the bare end of the measurement lead wire connected to each input terminal does not protrude from the terminal. Also make sure that the measurement lead wires are connected to the terminals securely.
- The voltage ratings across the measuring (voltage and current) input and the ground for this instrument varies under operating conditions.
  - When protective covers are used on GP-IB or RS-232-C and external input/output connectors;
    Voltage across each measuring input terminal and ground 600Vrms max.
  - When protective covers are removed from GP-IB or RS-232-C and from external input/output connectors; or when connectors are used;
    Voltage across A, ±(V and A side) input terminals and ground 400Vrms max.
    Voltage across V terminal and ground 600Vrms max.

CAUTION

- The lead wires must have a sufficient margin in both withstand voltage and current against those to be measured. They must also have insulation resistance appropriate to their ratings. Ex. If measurement is carried out on a current of 20A, use copper wires with a conductor cross-sectional area of at least 4mm^2.

Note

- After completing the wiring of the WT130, the WIRING key needs to be used to select the wiring system before starting measurements. Refer to section 3.9, page 3-15.
- When measuring high currents, or currents or voltages that contain high-frequency components, wiring should be made with special attention paid to possible mutual interference and noise problems.
- Keep the lead wires short as possible.
- For current circuits indicated by thick lines in the wiring diagrams shown in section 3.3, use thick lead wires appropriate for the current to be measured.
- The lead wire to the voltage input terminal should be connected as close to the load of the object under measurement as possible.
- To minimize stray capacitance to ground, route both lead wires and grounding wires so that they are as away from the instrument's case as possible.

3.4 Wiring the Measurement Circuit

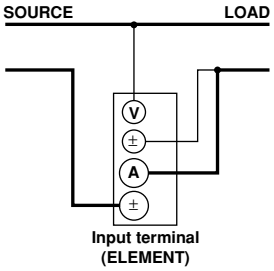
WARNING

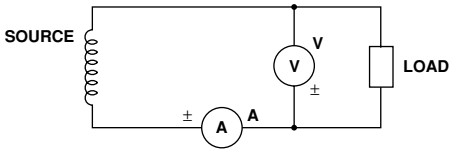
- When applying a current to be measured directly to the input terminals of the instrument, disconnect the input cable of the external sensor. A voltage might be generated by the external sensor input terminal when connected.

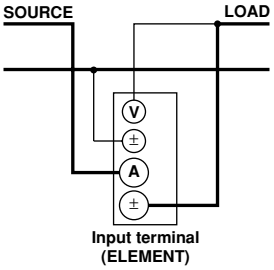
CAUTION

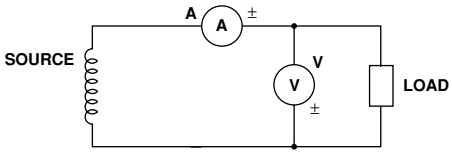
- A load current flows in the thick lines show in the diagrams; therefore, a wire with sufficient current capacity must be used for these lines.

Wiring diagram for single-phase, two-wire system (253401, 253502, 253503)

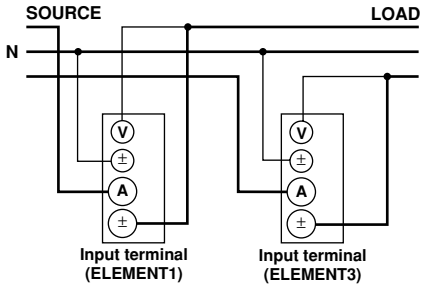


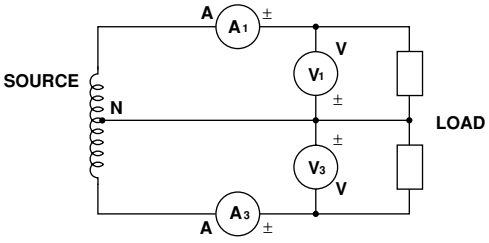






Wiring diagram for single-phase, three-wire system (253502, 253503)

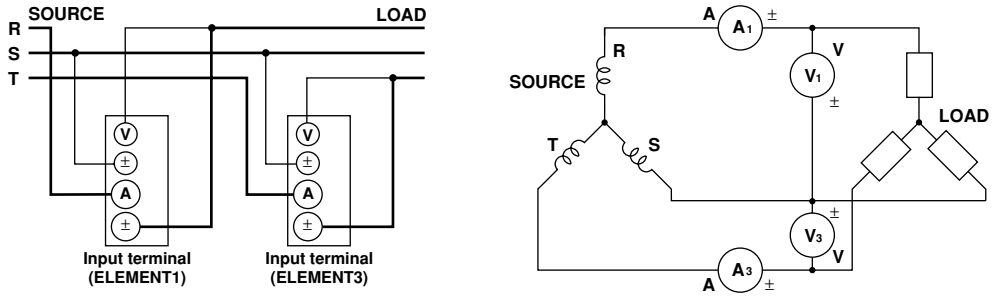




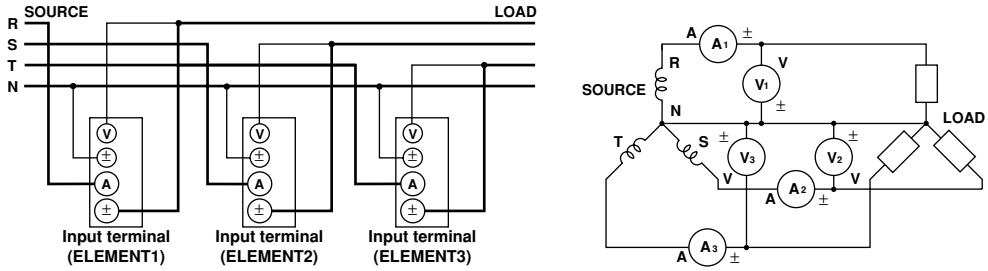
Note

The wire connected from the source the ± current terminal must be routed as close as possible to the ground potential in order to minimize measurement error.

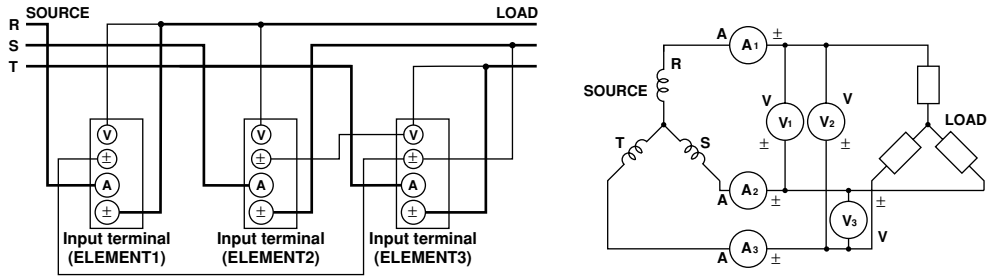
Wiring diagram for three-phase, three-wire system (253502, 253503)



Wiring diagram for three-phase, four-wire system (253503)



Wiring diagram for three-voltage, three-current system (253503)



3.5 Wiring the Measurement Circuit when Using External PT/CT

WARNING

- When using an external CT, do not allow the secondary side of the CT to go open-circuit while power is supplied, otherwise an extremely high voltage will be generated on the secondary side of the CT.

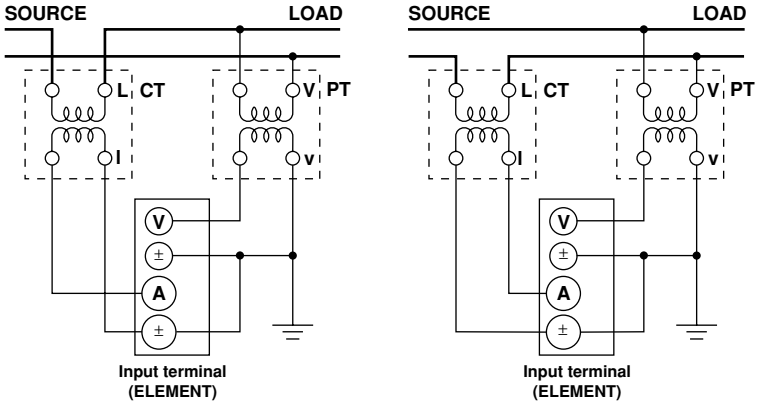
CAUTION

- A load current flows in the thick lines shown in the diagrams; therefore, a wire with sufficient current capacity must be used for these lines.

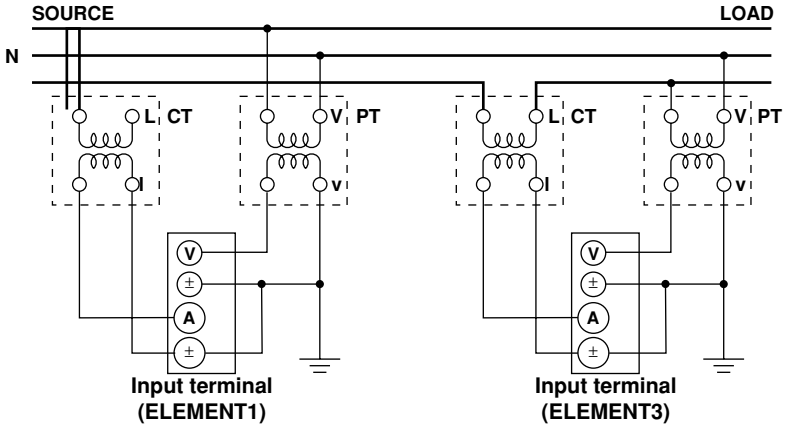
Use of a PT (or CT) enables measurement of voltage or current even if the maximum voltage or maximum current of the object to be measured exceeds the maximum measuring range.

- If the maximum voltage of the object to be measured exceeds 600V, connect an external potential transformer (PT), and connect the secondary side of the PT to the voltage input terminals.
- If the maximum current of the object to be measured exceeds 20A, connect an external current transformer (CT), and connect the secondary side of the CT to the current input terminals.

Wiring diagram for single-phase, two-wire system with PT and CT connected (253401, 253502, 253503)



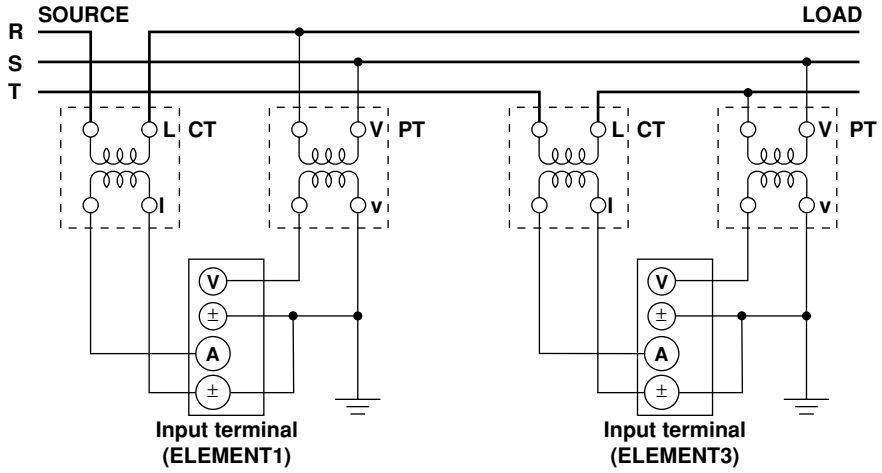
Wiring diagram for single-phase, three-wire system with PT and CT connected (253502, 253503)



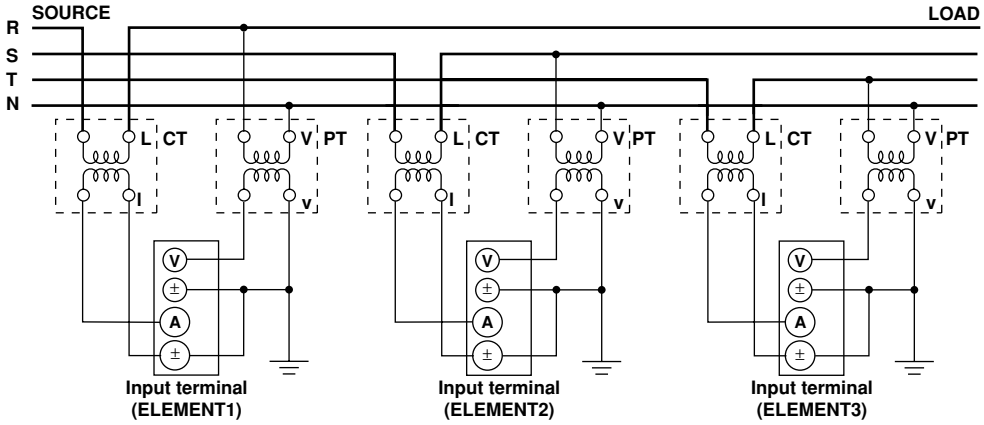
Note

- Using the scaling function enables direct reading of measured values on the display. Refer to section 4.4 on page 4-6.
- It must be noted that measured values are affected by the frequency and phase characteristics of PT and CT.

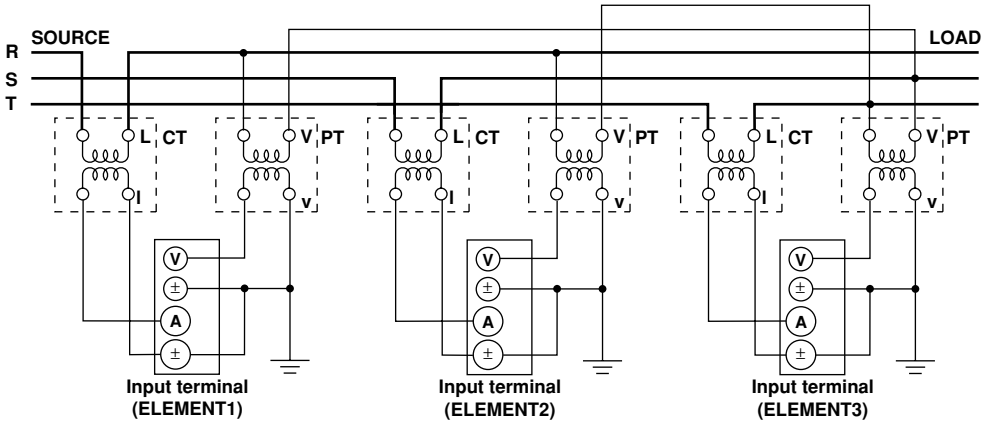
Wiring diagram for three-phase, three-wire system with PT and CT connected (253502, 253503)



Wiring diagram for three-phase, four-wire system with PT and CT connected (253503)



Wiring diagram for three-voltage, three-current system with PT and CT connected (253503)



3.6 Wiring the Measurement Circuit when Using the External Sensor

WARNING

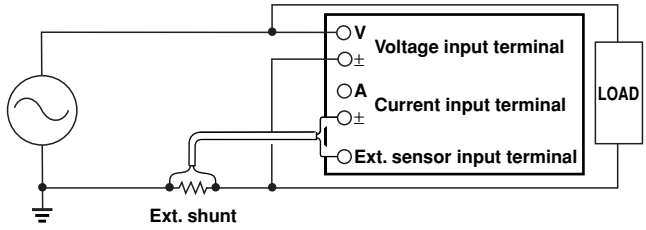
- Use an external sensor that is enclosed in a case which has sufficient withstand voltage against the voltages to be measured. Use of bare sensor may cause an electric shock if the sensor is touched accidentally.
- Before connecting an external shunt, make sure the power to the shunt is turned OFF. Always make sure to turn OFF the power switch of the source. When the power is supplied a voltage will be present at the shunt, so don't touch the shunt with your hands.
- When using the clamp sensor, make sure to fully understand the specifications/instruction manual regarding voltages of the measurement circuit and the clamp sensor, and verify that no hazard exists.
- Do not touch the current terminal of the input element and not connect any measurement lead. When power is applied to the measurement circuit, a voltage will be generated at the current terminal, which constitutes a hazard.
- The connector to the input terminal for the external sensor should not have bare wires protruding; make sure to make connections to this terminal according to safety measures, since voltages will be present at the bare wires, which constitutes a hazard.

CAUTION

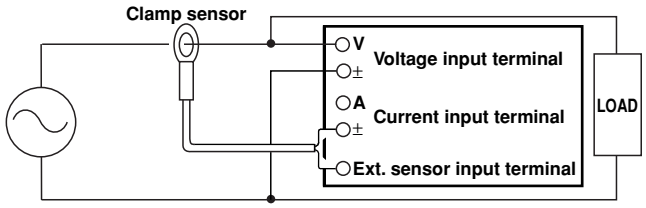
- A load current flow in the thick lines shown in the diagrams; therefore, a wire with sufficient current capacity must be used for these lines.

Note

- The external sensor must be selected carefully and its frequency and phase characteristics taken into account.
- The external sensor must be wired so that the area between the wires connected to both ends of the sensor is minimized, in order to reduce the effect of the magnetic field generated by the current to be measured. Measurement is affected by field lines entering this area. Minimizing this area also reduces the effects of external noise.
- Connect the external shunt as in the figures below. To avoid the effects of common-mode voltage, the external shunt must be connected using AWG18 wires (cross sectional area of 1mm^2).
- Since measurement accuracy decreases as an effect of an increase of wiring resistance and floating capacity, keep the wiring between the external sensor and this instrument as short as possible.



- If the measuring object is high frequency and high power and is not grounded, use an isolation sensor (CT, DC-CT, clamp)

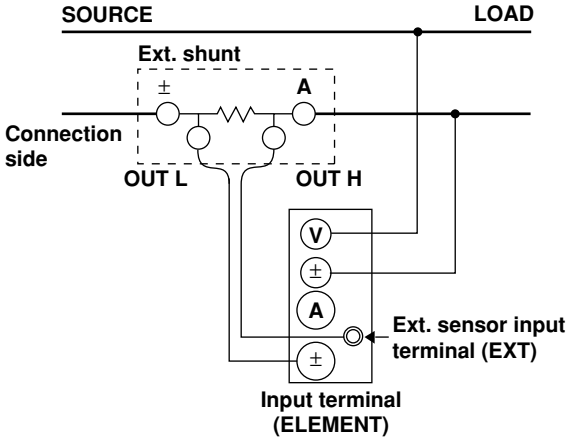


In cases where the maximum current of the object under measurement exceeds 20A, measurement becomes possible by connecting an external sensor. The range for external sensor input is either 2.5/5/10V or 50/100/200mV. Either range is available as an option.
In the following wiring diagrams, the external shunt is grounded. When using the clamp sensor, replace the shunt with the clamp sensor.

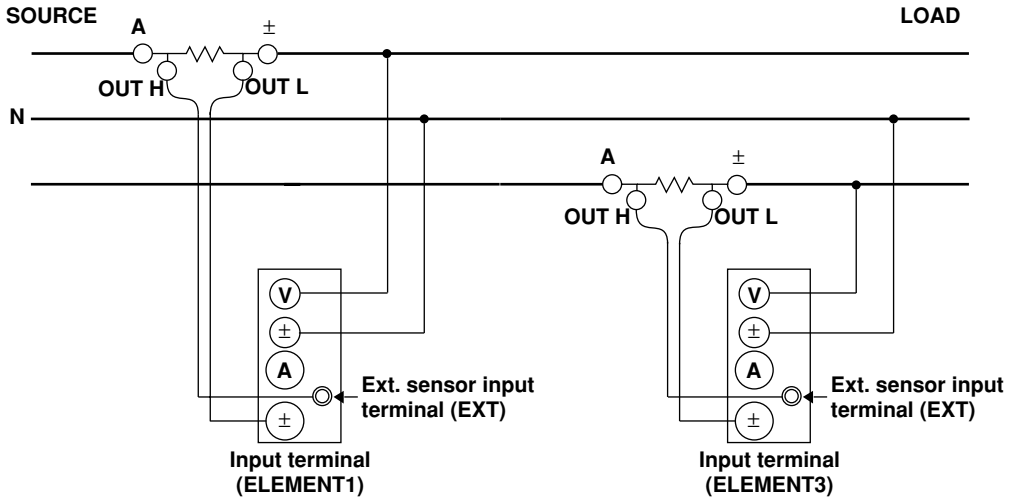
Note

- When using the external sensor or the clamp sensor, take care not to reverse the polarity when applying the clamp to the measurement circuit.
- Using the scaling function enables direct reading of measured values on the display. Refer to section 4.5 on page 4-8.

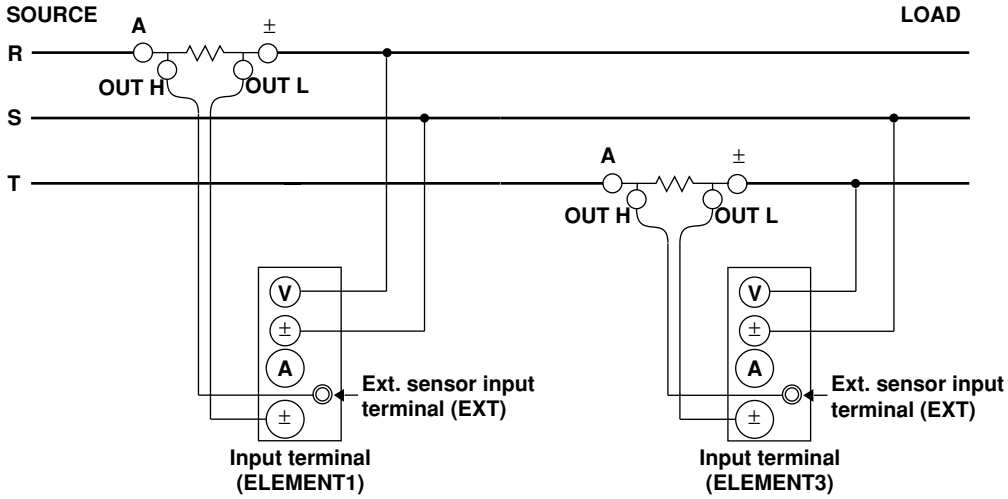
Wiring diagram for single-phase, two-wire system with external shunt connected (253401, 253502, 253503)



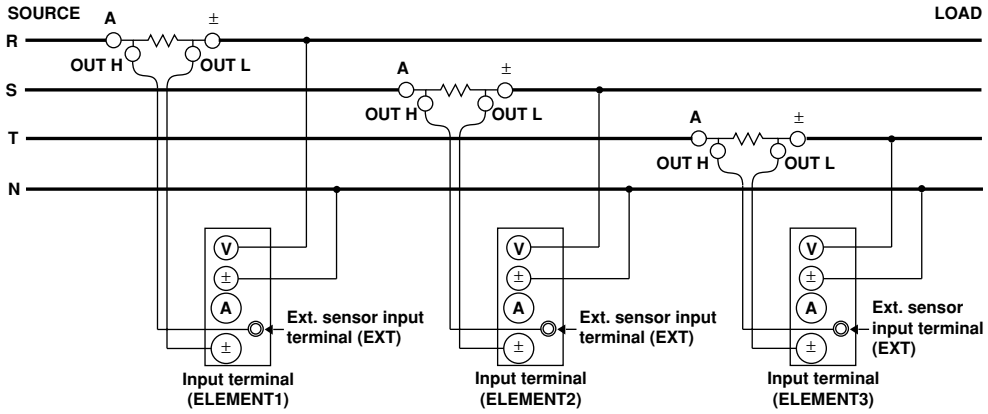
Wiring diagram for single-phase, three-wire system with external shunt connected (253502, 253503)



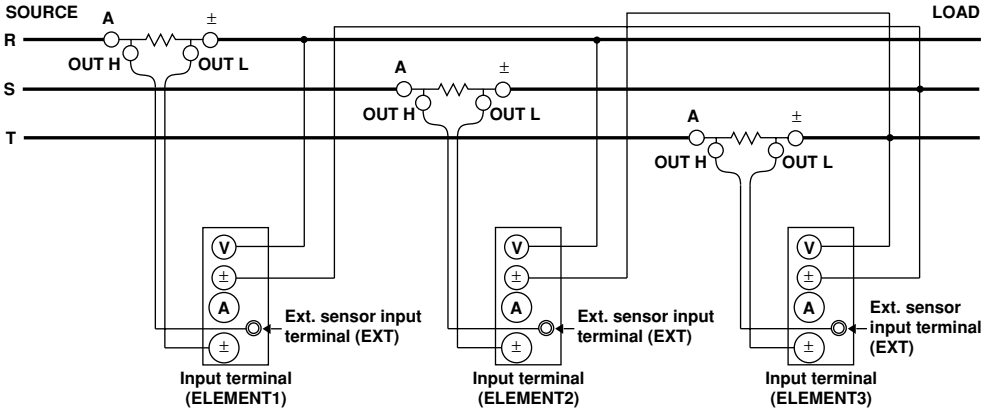
Wiring diagram for three-phase, three-wire system with external shunt connected (253502, 253503)



Wiring diagram for three-phase, four-wire system with external shunt connected (253503)



Wiring diagram for three-voltage, three-current system with external shunt connected (253503)



3.7 Connecting the Power Supply

Before Connecting the Power Supply

WARNING

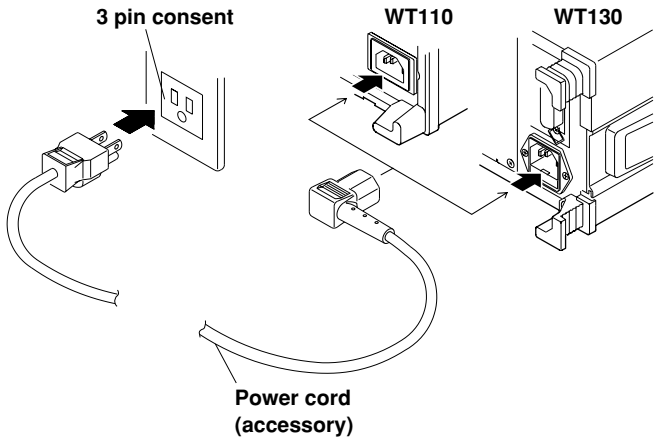
- Be sure to connect the protective grounding to prevent an electric shock before turning on the power.
- Be sure to use the power supply cord provided by YOKOGAWA. The mains power plug can only be plugged into an outlet with a protective grounding terminal.
- Ensure that the source voltage matches the voltage of the power supply before turning on the power.
- Connect the power cord only after having verified that the power switch is turned OFF.
- Never use an extension cord without protective grounding wire since this will invalidate the protection feature.

Connecting Procedure

1 Make sure that the power switch of the instrument is turned OFF.
2 Connect the accessory power cord to the power connector on the back of the instrument.
3 Insert the power cord to the power outlet which conforms to the following specifications. Make sure that you use an outlet with a protective grounding terminal only.

Rated supply voltage : 100 to 120VAC / 200 to 240VAC
Permitted supply voltage range : 90 to 132VAC / 180 to 264VAC
Rated supply voltage frequency : 50/60Hz
Permitted supply voltage frequency range : 48 to 63Hz
Power consumption : Model Max. power consumption

Model	Max. power consumption
253401	21VA (at 120VAC), 30VA (at 240VAC)
253502	30VA (at 120VAC), 45VA (at 240VAC)
253503	35VA (at 120VAC), 50VA (at 240VAC)



3.8 Turning the Power ON/OFF

Item to be Checked before Turning ON the Power

- Check that the instrument is installed correctly (refer to section 3.2, page 3-2).
- Check that the power cord is connected properly (refer to section 3.7, page 3-12).

Location of the Power Switch

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

Turning the Power ON

Turning the power ON will result in staring the test program, which checks each memory. When the results of these checks are all satisfactory, opening, messages will appear as described on the next page, after which the instrument will be ready for measurement.
When the test program results in displaying error codes, proper operation of the instrument cannot be performed. Immediately turn OFF the power and contact you nearest representative. Addresses may be found on the back cover of this manual. When contacting your representative, inform him of the name, suffix and No. code as on the right side panel, and of the displayed error code(s).

Note

- In case of an error code, refer to section 14.4, page 14-11, for a description and corrective action.
- A warm-up time of approx.30 minutes is required before all spesifications of the instrument can be met.

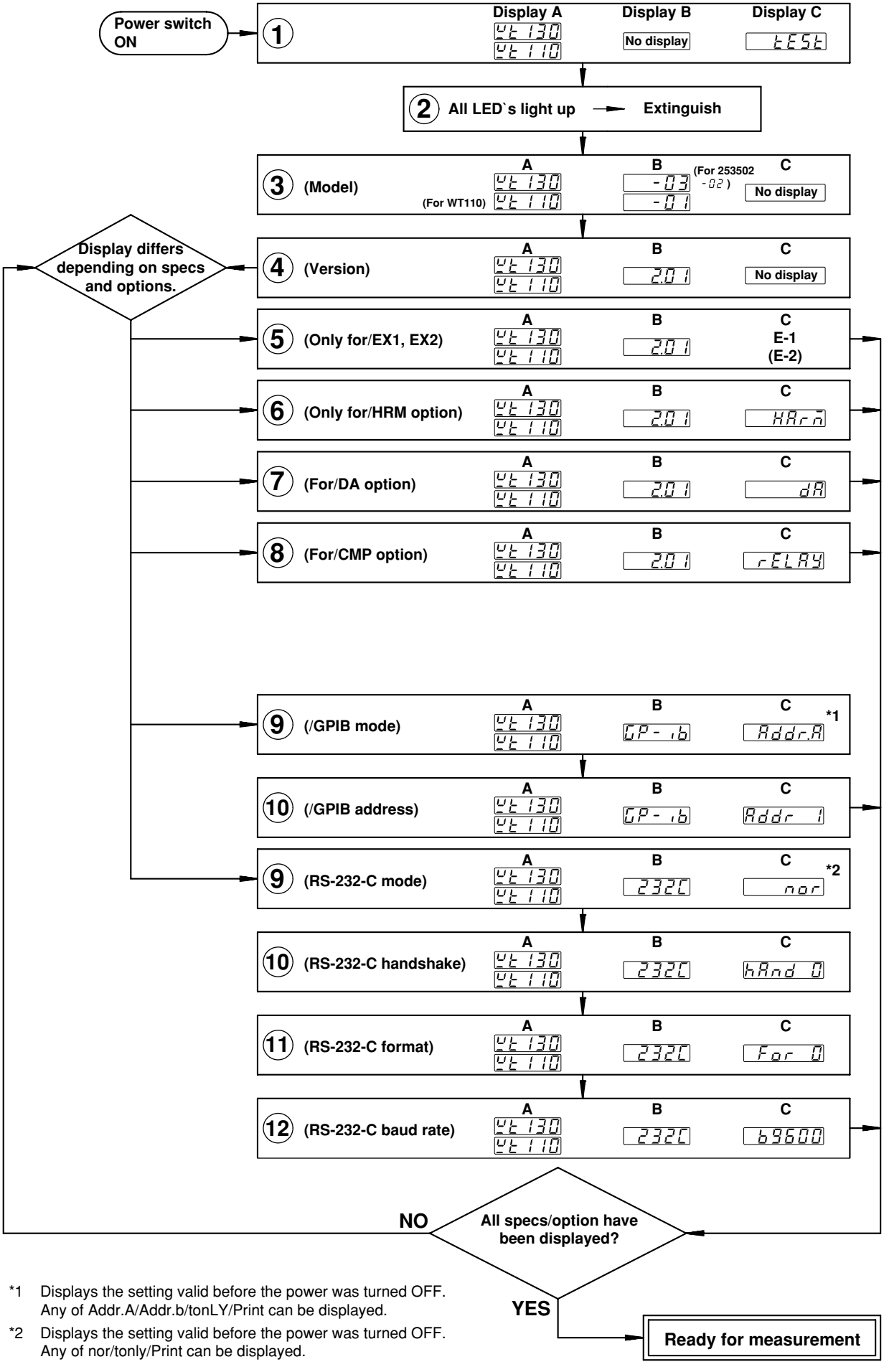
Turning the Power OFF

When turning the power OFF, the previous set-up parameters will be kept. Consequently, turning the power ON again will result in the appearance of the setting condition of the previous measurements.

Note

The instrument uses a lithium battery to back up set-up information. The life of the battery under normal operating temperature of 23˚C is approx. ten years. When the battery life is exhausted, turning ON the power switch will result in an error code and the battery needs to be replaced. Never replace the battery yourself, but inform your nearest representative. Addresses may be found on the back cover of this manual.

Opening Messages

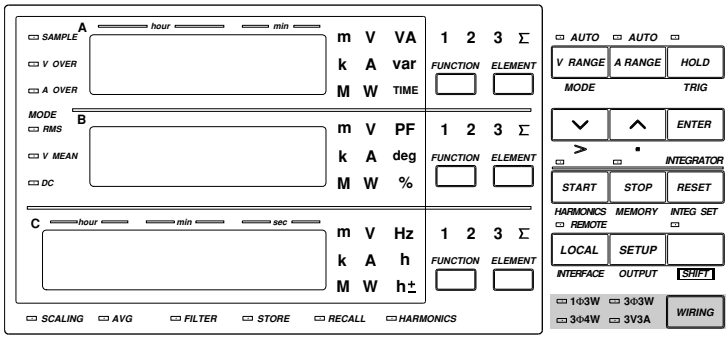


*1 Displays the setting valid before the power was turned OFF. Any of Addr.A/Addr.b/tonLY/Print can be displayed.

*2 Displays the setting valid before the power was turned OFF. Any of nor/tonly/Print can be displayed.

3.9 Selecting the Wiring Method (for WT130)

Relevant Keys



Displays relevant keys and indicator

***Shows the operation panel of the WT130. For the differences between WT110 and WT130, refer to section 2.2, page 2-2, 2-3**

Explanation

Wiring Method

The wiring method is selectable by pressing the WIRING key. The selectable wiring method depends on the model.

WT110 (253401)

This model has no such function. Only one (1) input element has been installed (ELEMENT1). Only single-phase, two-wire measurement is possible.

WT130 (253502)

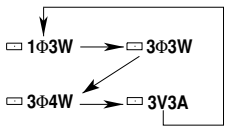
Pressing the WIRING key results in changing the wiring method in the following order. Two (2) elements have been installed (ELEMENT1, ELEMENT3).

1Φ3W :Single-phase, three-wire system
3Φ3W :Three-phase, three-wire system

*In case of a measurement circuit of single-phase, two-wire system, and having selected either element 1 or 3, selecting any of the above mentioned wring methods will result in correct measurement/computation. However, the measurement/computation results in case element Σ has been selected lose the physical meaning.

WIT130 (253503)

Pressing the WIRING key results in changing the wiring method in the following order. Three (3) elements have been installed (ELEMENT1, ELEMENT2, ELEMENT3).



1Φ3W :Single-phase, three-wire system
3Φ3W :Three-phase, three-wire system
3Φ4W :Three-phase, four-wire system
3V3A :Three-voltage, three-current system

*In case of a measurement circuit of single-phase, two-wire system, and having selected either element 1, 2, or 3, selecting any of the above mentioned wring methods will result in correct measurement/computation. However, the measurement/computation results in case element Σ has been selected lose their physical meaning.

Note

Select a wiring method which matches the actual wiring, since the computation method varies according to the wiring method. Consequently, when the wiring method does not match the actual wiring, measurement errors may occur.

3.10 Improving the Measurement Accuracy

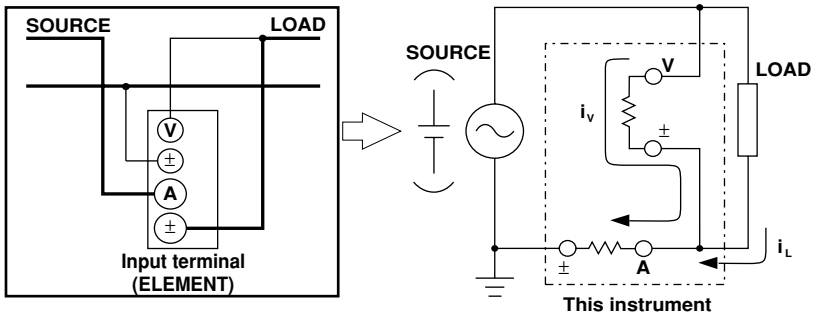
Recommended Wiring Method

The instrument is designed so that voltage input impedance is high and current input impedance is low to reduce the effect of power loss on measurement accuracy.

Voltage input impedance : Approx. 2MΩ (all ranges), with a capacitance of appox. 15pF connected in parallel

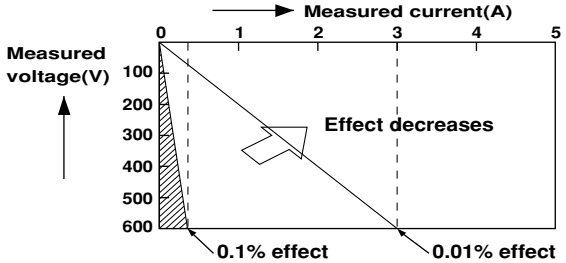
Current input impedance : Approx. 6mΩ+0.1μH (all ranges)

From the explanation given below, it can be understood that the effect of power loss on measurement accuracy can be reduced by wiring according to the load resistance.



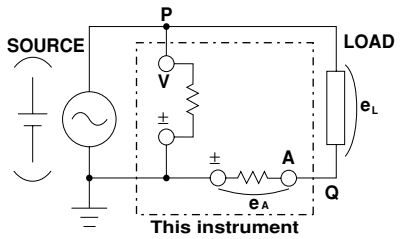
In the above diagram, the voltage measurement circuit is connected to the load side. The effects of power loss on measurement accuracy are explained below. For simplification, it is assumed that a DC power source and resistive load are used. The current measurement circuit measures the sum of the current iL that flows to the load (object being measured) and the current iV that flows to the voltage measurement circuit. This means that the current iV is erroneous since the current to be measured is iL.

Since the input impedance of the voltage measurement circuit is high (appox. 2MΩ), and even if the input voltage is 600V iV becomes approx. 0.3mA (=600V/2MΩ). If the instrumental error is assumed to be lower than 0.1%, the measured current (iL) will be 300mA or higher (load resistance is 2kΩ or lower). If the input voltage is 10V, iL is 5mA or higher. The relationship between the input voltage and the measured current in cases where instrumental error is within 0.1% and 0.01% is given below as a reference.



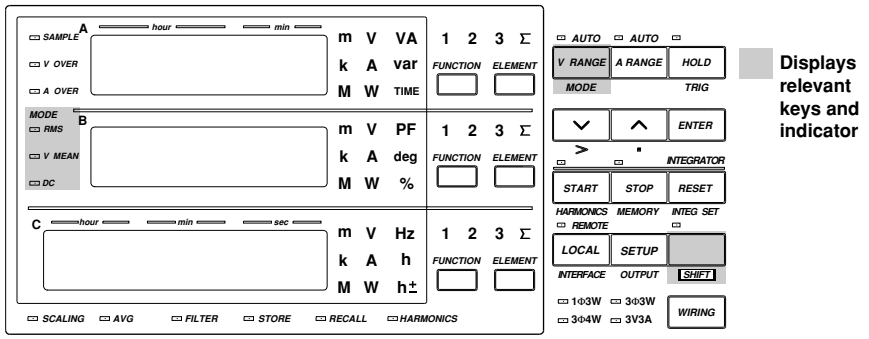
In many cases the recommended wiring method is suitable. For instance, when input voltage and current are 100V and 5A, iV is 0.05mA (=100V/2MΩ), therefore the effect on measurement accuracy is 0.001% (=0.05mA/5A), which is low.

On the other hand, measurement accuracy is significantly affected when the measured current is low (i.e. high load resistance). In this case, make the connections as follows so that the current measurement circuit is located on the load side. The voltage measurement circuit measures the sum of the voltage drop eL at the load and eA at the current measurement circuit, therefore eA is erroneous. However, the effect of this error is small since the input impedance of the current measurement circuit is low. For instance, if the load resistance is 600Ω, the input impedance is approx. 6mΩ, therefore the error in measurement is approx. 0.001% (=eA/(eL+eA)), which is low



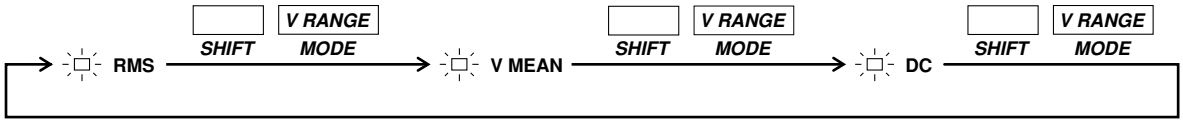
4.1 Selecting the Measurement Mode

Relevant Keys



***Shows the operation panel of the WT130. For the differences between WT110 and WT130, refer to section 2.2, page 2-2, 2-3**

Operating Procedure



Explanation

Measurement Mode

One of the following measurement modes can be selected for measurement of voltage and current. The initial value is “RMS”.

Indicator	Voltage	Current
RMS	Measures and displays true RMS value	Measures and displays true RMS value
V MEAN	Displays rectified mean value calibrated to the RMS value	Measures and displays true RMS value
DC	Displays DC value obtained by averaging the input signal	Displays DC value obtained by averaging the input signal

Theoretical Equations

- **RMS**

  This mode is selected to display input voltage or current as a true RMS value.

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

  f (t) : input signal
  T : one period of the input signal

- **V MEAN**

  This mode is selected to display input voltage or current as a rectified mean value calibrated to the RMS value. Since a sine wave is used for calibration, the value displayed will be the same as that obtained in RMS mode if a sine wave is measured. The value displayed will be different from that obtained in RMS mode if a distorted or DC waveform is measured.

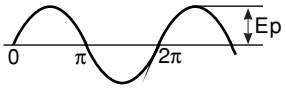
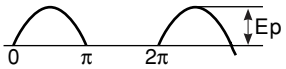
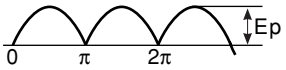
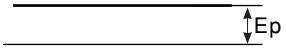
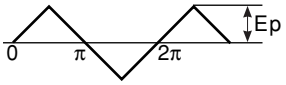
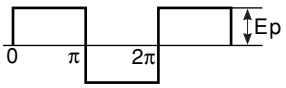
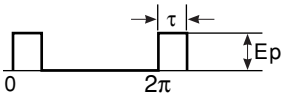
$$\frac{\pi}{2\sqrt{2}} \cdot \frac{2}{T}\int_0^{\frac{T}{2}} |f(t)|\,dt$$

  f (t) : input signal
  T : one period of the input signal

- **DC**

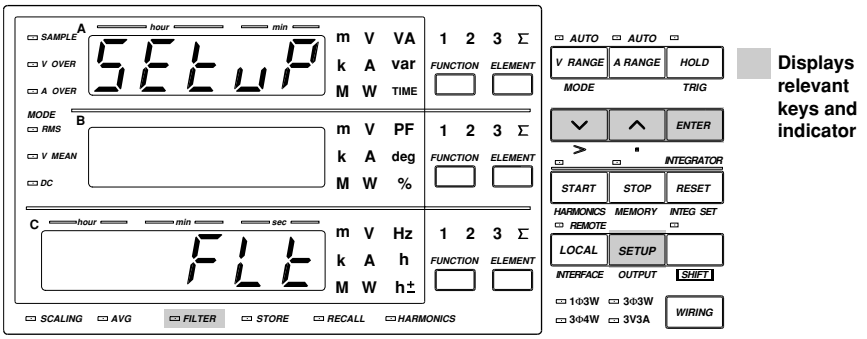
  This mode is selected when the input voltage or current is DC. The input signal is averaged and the result is displayed.

Typical Waveform Types and Differences in Measured Values between Measurement Modes

Name	Measurement mode / Display / Waveform	RMS value	Mean value	Mean-value rectification	Linear averaging
		RMS	—	V MEAN	DC
Sinewave		$\frac{Ep}{\sqrt{2}}$	$\frac{2}{\pi} \cdot Ep$	$\frac{Ep}{\sqrt{2}}$	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 Pulse		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 duty D ($=\frac{\tau}{2\pi}$) is applied.			
		$\sqrt{D} \cdot Ep$	$D \cdot Ep$	$\frac{\pi D}{2\sqrt{2}} \cdot Ep$	$D \cdot Ep$

4.2 Turning the Filter ON/OFF

Relevant Keys

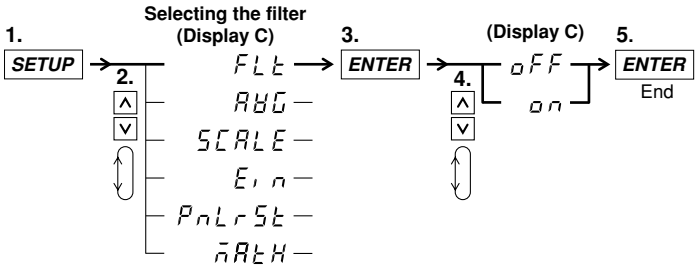


Displays relevant keys and indicator

***Shows the operation panel of the WT130. For the differences between WT110 and WT130, refer to section 2.2, page 2-2, 2-3**

Operating Procedure

- **Perform operations following the thick line in the below menu.**
- **Press the ENTER key to confirm the selection or setting.**
- **When you want to leave the current menu during operation, press the key described under step 1. The confirmed settings made until that point will be kept.**



Explanation

Filter Function

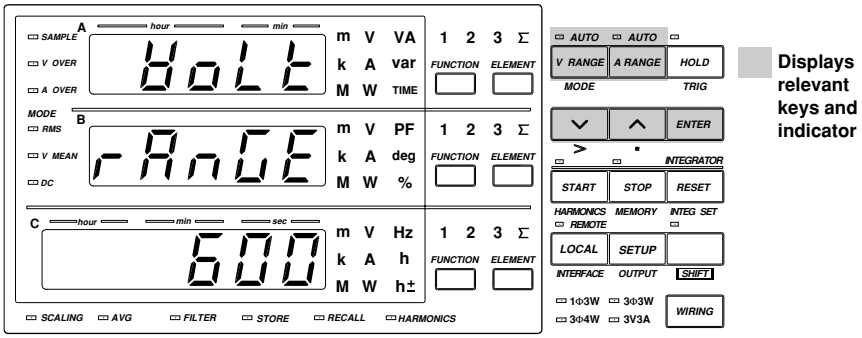
The instrument will perform measurements after synchronizing to the cycle of the input signal. Consequently, the frequency of the input signal can be measured properly. The filter, at a cut-off frequency of 300Hz, will only be applied to the frequency measurement circuit and will remove noise from distorted and inverted waves, etc.. This allows the frequency to be measured correctly which improves the accuracy of each measurement value. The filter will not be applied to the voltage and current circuit. The initial value is OFF.

Note

The filter setting cannot be changed while integration is being carried out.

4.3 Selecting the Measurement Range in case of Direct Input

Relevant Keys

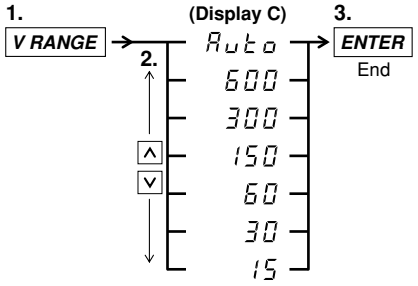


***Shows the operation panel of the WT130. For the differences between WT110 and WT130, refer to section 2.2, page 2-2, 2-3**

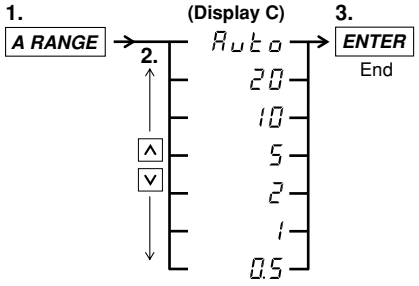
Operating Procedure

- **Perform operations following the thick line in the below menu.**
- **Press the ENTER key to confirm the selection or setting.**
- **When you want to leave the current menu during operation, press the key described under step 1. The confirmed settings made until that point will be kept.**

• Voltage Range Setting



• Current Range Setting



Explanation

Manual Range (fixed) versus Automatic Range (auto)

The measurement range can be of one of the following types. The initial setting is Auto range ON.

- **Manual range**

  Voltage range : selectable from 600/300/150/60/30/15V

  Current range : selectable from 20/10/5/2/1/0.5A

- **Auto range: Auto**

  The measuring range is adjusted automatically according to the input voltage or current as follows. Overrange is handled the same way as for the manually selected range.

Range up:

A higher range is selected immediately if the instantaneous input voltage or current exceeds approx. 300% of the rated value during sampling. If the meaured voltage or current exceeds 110% of the rated value, a higher range will be selected at the end of the current measurement cycle.

Range down:

A lower range is selected if the measured voltage or current drops below 30% of the rated value. However, even when the measured voltage or current drops below 30% of the rated value, range down will not be done when this would result in waveforms with a high crest factor causing peak over.

Verifying the Range

To verify the current range setting press the V RANGE key or the A RANGE key. The result will be shown at display C. In order to return to the measurement status, press the same key again.

Note

- When the range is set to auto, you cannot move to the minimum range by pressing the ∧ key. On the other hand, when the range is set to the minimum, you cannot move to auto range by pressing the ∨ key.
- When the range is set to auto, the range may be adjusted frequently if a waveform such as a pulse is input. In such a case, set the range manually.

Power Range

The measuring range for active power, apparent power and reactive power is determined as follows.

Wiring method	Power range
single-phase, two-wire (1Φ2W)	voltage range × current range
single-phase, three-wire (1Φ3W) three-phase, three-wire (3Φ3W) three-voltage, three-current (3A3V)	voltage range × current range × 2
three-phase, four-wire (3Φ4W)	voltage range × current range × 3

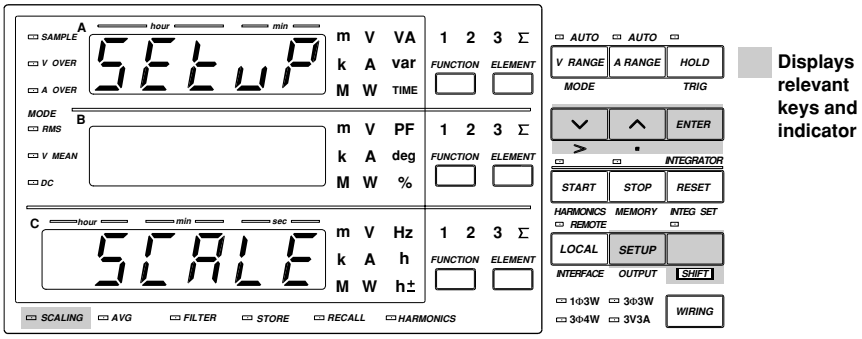
The maximum display is 9999.
When the result of “voltage range × current range” exceeds 1000W, the unit on the display will change to “kW”; When this result exceeds 1000kW, the unit on the display will change to MW.

Note

When the range is set to auto, the measuring range switches according to range up/range down conditions. Therefore, the range may vary even if the measured values remain the same.

4.4 Setting the Scaling Value when External PT/CT is Used

Relevant Keys



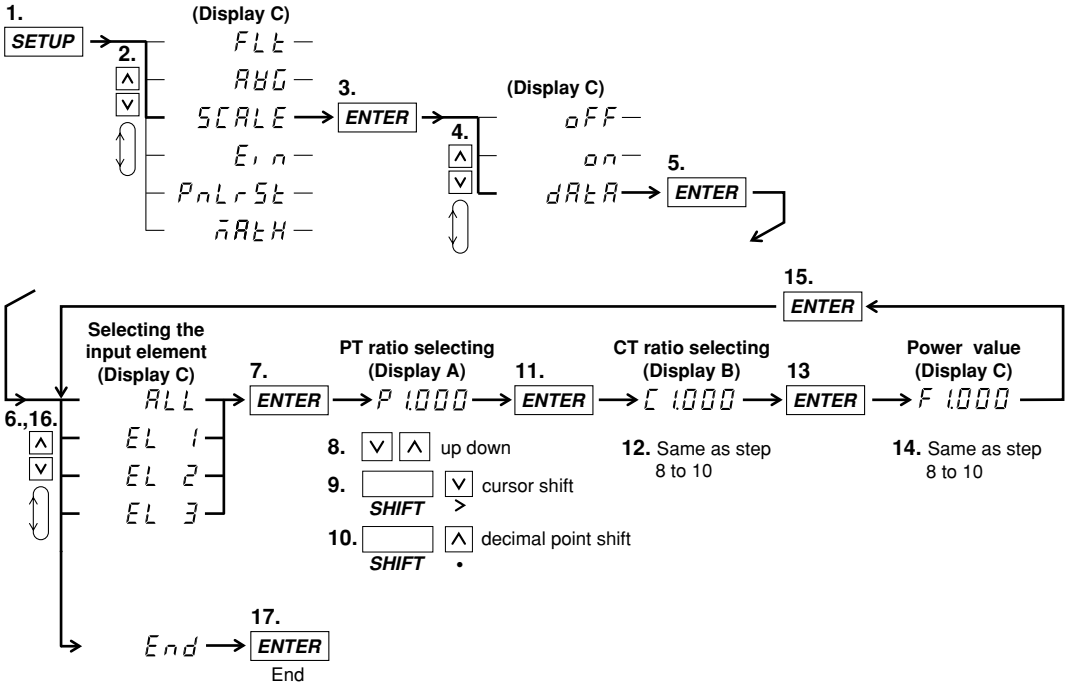
Displays relevant keys and indicator

*Shows the operation panel of the WT130. For the differences between WT110 and WT130, refer to section 2.2, page 2-2, 2-3

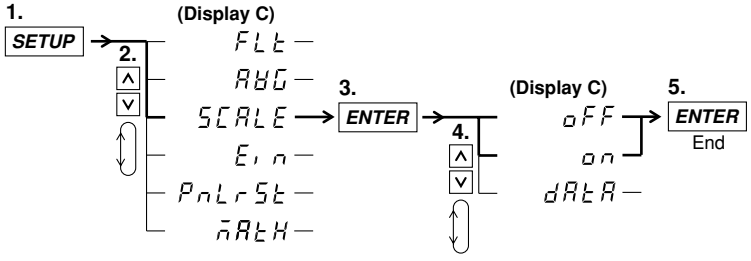
Operating Procedure

- Perform operations following the thick line in the below menu.
- Press the ENTER key to confirm the selection or setting.
- When you want to leave the current menu during operation, press the key described under step 1. The confirmed settings made until that point will be kept.

• Setting the Scaling Value



• Selecting Scaling ON/OFF



Explanation

About the Scaling Function

This function is useful for measuring voltage, current, power and such when you are using an external potential transformer (PT), current transformer (CT) or such, and have connected their secondary side outputs to the input elements. You set the scaling value to the PT ratio, CT ratio or power factor. When the scaling function is turned ON, measured values which have been converted to the corresponding values for the transformer primary sides, can been displayed or otherwise output.

Measured/computed value	Scaled result
Voltage V	P × V
Current A	C × A
Active power W	F × P × C × W
Reactive power var	F × P × C × var
Apparent power VA	F × P × C × VA

P: Voltage scaling value
C: Current scaling value
F: Power scaling value

Selecting the Input Element

This setting is to select to which element scaling will be applied. The initial value is “ALL”. At the WT110, this selection menu will not appear.

- ALL : Select this when the same scaling values should be applied to all elements together.
- EL1 : Select this when the scaling values should only be applied to element 1.
- EL2 : Select this when the scaling values should only be applied to element 2. This selection will not appear on model 253502.
- EL3 : Select this when the scaling values should only be applied to element 3.
- End : Select this when you finished the setting, or when you want to abort the setting.

Setting the Scaling Value

The scaling values are set in the following order. The setting ranges from 0.001 to 1000. The initial value is 1.000.

- P : Sets the PT ratio on display A
- C : Sets the CT ratio on display B
- F : Sets the power value on display C

In case of the WT110, pressing the ENTER key after setting P, C and F respectively will end this scaling setting. In case of the WT130, selecting End at the input element menu will end this scaling setting.

Turning Scaling ON/OFF

Select the scaling menu once again after having set the scaling values. The initial value is oFF.

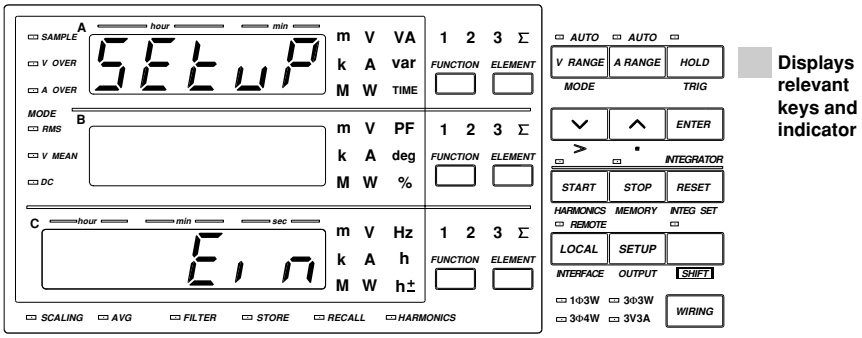
- on : When this setting is selected, pressing the ENTER key will start scaling and the SCALING indicator will light.
- oFF : When this setting is selected, pressing the ENTER key will stop scaling and SCALING indicator will extinguish.

Note

When the scaling value x measurement range exceeds 9999M, the computation over display will appear (refer to page 2-3).

4.5 Selecting the Measurement Range and Setting the Scaling Value when External Sensor is Used (option)

Relevant Keys



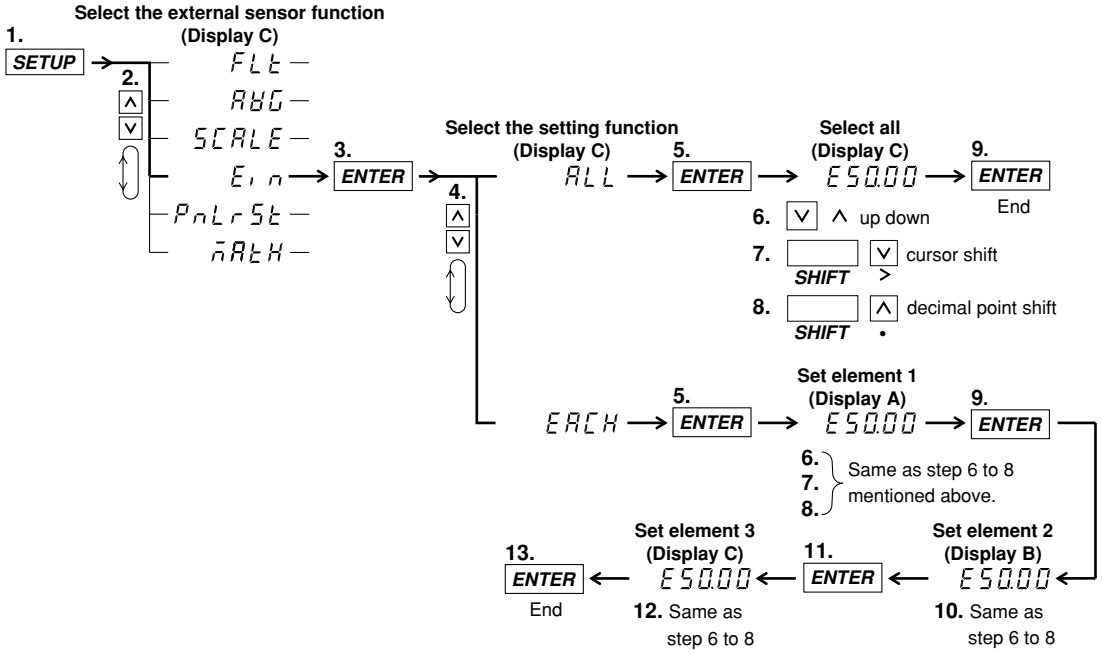
Displays relevant keys and indicator

*Shows the operation panel of the WT130. For the differences between WT110 and WT130, refer to section 2.2, page 2-2, 2-3

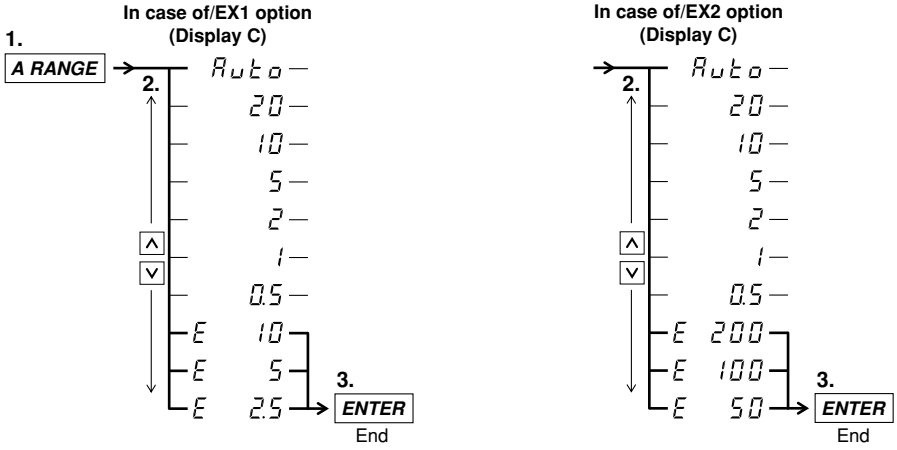
Operating Procedure

- Perform operations following the thick line in the below menu.
- Press the ENTER key to confirm the selection or setting.
- When you want to leave the current menu during operation, press the key described under step 1. The confirmed settings made until that point will be kept.

• Setting the Scaling Value of the External Sensor Input



• Selecting the Measurement Range (Current, with Scaling function ON)



Explanation

Scaling Function in combination with External Sensor Input

This function is useful for measuring current, power and such when you are using an external sensor, and have connected their output to the input elements. You set the scaling value to the current or power value, computed from the sensor. When the scaling function is turned ON, measured values which have been converted to the corresponding values for the transformer primary sides, can been displayed or otherwise output. This function is exactly the same as the one described previously for use with PT/CT.

Measured/computed value	Scaled result	
Current A	E × A	E: External sensor scaling value
Active power W	E × W	
Reactive power var	E × var	
Apparent power VA	E × VA	

Selecting the Setting Format of the Scaling Value

The following two setting formats are available. The initial value is “ALL”. At the WT110, this selection menu will not appear.

- ALL : Select this when the same scaling values should be applied to all elements together.
- EACH: Select this when the scaling values should only be applied to each element seperately.

Setting the Scaling Value

The procedure to set the scaling values depends on the setting format (previous setting). The setting ranges from 0.001 to 1000. The initial value is 50.00. In case of the WT110, the scaling value is set at display C.

- When ALL is selected:
  The scaling value set at display C will be applied to all elements together.
- When EACH is selected:
  - The scaling value set at display A will be applied to element 1 only.
  - The scaling value set at display B will be applied to element 2 only. This selection will not appear on model 253502.
  - The scaling value set at display C will be applied to element 3 only.

After having selected ALL or EACH and entered the scaling values, press the ENTER key to end this scaling setting.

Selecting the Measurement Range (Current, with Scaling function ON)

After having set the scaling values, select the menu for the current measurement range. Select the rated output of the external sensor from this menu (refer to the Operating Procedure on the previous page). Scaling of the external sensor input will start as soon as you press the ENTER key after selecting. Scaling will stop as soon as you select a measurement range other than external sensor input from the menu.

Setting Example of Scaling Values for External Sensor Input

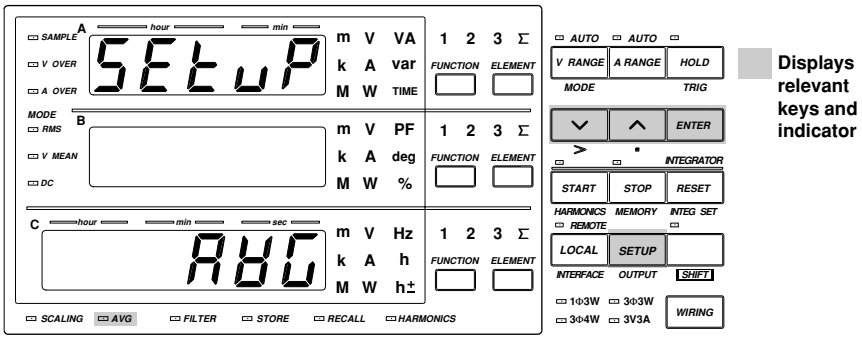
- In case the rated specs of the external sensor are 50A/50mV, measurement range is 50mV, then
  50A/50mV × 50mV = 50A: scaling value is 50.00
- In case the rated specs of the external sensor are 100A/50mV, measurement range is 50mV, then
  100A/50mV × 50mV = 100A: scaling value is 100.00
- In case the rated specs of the external sensor are 50A/80mV, measurement range is 50mV, then
  50A/80mV × 50mV = 31.25A: scaling value is 31.25
  However, since the setting range is 50mV, use a setting within the 0 to 50mV range.

Note

- When performing measurements using the external sensor, make sure to turn off the scaling function for the external PT/CT. When this function is ON, the scaling value of the CT ratio will interfere.
- The input range for the external sensor can only be of the manual type.
- When you switch from external sensor input to direct, auto range input, an error will appear. First, select manual range for direct input and afterwards select auto range. (same goes for setting by communication interface.)

4.6 Using the Averaging Function

Relevant Keys



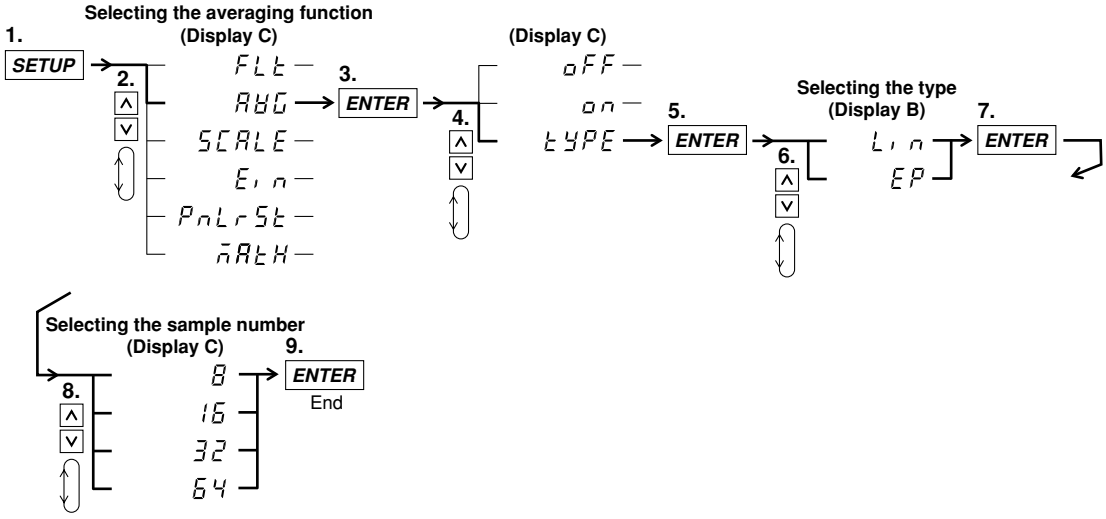
Displays relevant keys and indicator

***Shows the operation panel of the WT130. For the differences between WT110 and WT130, refer to section 2.2, page 2-2, 2-3**

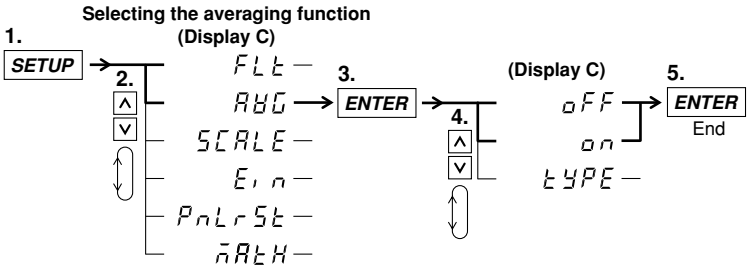
Operating Procedure

- **Perform operations following the thick line in the below menu.**
- **Press the ENTER key to confirm the selection or setting.**
- **When you want to leave the current menu during operation, press the key described under step 1. The confirmed settings made until that point will be kept.**

• Setting Averaging



• Averaging ON/OFF



Explanation

About the Averaging Function

This function performs exponential averaging or moving averaging on measurement values. When the displayed values are unsteady due to big fluctuations in power source or load, or due to the low frequency of the input signal, this function is useful to stabilize the displayed values for easier reading.

Selecting the Type of Averaging

The following two selections are available. The initial value is “Lin”.

- **Exponential Averaging : EP**

  Exponential averaging is expressed by the following equation.

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

  where

  D_n : the value at the “n”th display;
  D_{n-1} : the exponentially averaged value at the “n-1”th display;
  M_n : the measurement value at the “n”th display;
  K : attenuation constant

- **Moving Averaging: Lin**

  Moving averaging is expressed by the following equation.

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

  where

  D_n : the value at the “n”th display;
  $M_{n-(m-1)}$: the measurement value at (m-1) display before the “n”th display;
  $M_{n-(m-2)}$: the measurement value at (m-2) display before the “n”th display;
  :
  M_{n-2} : the measurement value at two displays before the “n”th display;
  M_{n-1} : the measurement value at one display before the “n”th display;
  M_n : the measurement value at the “n”th display;
  m : sample number

Setting the Averaging Sample Number/Attenuation Constant

The following selections are available. The attenuation constant (for exponential averaging) and the sample number (for moving averaging) are set and saved seperately. The initial value is “8”.

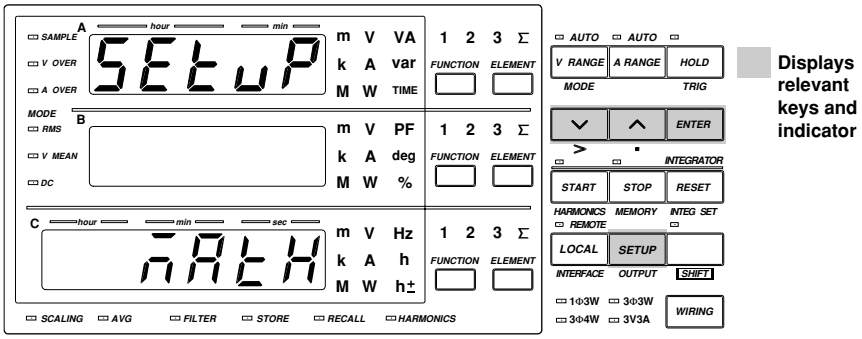
Setting Averaging ON/OFF

Select the averaging menu once again after having set the averaging values. The initial value is oFF.

- on : When this setting is selected, pressing the ENTER key will start averaging and the AVG indicator will light.
- oFF : When this setting is selected, pressing the ENTER key will stop averaging and the AVG indicator will extinguish.

4.7 Using the Four Arithmetical Operation Function (Applies to WT110/WT130 with ROM Version 2.01 or later)

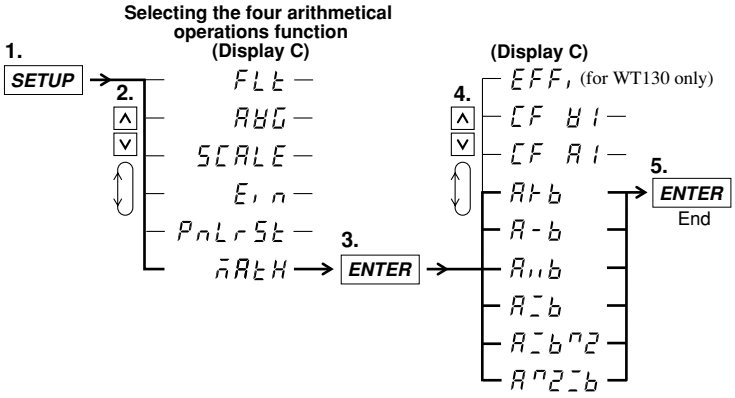
Relevant Keys



***Shows the operation panel of the WT130. For the differences between WT110 and WT130, refer to section 2.2, page 2-2, 2-3**

Operating Procedure

- **Perform operations following the thick line in the below menu.**
- **Press the ENTER key to confirm the selection or setting.**
- **When you want to leave the current menu during operation, press the key described under step 1. The confirmed settings made until that point will be kept.**



Explanation

Four Arithmetical Operations Function

Displays the following computation results on display C. "n" is displayed at the front when the computation results are being displayed.

- A+b : **A+B**
- A-b : **A–B**
- A*b : **A×B**
- A/b : **A÷B**
- A/bn2 : **A÷B²**
- An2/b : **A² ÷B**

A, B indicates display A, B respectively.

Note

- The meanings of the displayed symbols are as follows:
  - \+ : **+(Addition)**
  - \- : **–(Subtraction)**
  - * : **×(Multiplication)**
  - / : **÷(Division)**
  - n : **^(Exponent)**
- If the display A function is displaying INTEG TIME (elapsed time of integration), the computation result displays "- - - - -" (no data).
- If the value of display B function is less than 0.0001% of the rating, the computation result displays "- - oF - -".

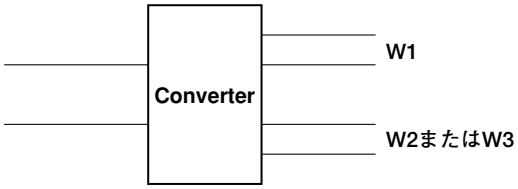
Application Example

• Power summation

A+b : Displays the result of display A + display B.

Computation example :

Display A	Display B	Display C	Wiring method
W1	W2 or W3	W1+W2 or W1+W3	Any

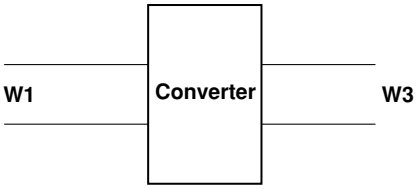


• Power loss

A-b : Displays the result of display A – display B.

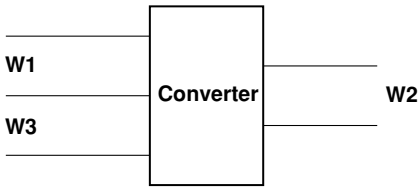
Computation example 1 :

Display A	Display B	Display C	Wiring method
W1	W3	W1–W3	Any



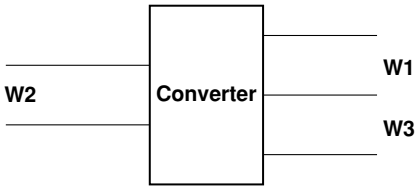
Computation example 2 :

Display A	Display B	Display C	Wiring method
∑W(=W1+W3)	W2	∑W–W2	3Φ3W



Computation example 3 :

Display A	Display B	Display C	Wiring method
W2	∑W(=W1+W3)	W2–∑W	3Φ3W



- **Useful when setting a function other than VA (apparent power) for display A and displaying VA on display C.**

  A,b : Displays the result of display A × display B.

  Computation example :

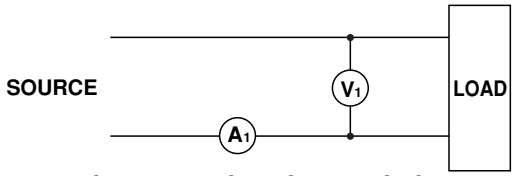
Display A	Display B	Display C	Wiring method
V1rms	A1rms	V1rms×A1rms	Any

- **Absolute value of the impedance**

  A_b : Displays the result of display A ÷ display B.

  Computation example :

Display A	Display B	Display C	Wiring method
V1rms	A1rms	$\|Z\|=\frac{V1rms}{A1rms}$	Any

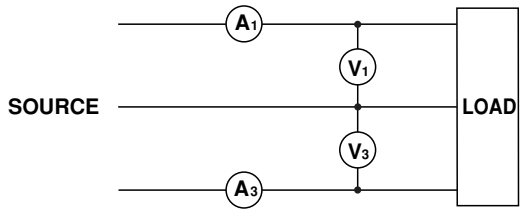


- **Voltage ratio across the wires and phase current ratio for a three-phase wiring.**

  A_b : Displays the result of display A ÷ display B.

  Computation example :

Display A	Display B	Display C	Wiring method
V1rms	A3rms	$\frac{V1rms}{A3rms}$	3Φ3W
A1rms	A3rms	$\frac{A1rms}{A3rms}$	

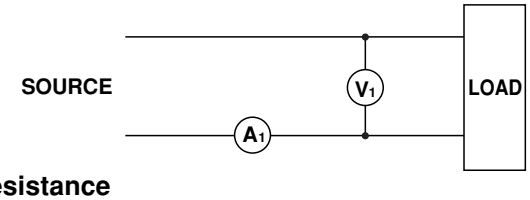


- **Impedance, resistance and reactance**

  A_bn2 : Displays the result of display A ÷ (display B)^2

  Computation example :

Display A	Display B	Display C	Wiring method
VA1	A1rms	$\|Z\|=\frac{VA1}{(A1rms)^2}$	Any
W1	A1rms	$R=\frac{W1}{(A1rms)^2}$	
Var1	A1rms	$\|X\|=\frac{Var1}{(A1rms)^2}$	

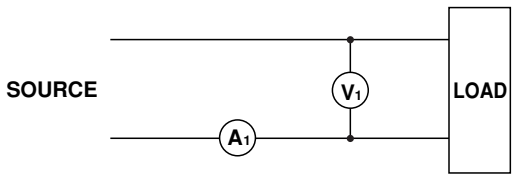


- **Resistance**

  An2_b : Displays the result of (display A)^2 ÷ display B

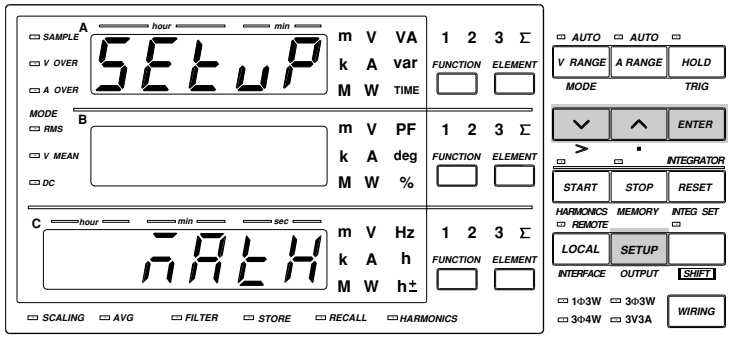
  Computation example :

Display A	Display B	Display C	Wiring method
V1rms	W1	$R=\frac{(V1rms)^2}{W1}$	Any



4.8 Computing the Crest Factor (Applies to WT110/ WT130 with ROM Version 2.01 or later)

Relevant Keys

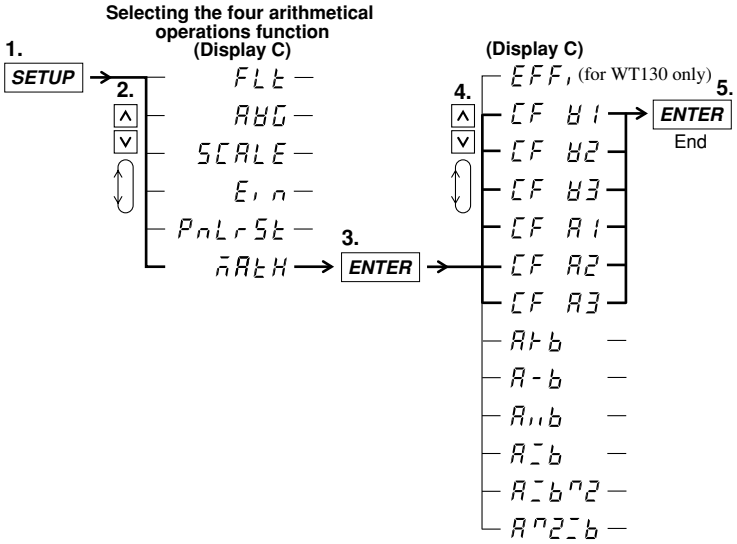


Displays relevant keys and indicator

***Shows the operation panel of the WT130. For the differences between WT110 and WT130, refer to section 2.2, page 2-2, 2-3**

Operating Procedure

- **Perform operations following the thick line in the below menu.**
- **Press the ENTER key to confirm the selection or setting.**
- **When you want to leave the current menu during operation, press the key described under step 1. The confirmed settings made until that point will be kept.**



Explanation

Crest factor computation

The crest factor is determined by peak value/rms value. The crest factors for voltage and current are computed and displayed. "$\bar{n}$" is displayed at the front when the crest factor is being displayed.

Computing equation for the crest factor and display

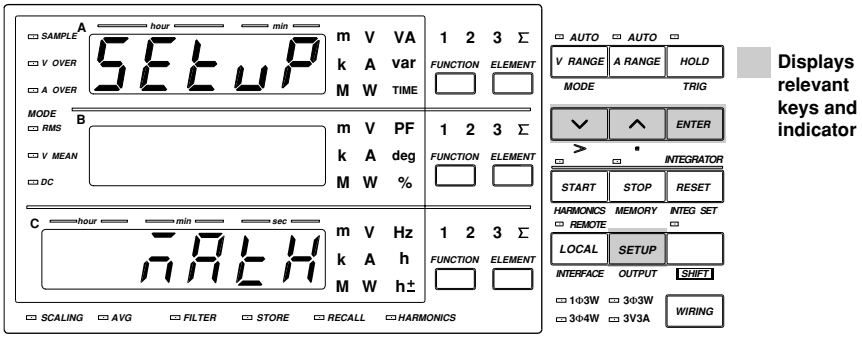
CF V1 : Displays the result of (Peak of V1)/(rms of V1)
CF V2 : Displays the result of (Peak of V2)/(rms of V2) (for 253503 only)
CF V3 : Displays the result of (Peak of V3)/(rms of V3) (for 253502 and 253503)
CF A1 : Displays the result of (Peak of A1)/(rms of A1)
CF A2 : Displays the result of (Peak of A2)/(rms of A2) (for 253503 only)
CF A3 : Displays the result of (Peak of A3)/(rms of A3) (for 253502 and 253503)

Note

- Definition of crest factor : $\frac{\text{PEAK value}}{\text{RMS value}}$
- If the measurement mode is V MEAN or DC, "- - - - -" is displayed.

4.9 Computing the Efficiency (Applies to WT130 with ROM Version 2.01 or later)

Relevant Keys

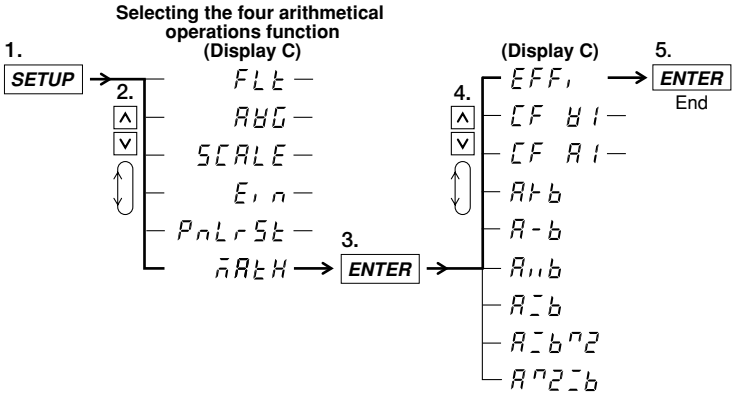


Displays relevant keys and indicator

***Shows the operation panel of the WT130. For the differences between WT110 and WT130, refer to section 2.2, page 2-2, 2-3**

Operating Procedure

- **Perform operations following the thick line in the below menu.**
- **Press the ENTER key to confirm the selection or setting.**
- **When you want to leave the current menu during operation, press the key described under step 1. The confirmed settings made until that point will be kept.**



Explanation

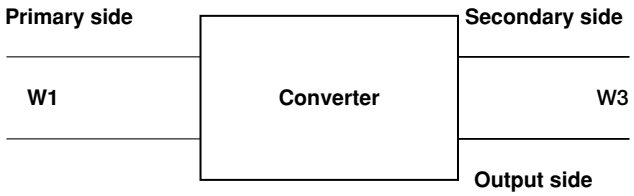
Setting the Wiring Method

The computing equation for efficiency changes according to the wiring method as indicated on the next page. For the operating procedure, see section 3.9 "Selecting the Wiring Method (for WT130)."

Wiring Method and Computing Equation

- **When the input and output are both two-wire**

  Select 1Φ2W, 1Φ3W, or 3Φ3W for the wiring method for the three-phase three-wire system 253502) and 1Φ2W for the wiring method for the three-phase four-wire system (253503).

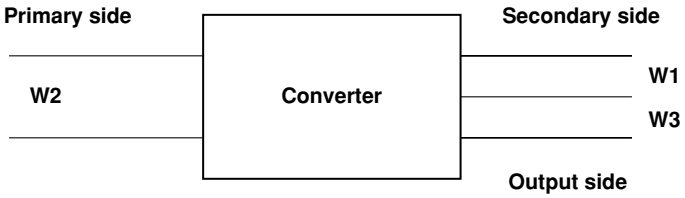


  Computing equation

  Efficiency(μ) = (W3/W1)×100

- **When the input is two-wire and the output is three-wire**

  Select 1Φ2W, 1Φ3W, 3Φ3W, or 3V3A for the wiring method. This only applies to model 253503.

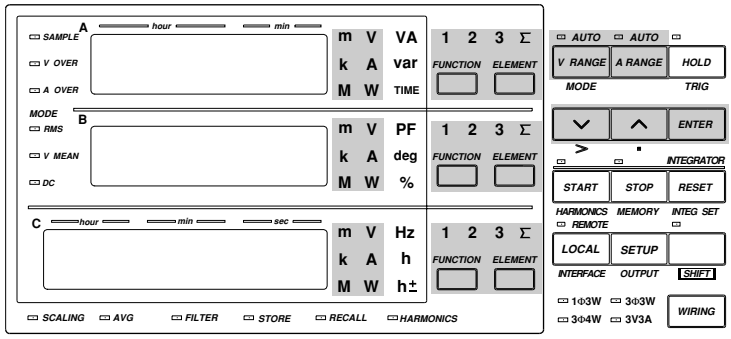


  Computing equation

  Efficiency(μ) = {(W1+W3)/W2}×100

5.1 Measuring/Displaying Voltage, Current and Active Power

Relevant Keys



Displays relevant keys and indicator

*Shows the operation panel of the WT130. For the differences between WT110 and WT130, refer to section 2.2, page 2-2, 2-3

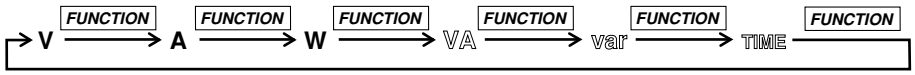
Operating Procedure

1 Selecting the Display Function

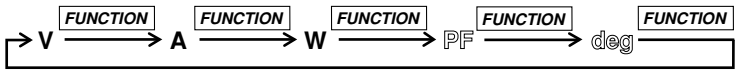
Select either V (voltage), A (current) or W (power) by pressing the FUNCTION key.

Display

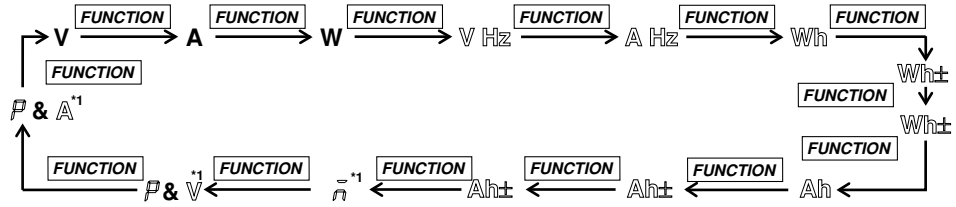
A



B



C



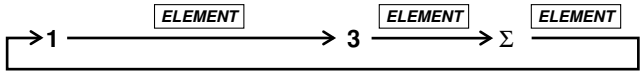
Wh± and Ah± will light twice. $\bar{n}$ and $\bar{P}$ are displayed on the top of display C.
You can reverse the order by first pressing the SHIFT key followed by the FUNCTION key.
*1 Displayed on WT110/WT130 with ROM version 2.01 or later.

2 Selecting the Input Element

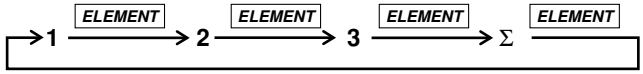
Select the input element by pressing the ELEMENT key.

WT110 (253401): No such function

WT130 (253502):



WT130 (253503):



3 Selecting the Measurement Range

You can select the voltage measurement range by pressing the V RANGE key, and the current measurement range by pressing the A RANGE key. For more details, refer to either of the following.

- 4.3 Selecting the Measurement Range in case of Direct Input, on page 4-4;
- 4.4 Setting the Scaling Value when External PT/CT is Used, on page 4-6;
- 4.5 Selecting the Measurement Range and Setting the Scaling Value when External Sensor is Used (option), on page 4-8.

4 Selecting the Measurement Mode

Select the measurement mode by pressing the V RANGE (MODE) key after having pressed the SHIFT key so that the SHIFT indicator is lit. For more details, refer to section 4.1 on page 4-1.

Explanation

Continuous Maximum Allowable Input

- Voltage : peak voltage is 1.5kV, or the RMS value is 1.0kV, whichever is less.
- Current : peak current is 100A or the RMS value is 30A, whichever is less. In case of external sensor input, the peak value is 5 times the measurement range or less.

Maximum Reading of the Display and Units

- Maximum reading : for voltage, current and power, each 9999
- Units : V (voltage), A (current), W (power)
- Prefix : m, k, M

Selecting the Display Function

The following selections are available.

- V : voltage will be displayed
- A : current will be displayed
- W : power will be displayed

Selecting the Input Element

The type of input element which can be selected depends on the model number. Make your selection after having verified your model number.

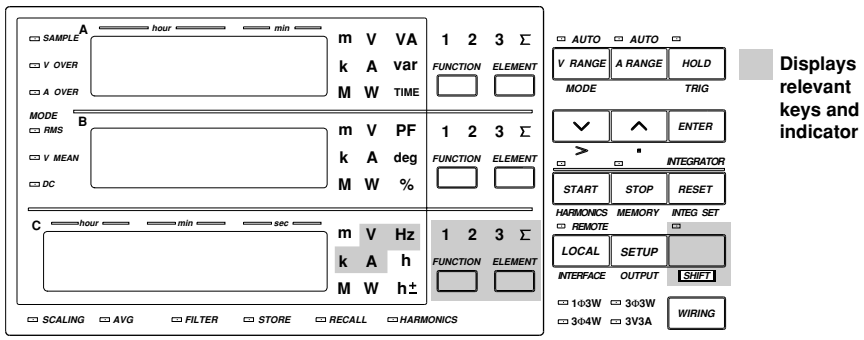
- 1/2/3 : Displays the measurement values of element 1/2/3
- ∑ : Displays according to the wiring method, and is as follows.

Wiring method	ΣV	ΣA	ΣW	ΣVA	Σvar
1Φ3W	$\frac{V_1+V_3}{2}$	$\frac{A_1+A_3}{2}$	W_1+W_3	$V_1A_1+V_3A_3$	var_1+var_3
3Φ3W	$\frac{V_1+V_3}{2}$	$\frac{A_1+A_3}{2}$	W_1+W_3	$\frac{\sqrt{3}}{2}(V_1A_1+V_3A_3)$	var_1+var_3
3Φ4W	$\frac{V_1+V_2+V_3}{3}$	$\frac{A_1+A_2+A_3}{3}$	$W_1+W_2+W_3$	$V_1A_1+V_2A_2+V_3A_3$	$var_1+var_2+var_3$
3V3A	$\frac{V_1+V_2+V_3}{3}$	$\frac{A_1+A_2+A_3}{3}$	W_1+W_3	$\frac{\sqrt{3}}{3}(V_1A_1+V_2A_2+V_3A_3)$	var_1+var_3

Wiring method	ΣPF	Σdeg
1Φ3W 3Φ3W 3Φ4W 3V3A	$\frac{\Sigma W}{\Sigma VA}$	$\cos^{-1}\Sigma PF$

5.2 Measuring/Displaying Frequency

Relevant Keys

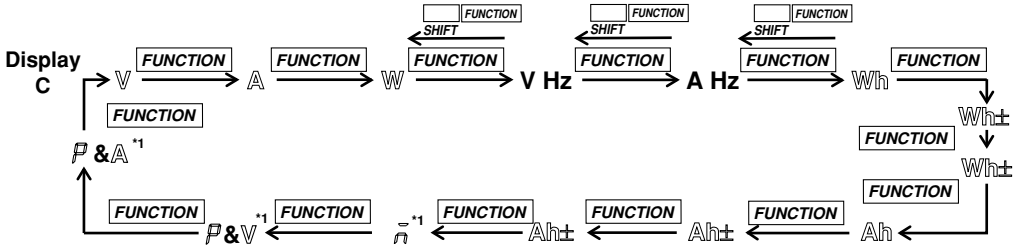


***Shows the operation panel of the WT130. For the differences between WT110 and WT130, refer to section 2.2, page 2-2, 2-3**

Operating Procedure

1 Selecting the Display Function

Select either V Hz (voltage frequency) or A Hz (current frequency) by pressing the FUNCTION key of display C.



Wh± and Ah± will light twice. $\bar{f}$ and $\bar{P}$ are displayed on the top of display C.
You can reverse the order by first pressing the SHIFT key followed by the FUNCTION key.
***1 Displayed on WT110/WT130 with ROM version 2.01 or later.**

2 Selecting the Input Element

Select the input element by pressing the ELEMENT key of display C. The operation is the same as the one described on page 5-1.

Explanation

Measurement Range

The measurement range lies from 10 to 50kHz. Depending on the internal timing, however, measurements can be done in the range from 4 to 10Hz. At 100Hz/1kHz/10kHz/100kHz, the measurement range is auto range.

Maximum Reading of the Display and Units

- Maximum reading : 9999
- Units : Hz
- Prefix : k

Selecting the Display Function

The following selections are available.
- V Hz: voltage frequency will be displayed
- A Hz: current frequency will be displayed

Selecting the Input Element

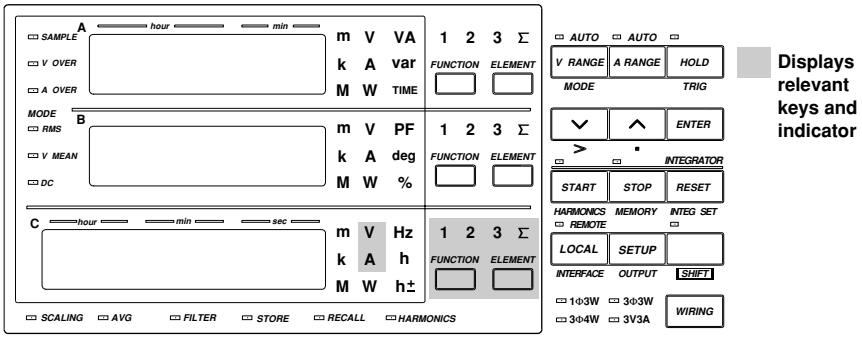
The type of input element which can be selected depends on the model number. Make your selection after having verified your model number.
- 1/2/3 : Displays the measurement values of element 1/2/3
- Σ : Displays no measurement values, only dots.

Note

- In case the level of the input signal is low (below approx. 7%), or when the frequency is smaller than the measurement range, the display will show “ErrLo”. When the frequency is larger than the measurement range, the display will show “ErrHi”.
- This instrument measures the frequency after synchronizing to the cycle of the input signal. We recommend to turn ON the filter when measuring an inverted waveform or a waveform with high noise. However, depending on the signal’s frequency and level, “ErrLo” might appear on the display. Since the filter’s cutoff frequency is 300Hz, the signal attenuates and no signal will be detected.
- Even when the filter is set OFF but the frequency exceeds the measurement range, “ErrLo” might appear since no signal will be detected anymore due to the internal circuit’s attenuation.

5.3 Measuring/Displaying Four Arithmetic Operation Value, Crest Factor and Peak Value

Relevant Keys



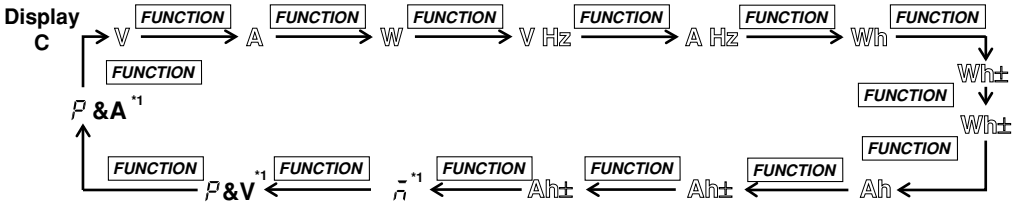
Displays relevant keys and indicator

***Shows the operation panel of the WT130. For the differences between WT110 and WT130, refer to section 2.2, page 2-2, 2-3**

Operating Procedure

1 Selecting the display Function

Select either $\bar{\Pi}$(four arithmetical operations, crest factor), ρ(voltage peak value) or ρ(current peak value) by pressing the FUNCTION key.



Wh± and Ah± will light twice. $\bar{\Pi}$ and ρ are displayed on the top of display C.
You can reverse the order by first pressing the SHIFT key followed by the FUNCTION key.
***1** Displayed on WT110/WT130 with ROM version 2.01 or later.

2.Selecting the Input Element

To measure or display the peak value, press the ELEMENT key of display C and select the input element.

The procedure is the same as shown on page 5-1.

Explanation

Measureing/displaying peak value

ρ is displayed at the front of display C for both voltage and current.

- If the function is set to "V," the peak value of the voltage is measured and displayed.
- If the function is set to "I," the peak value of the current is measured and displayed.

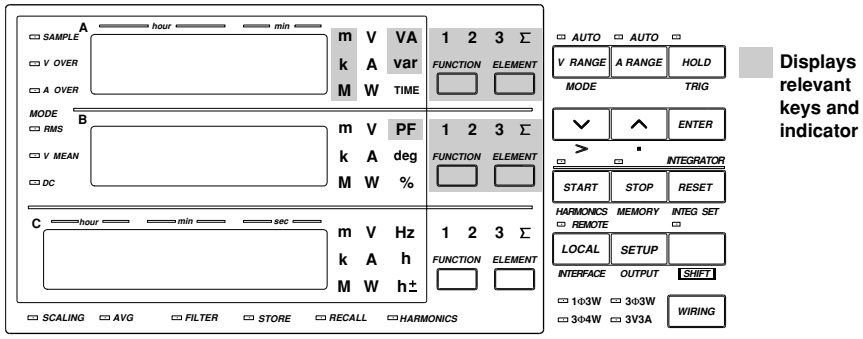
Displaying the result of the four arithmetical operation abd the crest factor

When display C is set to $\bar{\Pi}$, the result of the computing equation specified in Section 4.7 or the crest factor specified in Section 4.8 is displayed.

However, if the value of display B function is less than 0.0001% of the rating, "- - oF - -" is displayed for the computation result.

6.1 Computing / Displaying Apparent Power, Reactive Power and Power Factor

Relevant Keys



Displays relevant keys and indicator

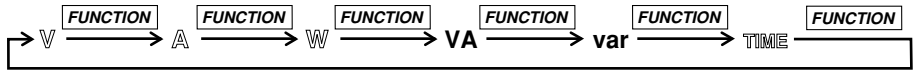
***Shows the operation panel of the WT130. For the differences between WT110 and WT130, refer to section 2.2, page 2-2, 2-3**

Operating Procedure

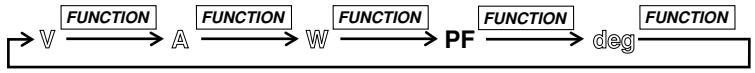
1 Selecting the Display Function

Select either VA (apparant power), var (reactive power) or PF (power factor) by pressing the FUNCTION key of display A or B.

Display A



B



You can reverse the order by first pressing the SHIFT key followed by the FUNCTION key.

2 Selecting the Input Element

Select the input element by pressing the ELEMENT key of display A or B. The operation is the same as the one described on page 5-1.

Explanation

Maximum Reading of the Display and Units

- Maximum reading of apparent and reactive power: 9999
- Display range of power factor : –1.000 to 1.000
  (when the computed result lies between 1.001 and 2.000, 1.000 will be displayed. When the result is 2.001 or more, PFErr will be displayed.)
- Units : VA (apparent power), var (reactive power), power factor (no unit)
- Prefix : m, k, M,

Selecting the Display Function

The following selections are available.

- VA : apparent power will be displayed
- var : reactive power will be displayed
- PF : power factor will be displayed

Selecting the Input Element

The type of input element which can be selected depends on the model number. Make your selection after having verified your model number.

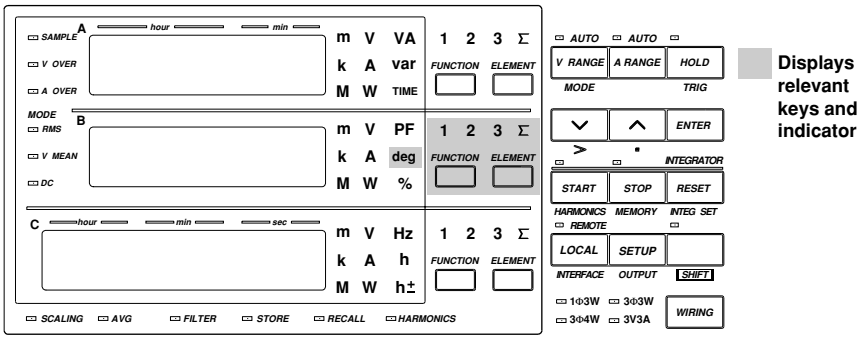
- 1/2/3 : Displays the measurement values of element 1/2/3
- ∑ : Refer to page 5-2.

Note

- Changing the measurement mode might result in different computed results, even when the input signal is the same. For more details on the measurement mode, refer to page 4-1.
- When either the voltage or current drops below 0.5% of the measurement range, PFErr will be displayed.

6.2 Computing/Displaying the Phase Angle

Relevant Keys

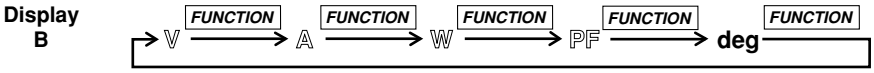


***Shows the operation panel of the WT130. For the differences between WT110 and WT130, refer to section 2.2, page 2-2, 2-3**

Operating Procedure

1 Selecting the Display Function

Select deg (phase angle) by pressing the FUNCTION key of display B.



You can reverse the order by first pressing the SHIFT key followed by the FUNCTION key.

2 Selecting the Input Element

Select the input element by pressing the ELEMENT key of display B. The operation is the same as the one described on page 5-1.

Explanation

Display Range and Units

Display range : G180.0 to d180.0 (G meaning phase lag, d meaning phase lead)
Unit : deg

Selecting the Display Function

When you select deg, the phase angle will be displayed.

Selecting the Input Element

The type of input element which can be selected depends on the model number. Make your selection after having verified your model number.

- 1/2/3 : Displays the measurement values of element 1/2/3
- Σ : Refer to page 5-2.

Note

- Changing the measurement mode might result in different computed results, even when the input signal is the same. For more details on the measurement mode, refer to page 4-1.
- When either the voltage or current drops below 0.5% of the measurement range, dEGErr will be displayed.
- Distinction between phase lag and lead can be made properly, only when both voltage and current are sine waves, and when the percentage of voltage or current input relating to the measurement range does not fluctuate much.
- If the computed result of the power factor exceeds 1, the display will be as follows.
  - when the power factor ranges between 1.001 to 2.000; the phase angle displays 0.0;
  - when the power factor is 2.001 or more, the phase angle displays dEGErr.

7.1 Integrator Functions

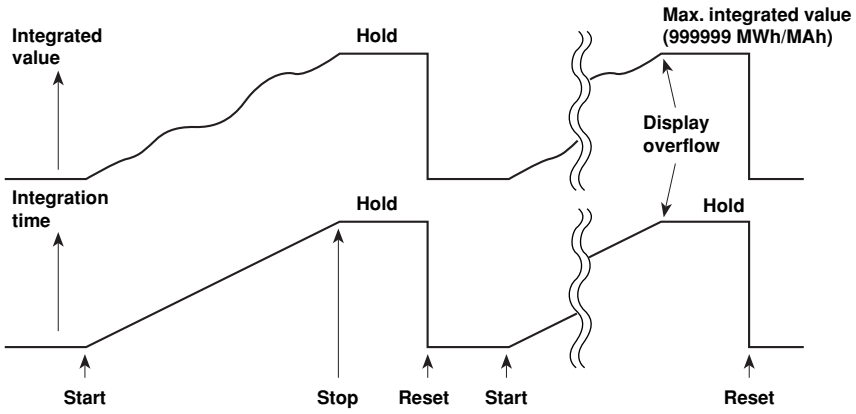
Active power integration and current integration can be carried out. All measurement values (and computed values) can be displayed, even when integration is in progress, except for the integrated values (watt hour or ampere hour) and integration elapsed time. Since integrated values of negative polarity can be also displayed, the consumed watt hour (ampere hour) value of the positive side and the watt hour value returning to the power supply of the negative side (ampere hour: only when the measurement mode is DC), can be displayed seperately.

Integration Modes

The following three modes are available as integration modes.

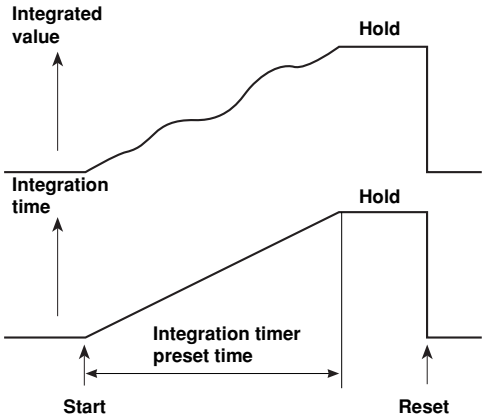
Manual Integration Mode

- Integration starts: after having pressed the START key
- Integration stops:
  - after having pressed the STOP key;
  - when the integrated value reaches the maximum of 999999MWh/MAh, or when the integrated value of negative polarity reaches –99999MWh/MAh;
  - when the integration elapsed time reaches the maximum of 999 hours and 59 minutes.
- Integration holds: the integration elapsed time and integrated values at the point where integration stopped will be held until the RESET key is pressed.



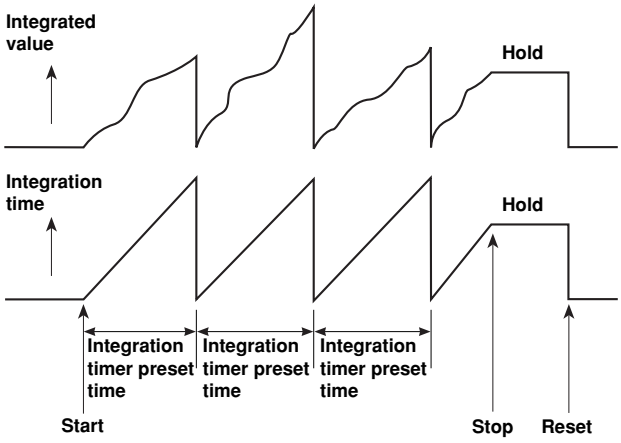
Standard Integration Mode

- Integration starts: after having pressed the START key
- Integration stops:
  - when the preset time for integration is reached;
  - when the integrated value reaches the maximum of 999999MWh/MAh, or when the integrated value of negative polarity reaches –99999MWh/MAh.
- Integration holds: the integration elapsed time and integrated values at the point where integration stopped will be held until the RESET key is pressed.



Continous Integration Mode (Repeat Integration)

- Integration starts:
  - after having pressed the START key;
  - when the preset time for integration is reached, the integrated value and integration elapsed time are reset automatically and restarted immediately.
- Integration stops:
  - when the preset time for integration is reached; however, the integrated value and integration elapsed time are reset automatically and restarted immediately;
  - after having pressed the STOP key;
  - when the integrated value reaches the maximum of 999999MWh/MAh, or when the integrated value of negative polarity reaches –99999MWh/MAh;
- Integration holds: the integration elapsed time and integrated values at the point where they reached the maximum or at the point where the STOP key was pressed will be held until the RESET key is pressed.



Integration Methods

Each display update interval (250ms) the apparent power values or current values are added to the integrated values, and will be time converted. The integration equations are as follows.

Power integration

$$\sum_{T=0}^{t} \frac{Wi}{4 \times 3600}$$

Wi : Active power between display update interval

t : Preset integration time

Current integration

$$\sum_{T=0}^{t} \frac{Ai}{4 \times 3600}$$

Ai : Current value between display update interval

t : Preset integration time

Display Resolution during Integration

The display resolution for integrated values is 100000 counts. The decimal point shifts automatically since the integrated value increases in accordance with the elapsed time.
The decimal point shifting timing is determined automatically according to the selected voltage and current measuring ranges. After the rated value is set for both voltage and current measuring ranges, the decimal point shifts when the integrated value exceeds 100000 counts. However, the minimum measurement unit is 1/1000 times the power range which is determined by the rated voltage and current ranges, and the maximum measurement unit is MWh (or MAh). The following shows the watt hour values when rated values are input at a 150V/5A range. The below mentioned "h", "m" and "s" stand for hour, minutes and seconds respectively.

Elapsed time	Integrated value
0s	0.000mWh
2s	416.67mWh
:	
4s	833.33mWh
5s	1.0417Wh
:	
47	9.7917Wh
48	10.000Wh
:	
7m59s	99.792Wh
8m00s	100.00Wh
:	
1h00m00s	750.00Wh
2h00m00s	1.5000kWh
:	
13h00m00s	9.7500kWh
14h00m00s	10.500kWh

Display Function of Integrator Values

By selecting the display function, you can display the polarity of the integrator values.

Display function	Measurement mode	Display contents
Wh	RMS,VMEAN,DC	both positive and negative watt hour values
Wh±*1	RMS,VMEAN,DC	positive watt hour value
Wh±*1	RMS,VMEAN,DC	negative watt hour value
Ah	RMS,VMEAN	total ampere hour values
	DC	both positive and negative ampere hour values
Ah±*2	RMS,VMEAN	total ampere hour values (same as Ah)
	DC	positive ampere hour value
Ah±*2	RMS,VMEAN	–0
	DC	negative ampere hour value

*1 When the Wh function is selected, pressing the FUNCTION key once or twice will result in Wh±. Pressing the FUNCTION key once will result in displaying the positive watt hour value, whereas pressing the FUNCTION key twice will result in displaying the negative watt hour value. In case of the negative watt hour value, "–" will appear in front of the value.

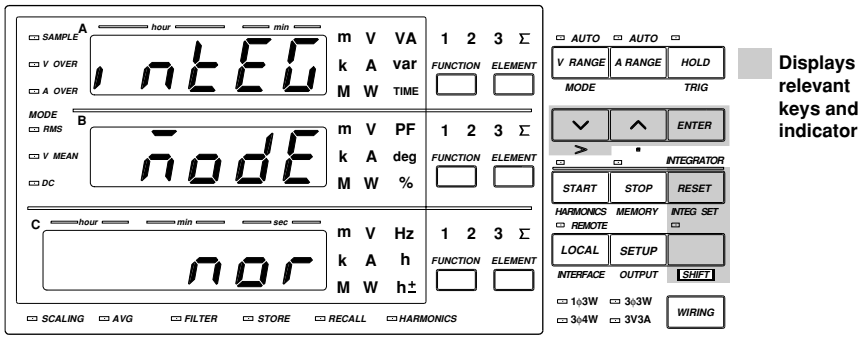
*2 When the Ah function is selected, pressing the FUNCTION key once or twice will result in Ah±. Pressing the FUNCTION key once will result in displaying the positive ampere hour value, whereas pressing the FUNCTION key twice will result in displaying the negative ampere hour value. In case of the negative ampere hour value, "–" will appear in front of the value.

Note

- When negative integrated values are displayed, the maximum display reading will become –99999MWh/MAh because of the added minus character.
- When the measurement mode is RMS/VMEAN and the current input drops below 0.5% of the rated range, the ampere hour value will become zero (0).
- During integration is in progress (until being reset), operation of other functions are restricted. Refer to page 7-8 for more details.

7.2 Setting Integration Mode and Integration Timer

Relevant Keys

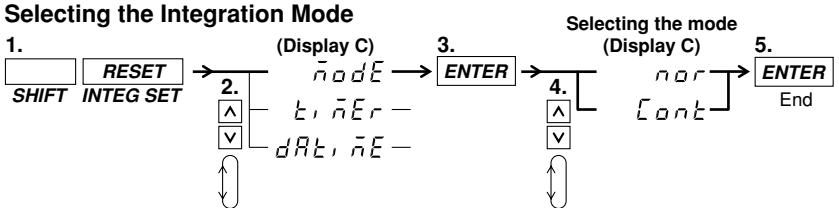


***Shows the operation panel of the WT130. For the differences between WT110 and WT130, refer to section 2.2, page 2-2, 2-3**

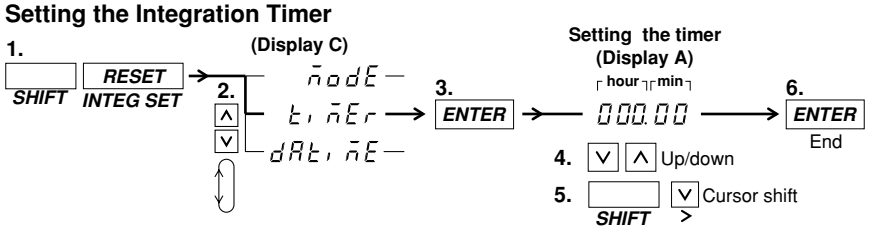
Operating Procedure

- **Perform operations following the thick line in the below menu.**
- **Press the ENTER key to confirm the selection or setting.**
- **When you want to leave the current menu during operation, press the key described under step 1. The confirmed settings made until that point will be kept.**

• Selecting the Integration Mode



• Setting the Integration Timer



Explanation

Selecting the Measurement Mode

The following selections are available. The initial value is nor.

- nor :Select this for manual or standard integration mode. Depending on the integration timer, this instrument will automatically decide the appropriate mode.
- Cont :Select this for the continuous integration mode.

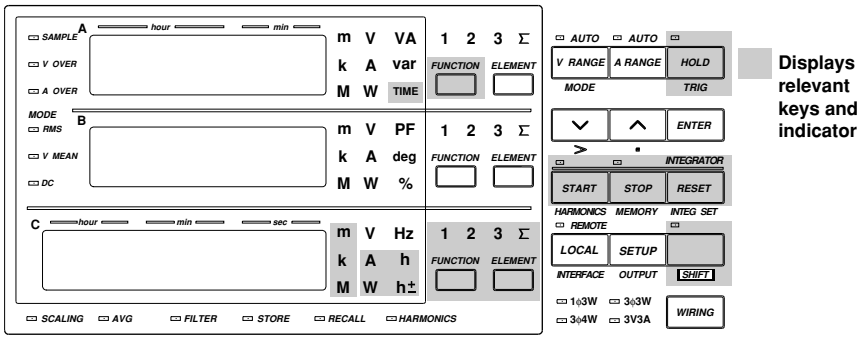
Setting the Integration Timer

This setting decides how long integration will be performed in terms of hours and minutes. The setting ranges from 000.00 (0 hrs, 0 min) to 999.59 (999 hrs, 59 min). The initial value is 000.00.

- 000.00 :When "nor" is selected on the integration menu, the manual integration mode will become valid. When "Cont" is selected, an error code will appear and integration will not be performed.
- 000.01 to 999.59 :The time during which integration will be performed when in the standard or continuous integration mode. The standard or continuous mode should be selected at the integration mode menu.

7.3 Displaying Integrated Values

Relevant Keys



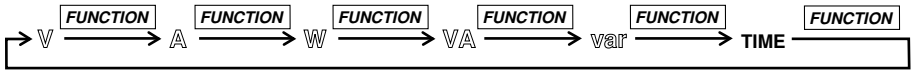
***Shows the operation panel of the WT130. For the differences between WT110 and WT130, refer to section 2.2, page 2-2, 2-3**

Operating Procedure

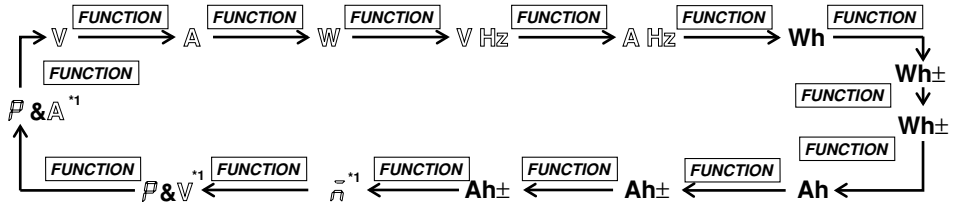
1 Selecting the Display Function

Pressing the FUNCTION key on display A will select TIME (integration elapsed time). Pressing the FUNCTION key on display C will select either Wh/Wh± (power) or Ah/Ah± (current).

Display A



C



Wh± and Ah± will light twice. $\bar{n}$ and P are displayed on the top of display C.
You can reverse the order by first pressing the SHIFT key followed by the FUNCTION key.
***1 Displayed on WT110/WT130 with ROM version 2.01 or later.**

2 Selecting the Input Element

Select the input element by pressing the ELEMENT key on display C. The operation is the same as the one described on page 5-1.

3 Starting Integration

Press the START key. The START indicator will light, the integrated value will appear on display C and the integration elapsed time will appear on display A.

START

4 Holding Integration

Press the HOLD key. The HOLD indicator will light, and the displayed values will be held.

HOLD

5 Cancelling HOLD, and Updating the Integration

Continuing from step 4, press the HOLD key once more, or press the SHIFT key followed by the HOLD (TRIG) key. The HOLD indicator will extinguish and the displayed value will be updated.

HOLD
TRIG

6 Stopping Integration

Press the STOP key. The START indicator will extinguish and the STOP indicator will light. The displayed values will be held.

STOP

7 Resetting Integration

Press the RESET key. The STOP indicator will extinguish and the values on display A and C will be reset to 000.00.

RESET

Explanation

Maximum Reading of the Display and Units

Maximum reading

- Integrated value :999999 (–99999 in case of minus display)
- Integration elapsed time :999.59
- Units : Wh (power integration : watt hour value), Ah(current integration : ampere hour value)
- Prefix : m, k, M

Selecting the Display Function

The following selections are available.

- Wh :displays both the positive and negative watt hour values
- Wh± :displays the positive watt hour value
- Ah :displays the total ampere hour values
- Ah± :displays the total ampere hour values or the positive ampere hour value

For more details, refer to page 7-3.

Selecting the Input Element

- 1/2/3 :Displays the measurement values of element 1/2/3
- ∑ :Displays the total integrated values of the elements installed. The method of computation depends on the wiring method. The computation method changes to Wh or Ah for the active power W (refer to chapter 15).

When the display function TIME is selected on display A, there is no element function available on display A. Pressing the ELEMENT key on display A will result in an error code.

Update Hold Function

Although the held values will not be updated, integration continues. When hold is being cancelled, the integration results (values and time) corresponding to the point of cancellation, will be displayed.

For details regarding the relation with the START/STOP key, refer to the following page.

Integration Reset

Resetting will result in returning the integration results to the status before integration started. Pressing the RESET key is useful after integration has been stopped.

For details regarding the relation with the START/STOP key, refer to the following page.

Display in case of Integration Over

When the maximum integration value has been reached (999999MWh/MAh or –99999MWh/MAh), integration will stop and that result will be held on the display.

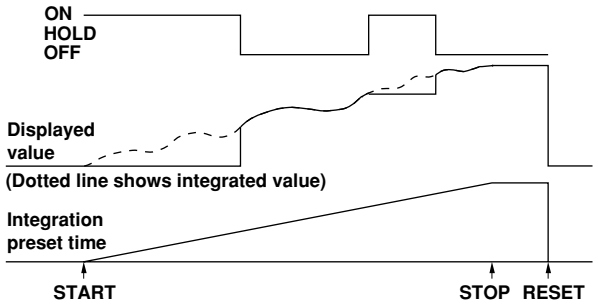
When the maximum integration time has been reached (up to 999hrs 59min), integration will stop and that result will be held on the display.

7.4 Precautions Regarding Use of Integrator Function

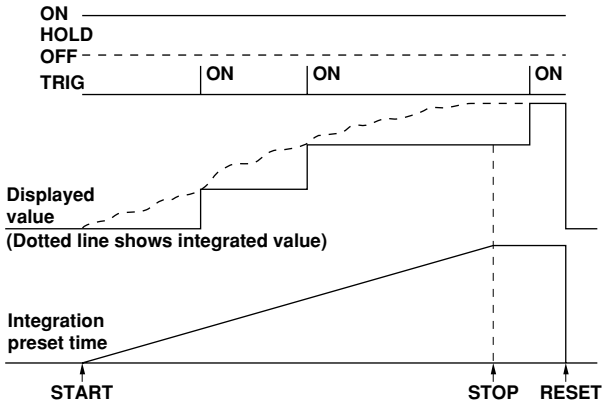
Relation between Integration Hold and the START/STOP key

When the HOLD key is pressed, the display and communication output of the integrated results is being held while integration continues. The relation between this hold function and the START/STOP key is as follows.

- Even when starting integration while the hold function is on, the display and communication output will remain unchanged. Only canceling the hold function or activating a trigger (pressing the SHIFT key followed by the HOLD (TRIG) key) will result in displaying or outputting the integrated results of the time of cancellation.

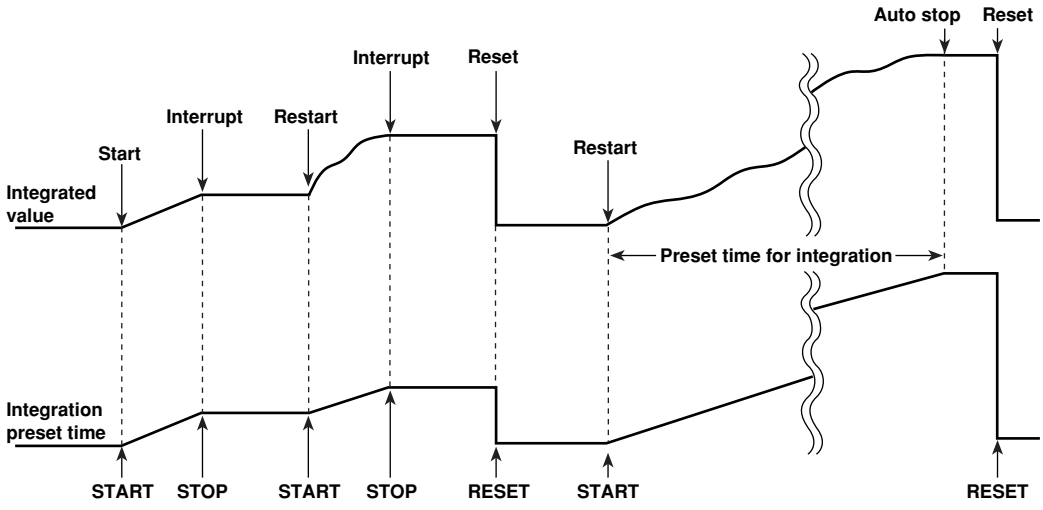


- Even when stopping integration while the hold function is on, the displayed integrated value will remain unchanged. However, as soon the hold function is turned off or a trigger is activated, the integrated results of the time when integration was stopped will be displayed or output.



Relation between Integration Reset and the START/STOP key

The relation between integration reset and the start/stop key is as follows.



Backup During Power Failures

- If there is a power failure while integration is in progress, the integrated value and integration elapsed time will be backed up. When the power is restored, the display will show the integrated results up to the time the power failure occurred.
- To start integration after the power is restored, it is necessary to reset integration first.

Operating Restrictions during Integration

Certain key operations are restricted during integration, and are shown below.

		Integration status	
	Integration reset	Integration in progress	Integration interrupted
(START Indicator) (STOP Indicator)	Not lit Not lit	Lit Not lit	Not lit Lit
Function			
Wiring method (only WT130)	O	O	O
Measurement mode	O	×	×
Filter	O	×	×
Measurement range	O	×	×
Scaling	O	O	O
Averaging	O	×	×
Display function	O	O	O
Input element (only WT130)	O	O	O
Hold	O	O	O
Trigger	O	O	O
Integration mode	O	Settings cannot be changed, but can be displayed	
Integration timer	O	Settings cannot be changed, but can be displayed	
Integration start	O	×	O
Integration stop	×	O	×
Integration reset	O	×	O
Harmonic analysis function (option)	O	×	×
Store/recall	O	×Store possible	×Store possible

·O:Settings can be changed
·×:Settings cannot be changed. Attempts will result in an error code.
·When integration is started during auto range, the measurement range will change to manual range.

Integration Computation when the Measured Value Exceeds Measurement Limits

When the active power, measurement current, instantaneous voltage or current exceeds the measurement range, the integration computation will be handled as follows.

- When the active power or measurement current exceeds the measurement range by 163.84%, their integrated values become 163.84% of the measurement range.
- When the instantaneous voltage or current exceeds the measurement range by 300%, their integrated values become 300% of the measurement range.

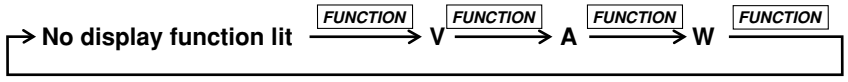
8.1 Harmonic Analysis Function

This chapter explains the harmonics analysis function which can be applied to normal measurements of voltage, current and power.

Analyzed/Displayed Items

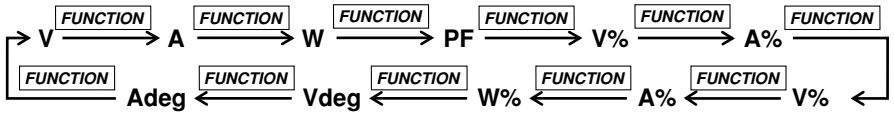
After having set the harmonic analysis function to ON, the harmonic component of voltage, current, or active power, will be analyzed and displayed for one of the input elements (not applicable for the WT110). Depending on the setting of the display function, the display changes as follows.

Display A



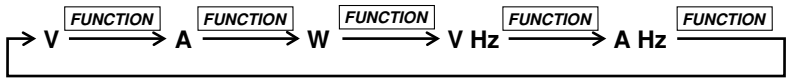
No display function lit : Displays the harmonic order (1 to 50)
Display function **V, A, W** : Displays all rms values (computed values) of 1up to 50 components of voltage, current or active power

Display B



Display function **V** : Displays the voltage analysis value of the order shown on display A
A : Displays the current analysis value of the order shown on display A
W : Displays the active power analysis value of the order shown on display A
PF : Displays the power factor of the fundamental (1st order)
V % : Displays the voltage harmonic distortion, proceeded by "t" on display B
A % : Displays the current harmonic distortion, proceeded by "t" on display B
V % : Displays the relative harmonic content of the voltage of the order shown on display A
A % : Displays the relative harmonic content of the current of the order shown on display A
W % : Displays the relative harmonic content of the active power of the order shown on display A
V deg : · In case the 1st order (fundamental) is shown on display A:
Displays the phase angle between the voltage of the first order and the current of the first order
· In case the order 2 to 50 is shown on display A:
Displays the phase angle between the voltage of the first order and each voltage of the 2nd to 50th order
A deg : · In case the 1st order (fundamental) is shown on display A:
Displays the phase angle between the voltage of the first order and the current of the first order (same as V deg)
· In case the order 2 to 50 is shown on display A:
Displays the phase angle between the current of the first order and each current of the 2nd to 50th order

Display C



Display function **V, A, W** : Displays all rms values (computed values) of 1 up to 50 components of voltage, current or active power.
V Hz : Displays the fundamental frequency of the voltage for PLL synchronization (displays the measurement value for only the selected voltage input)
A Hz : Displays the fundamental frequency of the current for PLL synchronization (displays the measurement value for only the selected current input)

Auto Range Operation

The up/down operation of the measurement range is the same as for normal measurement.

Note

When the range changes, the PLL synchronization will be re-established. Therefore, correct measurement values might not be obtained which might result in an unstable range. If this is the case, set the measurement range to a fixed range.

Display Renewal Rate

Harmonic analysis data will be updated approx. every 3 seconds.

Holding the Display

When you use the display hold function and change the order or display function while the harmonic analysis function is ON, you can display the harmonic data analyzed at the corresponding time.

Updating the Displayed Data

The display can be updated in the same way as for normal measurement.

Overrange/Error Displays

In case the fundamental frequency of the PLL synchronization signal lies outside the measurement range. Display B will show "FrqEr".

Note

The measurement range of the fundamental frequency of the harmonic analysis function is different from the frequency measurement range of normal measurement. Refer to Ch. 15 for more details.

Display in case of Overrange

The overrange display (being the same as for normal measurement) will appear when all rms values of the 1st to 50th order reach the following value:

• 140% of the rated range for the 600V voltage range, or 20A current range

• 200% of the rated range for voltage ranges except 600V, or current ranges except 20A

The relative harmonic content and harmonic distortion are related to voltage and current.

Error Display

The power factor or phase angle will show PFErr or dEGEr when either the voltage, range or power exceeds 200% of the range.

Computation Over Display

Appears in the same way as for normal measurement.

Dot Display

The display will show dots in any of the following cases.

- When there are no more analysis data to be displayed during harmonic analysis;
- Soon after the harmonic analysis function has been turned ON;
- When the PLL synchronization is being re-established;
- Until the initial analysis data are obtained, after having changed the settings;
- When the analysis order which depends on the fundamental frequency, exceeds the upper limit, after having set the order at display A;
- When the display function is set to relative harmonic content (%) and the order at display A is set to 1;
- When the PLL source is set to voltage, and an attempt is made to display the current frequency (AHz); or when the PLL source is set to current, and an attempt is made to display the voltage frequency (VHz);
- When an element which is not assigned to the measurement object, is selected. However, since the frequency is not related to the element setting, the fundamental frequency designated as the PLL source can be displayed.

Averaging Function

Exponential averaging is performed with an attenuation constant of 8.

Output to an External Plotter

Using the GP-IB or RS-232-C interface, harmonic analysis data can be printed as value or graph on an external plotter.

Effect of Aliasing

This instrument is not equipped with an internal aliasing filter. Due to aliasing accidental errors may occur under the following circumstances.

Fundamental frequency f in Hz

$40 \leq f < 70$ errors may occur in case of harmonic components of the 256th or higher;

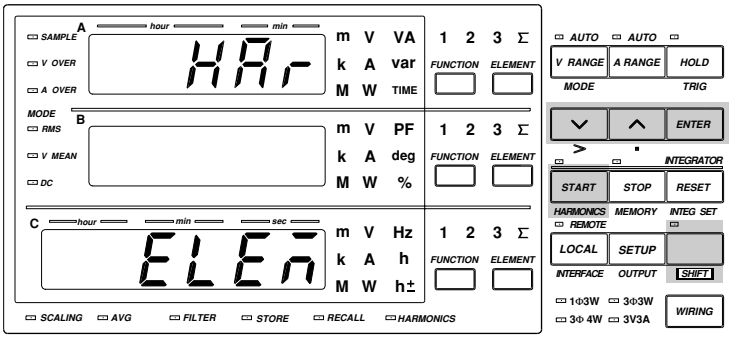
$70 \leq f < 130$ errors may occur in case of harmonic components of the 128th or higher;

$130 \leq f < 250$ errors may occur in case of harmonic components of the 64th or higher;

$250 \leq f \leq 440$ errors may occur in case of harmonic components of the 32nd or higher.

8.2 Setting the Element, PLL Source and Harmonic Distortion Method

Relevant Keys



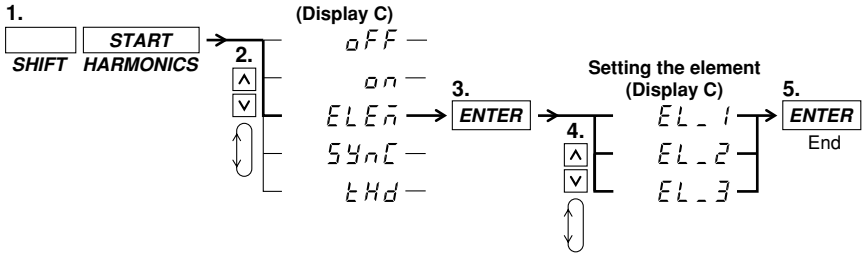
Displays relevant keys and indicator

***Shows the operation panel of the WT130. For the differences between WT110 and WT130, refer to section 2.2, page 2-2, 2-3**

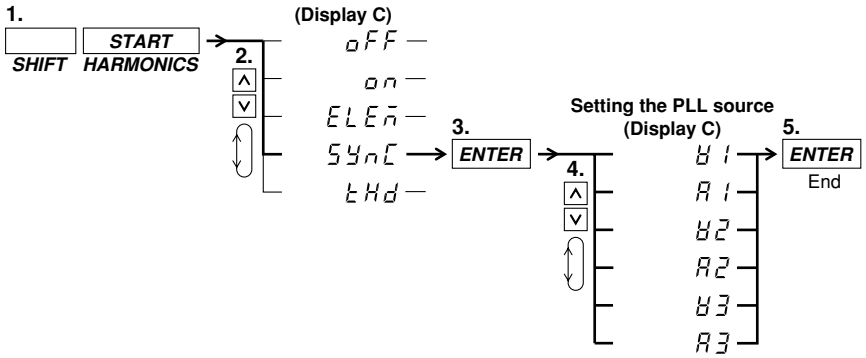
Operating Procedure

- **Perform operations following the thick line in the below menu.**
- **Press the ENTER key to confirm the selection or setting.**
- **When you want to leave the current menu during operation, press the key described under step 1. The confirmed settings made until that point will be kept.**

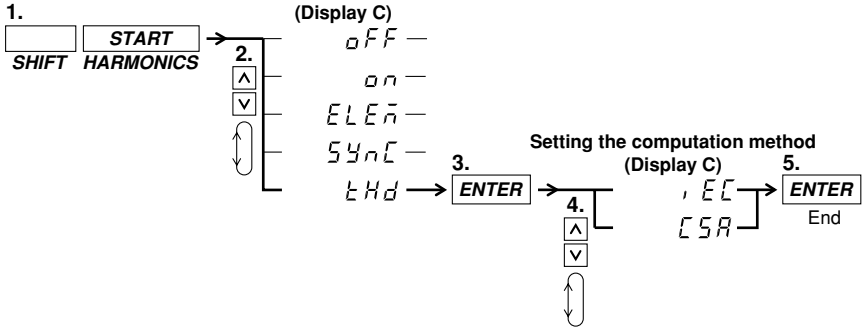
• Setting the Element



• Setting the PLL source



• Setting the Computation Method of the Harmonic Distortion



Explanation

Setting the Element

Only one input element should be set for harmonic analysis. The initial value is EL1. At the WT110 the element setting menu does not appear.

- EL1 : Element 1 will be used for analysis;
- EL2 : Element 2 will be used for analysis; In case of the 253502, this menu will not be shown;
- EL3 : Element 3 will be used for analysis.

Setting the PLL source

For harmonic analysis, it is necessary to select the input to be used as the fundamental frequency (PLL source) for synchronization. (PLL stands for Phase Locked Loop.)

- V1: Sets the voltage of element 1 as the PLL source;
- A1: Sets the current of element 1 as the PLL source;
- V2: Sets the voltage of element 2 as the PLL source;
- A2: Sets the current of element 2 as the PLL source;
- V3: Sets the voltage of element 3 as the PLL source;
- A3: Sets the current of element 3 as the PLL source.

Note

- If the fundamental frequency of the PLL source cannot be measured due to fluctuations or distortion, it is not possible to obtain correct measurement results. In this case, it is suggested that voltage with relatively small distortion be selected as the PLL source.
- It is recommended to turn ON the filter in cases where the fundamental frequency is 300Hz or less and high frequency components are present.
- If the amplitude of the input signal selected as the PLL source is smaller than the rated range value, PLL synchronization may sometimes fail. In this case, it is suggested that a suitable measurement range be selected so that the input level exceeds 30% of the rated range value.

Setting the Computation Method of Harmonic Distortion

The computation method of harmonic distortion can be selected from the following two. In the following explanation a maximum of 50 analysis orders is assumed. In case of a maximum less than 50, computation/display will be performed up to that order.

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

Computation Equation

In case of iEC

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

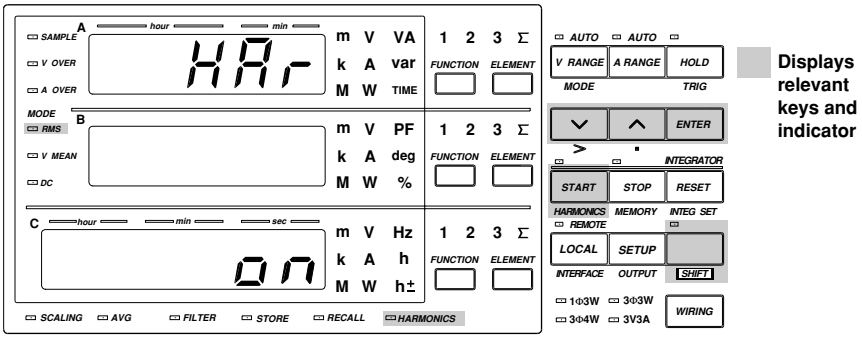
In case of CSA

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

C1 : Fundamental component (1st order)
Ck : Fundamental or harmonic component
k : Analysis order
n : Maximum order. The maximum order depends on the fundamental frequency of the input set as the PLL source. Refer to Ch. 15 for more details.

8.3 Switching the Harmonic Analysis Function ON/OFF

Relevant Keys

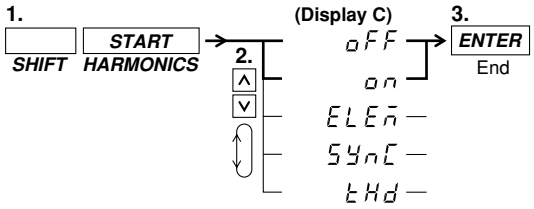


***Shows the operation panel of the WT130. For the differences between WT110 and WT130, refer to section 2.2, page 2-2, 2-3**

Operating Procedure

- **Perform operations following the thick line in the below menu.**
- **Press the ENTER key to confirm the selection or setting.**
- **When you want to leave the current menu during operation, press the key described under step 1. The confirmed settings made until that point will be kept.**

• Turning the Harmonic Analysis Function ON/OFF



Explanation

Turning the Harmonic Analysis Function ON/OFF

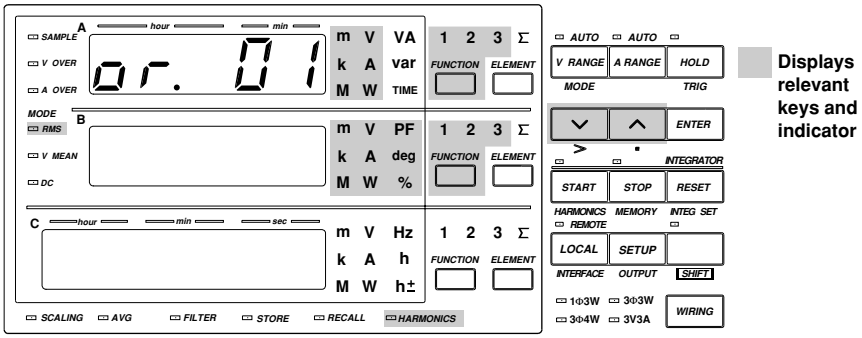
- on : Pressing the ENTER key after selecting on will result in starting of the harmonic analysis and the HARMONICS indicator will light up. The harmonic order will be displayed on display A.
- oFF : Pressing the ENTER key after selecing off will result in stopping of the harmonic analysis and the HARMONICS indicator will extinguish.

Note

- When the harmonic analysis function is turned ON, the measurement mode will automatically change to RMS mode. When the harmonic analysis function is turned OFF, the measurement mode will stay the RMS mode.
- When the harmonic analysis function is ON, integration cannot be started. And accordingly, when the integration is in progress, the harmonic analysis function cannot be started (refer to page 7-8).

8.4 Setting the Harmonic Order and Displaying the Results of Harmonic Analysis

Relevant Keys



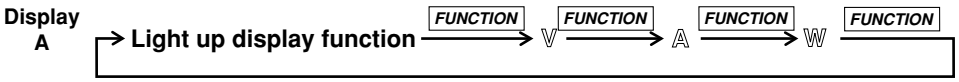
***Shows the operation panel of the WT130. For the differences between WT110 and WT130, refer to section 2.2, page 2-2, 2-3**

Operating Procedure

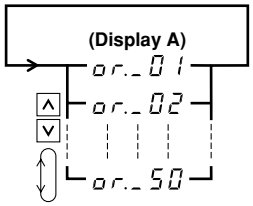
The following operations assume that the harmonic analysis function is turned ON.

Setting the Harmonics Order

1. Light up the display function indicator of display A.

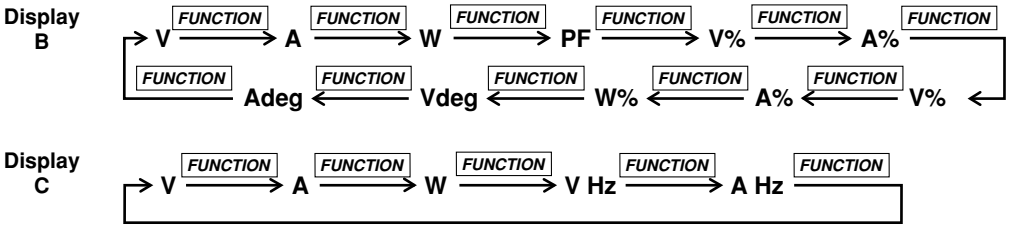


2. Set the harmonics order.



Displaying the Values of Harmonic Analysis

Displays each analysis value after having set the display function of either display B or C.



Explanation

Setting the Order of Harmonics

The maximum order for which analysis results can be displayed varies depending on the frequency of the fundamental.

Example

- When the fundamental frequency is 50Hz, up to 50 orders can be displayed;
- When the fundamental frequency is 400Hz, up to 30 orders can be displayed.

When an order is set exceeding the maximum order, display B will change to the dot display.

Refer to Ch. 15 for more details on upper limits of analysis orders.

Displaying the Results of Harmonic Analysis

Depending on the setting of display function of display B and C, the analyzed items will appear on the display as follows. In the following explanation a maximum of 50 analysis orders is assumed. In case of a maximum less than 50, computation/display will be performed up to that order.

Display B

V : Shows the analysis value of the voltage corresponding to the order shown on display A;

A : Shows the analysis value of the current corresponding to the order shown on display A;

W : Shows the analysis value of the active power corresponding to the order shown on display A;

PF : Shows the power factor of the fundamental (1st order);

V% : Shows the harmonic distortion of the voltage followed by the character “t”; Two computation methods are available; Refer to page 8-4 for details. The display range is 0.00 to 99.99 and 100.0 to 999.9%.

A% : Shows the harmonic distortion of the current followed by the character “t”; Two computation methods are available; Refer to page 8-4 for details. The display range is 0.00 to 99.99 and 100.0 to 999.9%.

V% : Shows the relative harmonic content of the voltage corresponding to the order shown on display A; The display range is 0.00 to 99.99 and 100.0 to 999.9%.

A% : Shows the relative harmonic content of the current corresponding to the order shown on display A; The display range is 0.00 to 99.99 and 100.0 to 999.9%.

W% : Shows the relative harmonic content of the active power corresponding to the order shown on display A; The display range is 0.00 to ±99.99 and ±100.0 to ±999.9%.

V deg : In case the fundamental (1st order) is shown on display A
Shows the phase angle between the 1st order of the current and the 1st order of the voltage. G (phase lag) or d (phase lead) will also be displayed.
In case the 2nd to 50th order is shown on display A
Shows the phase angle between the 1st order of the voltage and the 2nd to 50th order of each voltage. A – (minus) will be displayed in front of the order only when the 2nd to 50th order is phase-lagged. The display range is –180.0 to 180.0 deg.

A deg : In case the fundamental (1st order) is shown on display A
Shows the same as in case of V deg.
In case the 2nd to 50th order is shown on display A
Shows the phase angle between the 1st order of the current and the 2nd to 50th order of each current. A – (minus) will be displayed in front of the order only when the 2nd to 50th order is phase-lagged. The display range is –180.0 to 180.0 deg.

Display C

V : Shows each rms (computed) value of the 1st to 50th harmonic component of the voltage;

A : Shows each rms (computed) value of the 1st to 50th harmonic component of the current;

W : Shows each rms (computed) value of the 1st to 50th harmonic component of the active power;

Computation Equation

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

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

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

Vk, Ak, Wk : Each component of 1st to 50th order of voltage, current and active power;
k : Analysis order
n : Maximum order. The maximum order depends on the fundamental frequency of the input set as the PLL source. Refer to Ch. 15 for more details.

V Hz : Shows the fundamental frequency of the voltage of the PLL source. This frequency applies only to the element selected as PLL source. For details regarding the PLL source setting, refer to page 8-3. The measurement range is the same as in case of normal measurement.

The range of fundamental frequencies in case of harmonic analysis is 40 to 440Hz. However, depending on internal timing, there are cases where measurements in the 20 to 700Hz range can be performed.

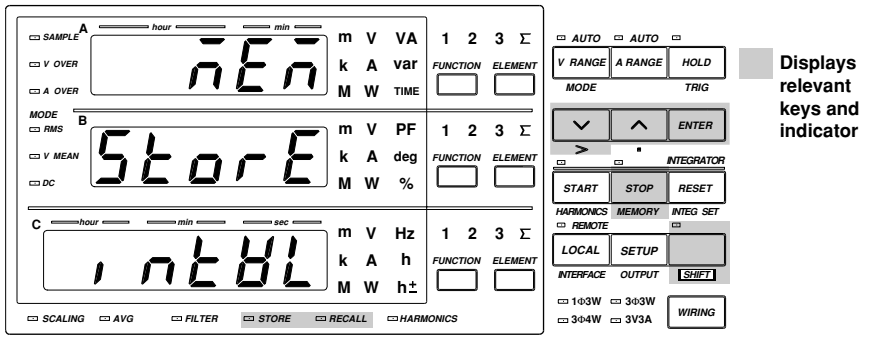
A Hz : Shows the fundamental frequency of the current of the PLL source. The rest is the same as in case of V Hz.

Note

- In case you select an input element using the ELEMENT key which is not the assigned element for the harmonic analysis or you selected a display function which is not being analyzed/measured, then the bar display appears.
- When the harmonic analysis function is turned ON on the WT130, pressing the ELEMENT key will not result in moving to Σ.
- When pressing the FUNCTION key on display A, and the display function becomes V, A or W, then display A will show the same analysis items as the V, A or W shown on display C.
- Characteristics such as maximum reading, display range, units, etc. which are not described on the previous page, are not different from the characteristics of normal measurement.

9.1 Storing/Recalling Measured Data

Relevant Keys



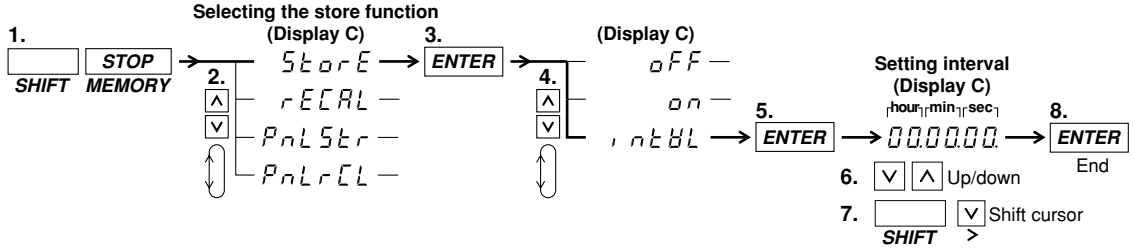
Displays relevant keys and indicator

*Shows the operation panel of the WT130. For the differences between WT110 and WT130, refer to section 2.2, page 2-2, 2-3

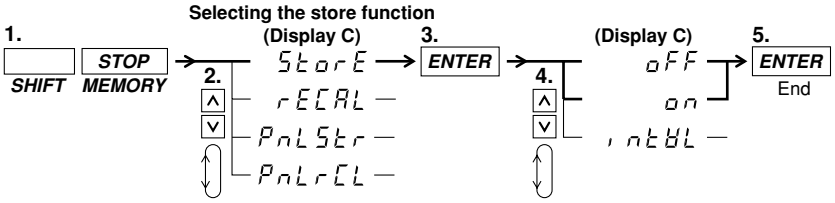
Operating Procedure

- Perform operations following the thick line in the below menu.
- Press the ENTER key to confirm the selection or setting.
- When you want to leave the current menu during operation, press the key described under step 1. The confirmed settings made until that point will be kept.

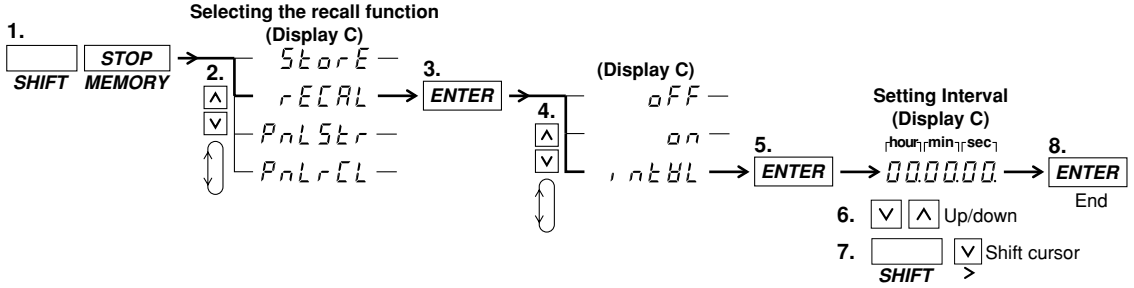
• Setting the Storage Interval for Measurement Data



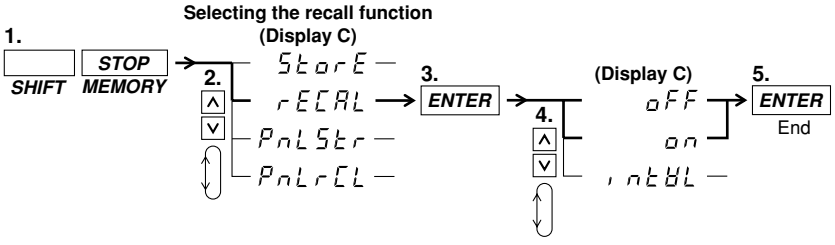
• Storage of Measurement Data ON/OFF



• Setting the Recall Interval for Measurement Data



• Recalling Measurement Data ON/OFF



Explanation

Storing Measured Data (Storing into Internal Memory)

The number of blocks which can be stored into the internal memory is as follows.

Model	In case of normal measurement	In case of harmonic analysis
253401	600 Blocks	30 Blocks
253402	300 Blocks	30 Blocks
353503	200 Blocks	30 Blocks

Items which can be stored

One block consists of all data which are obtained when the display is updated once. The data number increases by the number of used input elements and therefore the number of blocks that can be stored depends on the model as described above.

- when storing normal measured data (harmonic analysis function is turned OFF)
  Each measured/integrated data of normal measurement will be stored. However, only either the voltage frequency or current frequency will be stored *1.
  *1 When either the V Hz or A Hz display function is lit, the frequency of that function will be stored. When neither is lit, the frequency of the latest lit display function will be stored. Regarding the element, the frequency of the latest set element will be stored.
- when storing harmonic analysis data (harmonic analysis function is turned ON)
  Normal measured data will not be stored. All analysis data of the elements which are being used for analysis, will be stored.

Aborting Storage

- when all the above described blocks are full;
- when during the storage process “oFF” is selected at the store ON/OFF setting.

Setting the Storage Interval

Sets the time during which storage will be carried out.

- when storing normal measured data (harmonic analysis function is turned OFF)
  - Setting range : 00.00.00 (0hrs, 0min, 0sec) to 99.59.59 (99hrs, 59min, 59sec)
  - Initial value : 00.00.00

  When the setting is 00.00.00, the interval will become 250ms.
- when storing harmonic analysis data (harmonic analysis function is turned ON)
  - Setting range : 00.00.00 (0hrs, 0min, 0sec) to 99.59.59 (99hrs, 59min, 59sec)
  - Initial value : 00.00.00

  When the setting ranges from 00.00.00 to 00.00.03, the interval will become 3s; from 00.00.04 to 00.00.06, the interval will become 6s; from 00.00.07 to 00.00.09, the interval will become 9s; in other cases, the set interval will be valid.

Storage ON/OFF

After having set the storage interval, select the store menu once again. The initial value is oFF.

- on : Storing will start by pressing the ENTER key after selecting “on”; the STORE indicator will light while storage is in progress.
- oFF : Storing will stop by pressing the ENTER key after selecting “oFF”; the STORE indicator will extinguish.

Note

- After storing has been stopped and storing is restarted, the existing data in the memory will be overwritten. Previous data will therefore be lost.
- Stored data will be kept even after the power has been turned OFF because of the internal lithium battery.
- When integrated values are not present, the dot display will be stored as data, whereas 000.00 will be stored as integration preset time.
- When the fundamental frequency is high and up to 50 windows of harmonic analysis data are not present, the dot display will be stored as data.
- While storage is in progress, several settings cannot be changed, such as switching the harmonic analysis function ON/OFF, changing the related input element, the PLL source, the harmonic distortion factor computation method, nor can scaling, averaging and filter settings be changed, nor integration mode, integration time and storage interval.
- If you press the HOLD key while storing data, the measurement operation and the counting operation of the store interval are suspended. The storage operation itself is also suspended. However, if integration is in progress, measurement and integration continues internally.

Recalling Measured Data (Retrieving Data from the Internal Memory)

After displaying data stored in the internal memory on the panel, you can use all display functions and carry out integration and display these data. Furthermore, by using the communication function, data can be output.

Items which can be recalled

all data which can be stored.

Aborting Recalling

- when all stored data are retrieved;
- when during the recall process “oFF” is selected at the store ON/OFF setting.

Setting the Recalling Interval

Sets the time during which recalling will be carried out.

- Setting range : 00.00.00 (0hrs, 0min, 0sec) to 99.59.59 (99hrs, 59min, 59sec)
- Initial value : 00.00.00

When recalling normal measured data, the interval will become 250ms when the setting is 00.00.00.

When recalling harmonic analysis data, the interval will become 1s when the setting is 00.00.00.

Recalling ON/OFF

After having set the recalling interval, select the recall menu once again. The initial value is oFF.

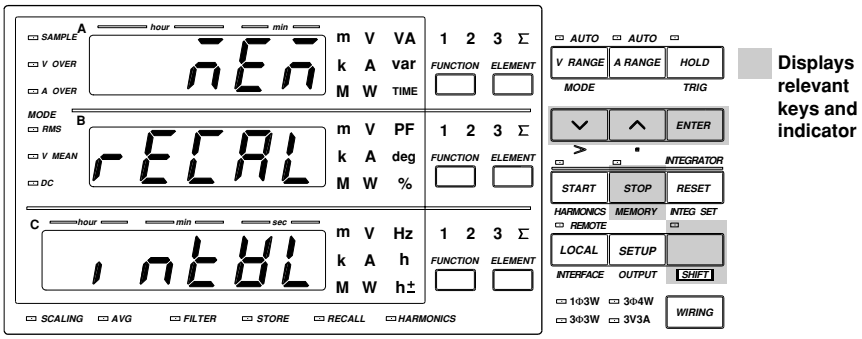
- on : Recalling will start by pressing the ENTER key after selecting “on”; the RECALL indicator will light while recalling is in progress.
- oFF : Recalling will stop by pressing the ENTER key after selecting “oFF”; the RECALL indicator will extinguish

Note

- During recalling, the measurement conditions/range [*1] will become as those of the data being recalled. After recalling finishes, the original measurement conditions will return.
  *1 measurement range, measurement mode, filter ON/OFF, scaling ON/OFF, scaling values, averaging ON/OFF, averaging mode, averaging values, integration mode, integration time, harmonic analysis function ON/OFF, PLL source, input element, computation method of harmonic distortion factor
- When recalling data to a personal computer by communication interface, data might be cut due to the data length or used personal computer. In such a case, increase the recalling interval.

9.2 Storing/Recalling Set-up Parameters

Relevant Keys



Displays relevant keys and indicator

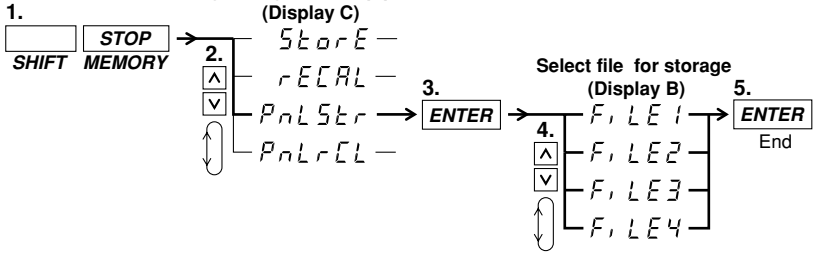
***Shows the operation panel of the WT130. For the differences between WT110 and WT130, refer to section 2.2, page 2-2, 2-3**

Operating Procedure

- **Perform operations following the thick line in the below menu.**
- **Press the ENTER key to confirm the selection or setting.**
- **When you want to leave the current menu during operation, press the key described under step 1. The confirmed settings made until that point will be kept.**

• Storing Set-up Parameters

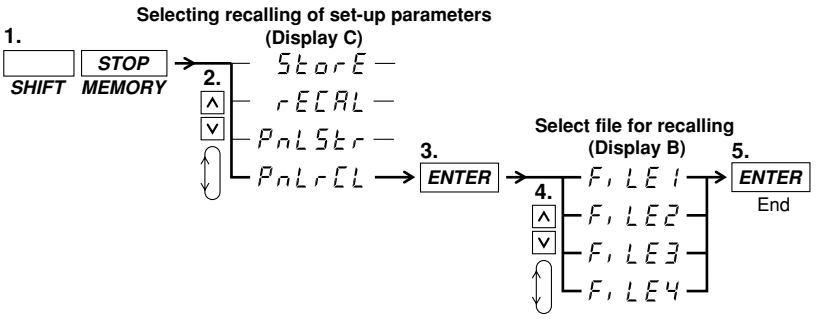
Selecting storage of set-up parameters



When set-up parameters are stored to a file, display C will show "SAVEd"
When no data are stored yet, display C will show "FrEE"

• Recalling Set-up Parameters

Selecting recalling of set-up parameters



When set-up parameters are stored to a file, display C will show "SAVEd"
When no data are stored yet, display C will show "FrEE"

Explanation

Storing Set-up Parameters

Stores the current set-up parameters which consist of the following. Four destinations (FiLE1/ FilE2/FiLE3/FiLE4) are available.
Measurement range, measurement mode, scaling settings, averaging settings, filter settings, integration settings, harmonic settings, plotter output settings, store/recall settings, and communication settings.
When data are saved in a file and you want to save data in the same file, display C will show "SAVEd". Pressing the ENTER key will result in overwriting the previously saved data.
Set-up parameters are saved in another internal memory than measured data.
Saved set-up parameters are backed up by the lithium battery in the same way as measured data.

Recalling Set-up Parameters

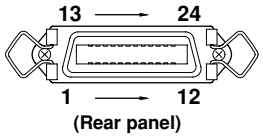
When set-up parameters are being retrieved, all set-up parameters are being set accordingly. After that, measurements can be carried out.

10.1 Remote Control and D/A Output Connector (optional)

Using the remote control and the D/A output connector, this instrument can be remotely controlled and D/A output can be done. The connector's pin sequence and signal assignment is as follows.

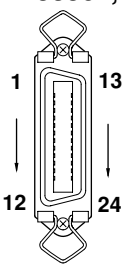
Connector's Pin Sequence

WT110 : 253401



(Rear panel)

WT130 : 253502, 253503



(Rear panel)

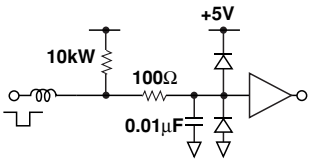
Pin Assignment

/DA4 specifications (for WT110: 253401 only)

remote control, 4 channel D/A output

Pin No.	Signal	Pin No.	Signal
1	DIGITAL COM	13	DIGITAL COM
2	$\overline{\text{EXT HOLD}}$ (Input)	14	$\overline{\text{EXT TRIG}}$ (Input)
3	$\overline{\text{EXT START}}$ (Input)	15	$\overline{\text{EXT STOP}}$ (Input)
4	$\overline{\text{EXT RESET}}$ (Input)	16	$\overline{\text{INTEG BUSY}}$ (Output)
5	No Connection	17	No Connection
6	No Connection	18	No Connection
7	No Connection	19	No Connection
8	No Connection	20	No Connection
9	No Connection	21	No Connection
10	DA 3ch (Output)	22	DA 4ch (Output)
11	DA 1ch (Output)	23	DA 2ch (Output)
12	DA COM	24	DA COM

Remote control:input circuit



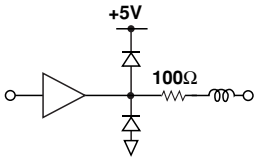
TTL level
L :0 to 0.8V
H :2.0 to 5V

/DA12 specifications (for WT130: 253502, 253503)

remote control, 12 channel D/A output

Pin No.	Signal	Pin No.	Signal
1	DIGITAL COM	13	DIGITAL COM
2	$\overline{\text{EXT HOLD}}$ (Input)	14	$\overline{\text{EXT TRIG}}$ (Input)
3	$\overline{\text{EXT START}}$ (Input)	15	$\overline{\text{EXT STOP}}$ (Input)
4	$\overline{\text{EXT RESET}}$ (Input)	16	$\overline{\text{INTEG BUSY}}$ (Output)
5	No Connection	17	No Connection
6	DA 11ch (Output)	18	DA 12ch (Output)
7	DA 9ch (Output)	19	DA 10ch (Output)
8	DA 7ch (Output)	20	DA 8ch (Output)
9	DA 5ch (Output)	21	DA 6ch (Output)
10	DA 3ch (Output)	22	DA 4ch (Output)
11	DA 1ch (Output)	23	DA 2ch (Output)
12	DA COM	24	DA COM

Remote control:output circuit



TTL level
L :0 to 0.4V(8mA)
H :2.4 to 5V(–400μA)

/CMP specifications (for WT110/130: 253401, 253502, 253503)

remote control, 4 channel D/A output, 4 channel comparator output

Pin No.	Signal	Pin No.	Signal
1	DIGITAL COM	13	DIGITAL COM
2	$\overline{\text{EXT HOLD}}$ (Input)	14	$\overline{\text{EXT TRIG}}$ (Input)
3	RELAY 3ch NC	15	RELAY 4ch NC
4	COM	16	COM
5	NO	17	NO
6	RELAY 1ch NC	18	RELAY 2ch NC
7	COM	19	COM
8	NO	20	NO
9	No Connection	21	No Connection
10	DA 3ch (Output)	22	DA 4ch (Output)
11	DA 1ch (Output)	23	DA 2ch (Output)
12	DA COM	24	DA COM

WARNING

The connectors used in this function have protective covers. When the covers are removed or when using connectors, the voltage ratings across the measuring input and the ground become as follows:

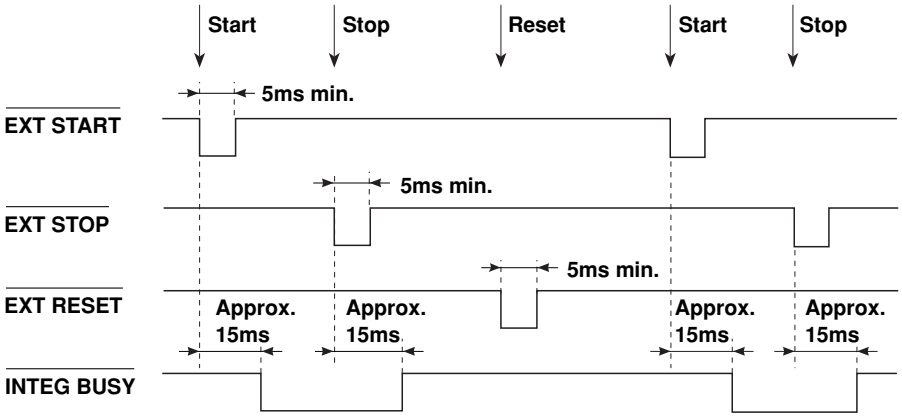
Voltage across A, ±(V and A side) input terminals and ground 400 Vrms max.
Voltage across V terminal and ground 600 Vrms max.

Put the protective cover on the connector when this function is not used.

10.2 Remote Control (optional)

Controlling Integration

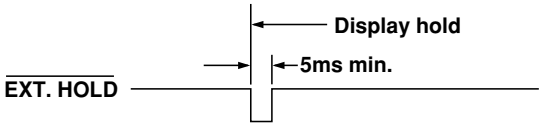
To control integration, apply timing signals according to the timing chart below.



As shown in the timing chart, the **INTEG BUSY** output signal level goes low while integration is in progress. The signal can be used to monitor integration, etc.

Holding Display Data Update (same function as HOLD key)

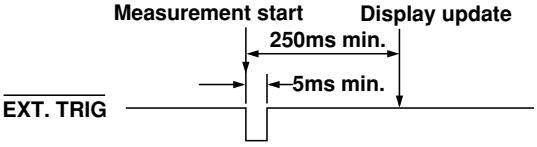
To hold the display update, apply the **EXT. HOLD** signal according to the timing chart below.



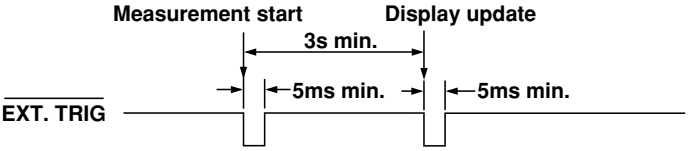
Updating Display Data which has been held (same function as TRIG key)

Applying an **EXT.TRIG** signal when the display is on hold updates the display data.

- **Update timing during normal measurement/integration**



- **Update timing while harmonic analysis function is in progress**

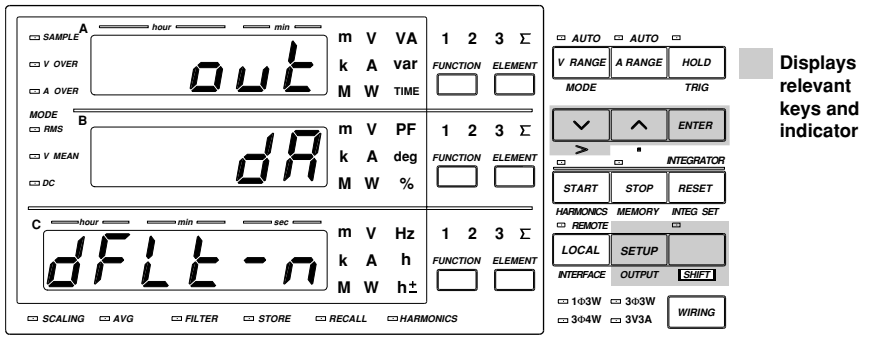


CAUTION

- Do not apply a voltage which exceeds the TTL level to the remote controller pin. Also, do not short the output pins nor apply a voltage to them.
- The instrument might be damaged.

10.3 D/A Output (optional)

Relevant Keys

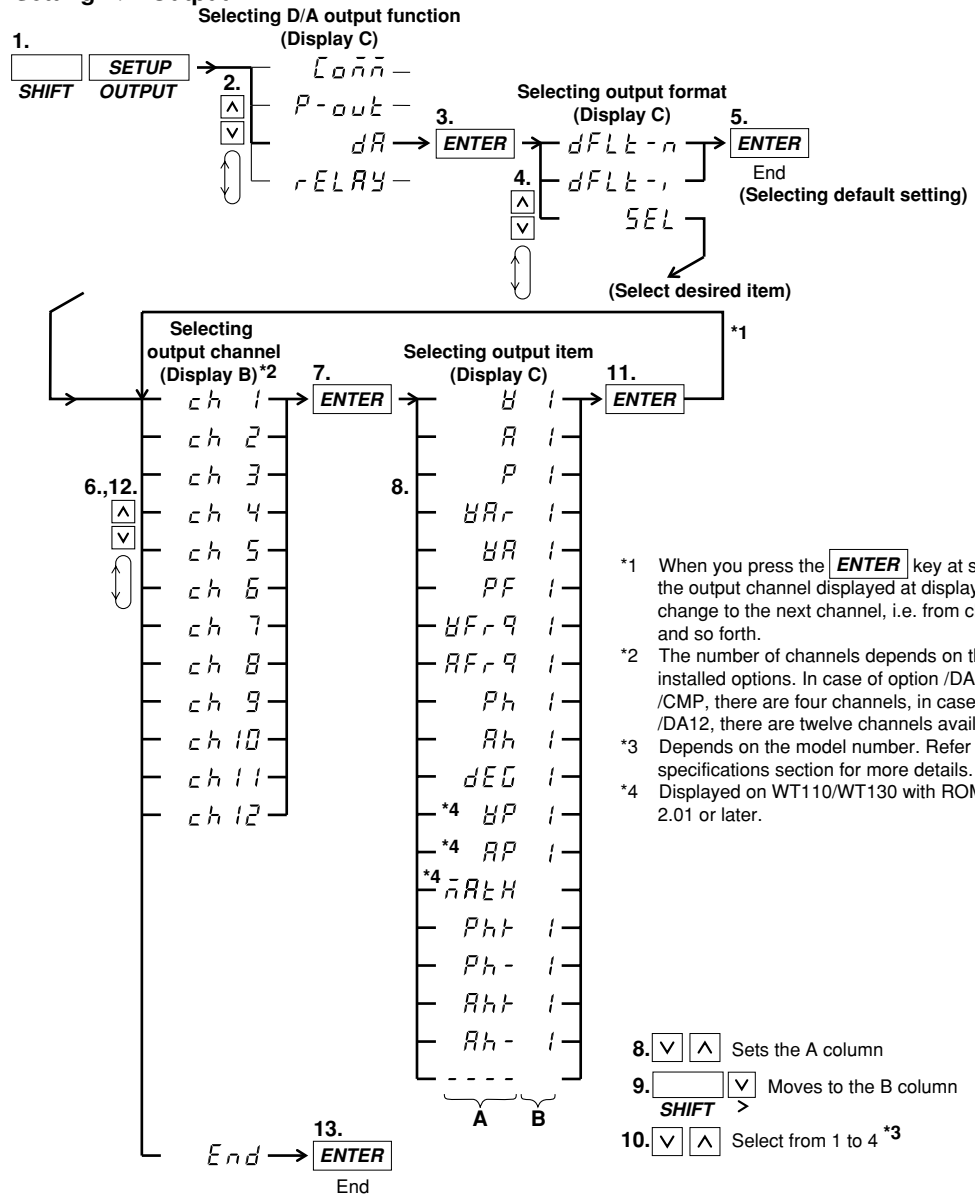


***Shows the operation panel of the WT130. For the differences between WT110 and WT130, refer to section 2.2, page 2-2, 2-3**

Operating Procedure

- **Perform operations following the thick line in the below menu.**
- **Press the ENTER key to confirm the selection or setting.**
- **When you want to leave the current menu during operation, press the key described under step 1. The confirmed settings made until that point will be kept.**

• Setting D/A Output



*1 When you press the ENTER key at step 11, the output channel displayed at display B will change to the next channel, i.e. from ch1 to ch2 and so forth.

*2 The number of channels depends on the installed options. In case of option /DA4 or /CMP, there are four channels, in case of option /DA12, there are twelve channels available.

*3 Depends on the model number. Refer to the specifications section for more details.

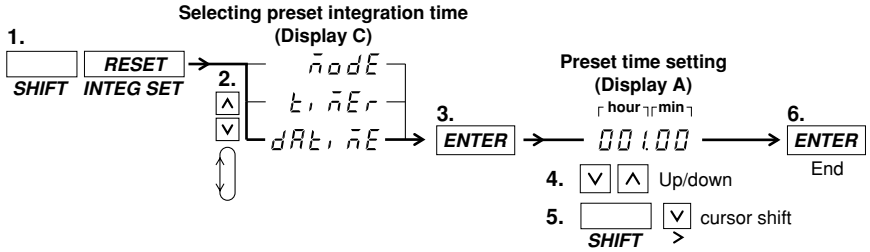
*4 Displayed on WT110/WT130 with ROM version 2.01 or later.

8. ∨ ∧ Sets the A column

9. SHIFT ∨ (>) Moves to the B column

10. ∨ ∧ Select from 1 to 4 *3

• **Setting Preset Integration Time**



Explanation

D/A Output

Voltage, current, active power, apparent power, reactive power, power factor, phase angle, harmonic analysis data and integrated data values will be output as a 5V FS analog voltage. The number of items which can be output (number of output channels) depends on the installed options.

Default Setting of the Output Format

The default items which will be output can be selected as follows.

- **dFLt-n (normal measurement values are set as default)**

  Select this when you want to output normal measurement values. Which items are output to which channel is described below.

Option	/DA4	/DA12		/CMP		
Model	253401	253502	253503	253401	253502	253503
ch1	V	V1 *2	V1 *2	V	V1 *2	V1 *2
ch2	A	-	V2	A	A1	A1
ch3	W	V3	V3	W	W1	W1
ch4	Hz *1	ΣV	ΣV	Hz *1	Hz *1	Hz *1
ch5	These channels cannot be set.	A1	A1	These channels cannot be set.		
ch6		-	A2			
ch7		A3	A3			
ch8		ΣA	ΣA			
ch9		W1	W1			
ch10		-	W2			
ch11		W3	W3			
ch12		ΣW	ΣW			

Output channel

*1 :When either the function indicator of V Hz or A Hz is lit, the frequency corresponding to the lit function indicator will be output. When neither indicator is lit, the frequency of the last used function indicator will be output. The frequency of the last assigned element will be output.

*2 :The number corresponds to input element 1, 2, or 3.

- **dFLt-i (integration measurement values are set as default)**

  Select this when you want to output integration measurement values. Which items are output to which channel is described below.

Option	/DA4	/DA12		/CMP		
Model	253401	253502	253503	253401	253502	253503
ch1	W	W1 *2	W1 *2	W	W1 *2	W1 *2
ch2	Wh	-	W2	Wh	Wh1	Wh1
ch3	Ah	W3	W3	Ah	Ah1	Ah1
ch4	Hz *1	ΣW	ΣW	Hz *1	Hz *1	Hz *1
ch5	These channels cannot be set.	Wh1	Wh1	These channels cannot be set.		
ch6		-	Wh2			
ch7		Wh3	Wh3			
ch8		ΣWh	ΣWh			
ch9		Ah1	Ah1			
ch10		-	Ah2			
ch11		Ah3	Ah3			
ch12		ΣAh	ΣAh			

Output channel

*1 :When either the function indicator of V Hz or A Hz is lit, the frequency corresponding to the lit function indicator will be output. When neither indicator is lit, the frequency of the last used function indicator will be output. The frequency of the last assigned element will be output.

*2 :The number corresponds to input element 1, 2, or 3.

Selecting the Desired Item of the Output Format

The items to be output are set per each output channel.

- **Setting the output channel**

  The number of channels depends on the installed options and can be selected from the following.

  - /DA4 : 4 channels
  - /DA12: 12 channels
  - /CMP : 4 channels

- **Setting the output function (corresponds to column A in the procedure)**

  The output function can be set to any of the following.

  V (voltage), A (current), P (active power), VAr (reactive power), VA (apparent power), PF (power factor), VFrq (voltage frequency), AFrq (current frequency), Ph (total Watt-hour Wh), Ah (total Ampere-hour), dEG (phase angle), VP(peak value of voltage)*2, AP(peak value of current)*2, MATH(computation)*2, Ph+ (positive watt hour value Wh+), Ph– (negative watt hour value Wh–), Ah+ (positive ampere hour value*1), Ah– (negative ampere hour value*1), – – – – (D/A output 0V; no further elements can be set)

  *1 For details concerning the positive value of the ampere hour, refer to page 7-3.

  *2 Available on WT110/WT130 with ROM version 2.01 or later.

- **Setting the element (corresponds to colum B in the operating procedure)**

  - WT110 (253401) no such element setting available;
  - WT130 (253502) element can be selected from 1, 3 or 4
  - WT130 (253503) element can be selected from 1, 2, 3 or 4

  The element number 4 represents ∑.

Note

- D/A output of each display function can be done when the rated range of voltage, current and power is 5.0V FS. This is also true when scaling function is being used.
- When the scaling value is different for each element and the element is set to ∑, D/A output can be done when the rated range is set to 5.0V FS for each element.

Setting the Integration Preset Time

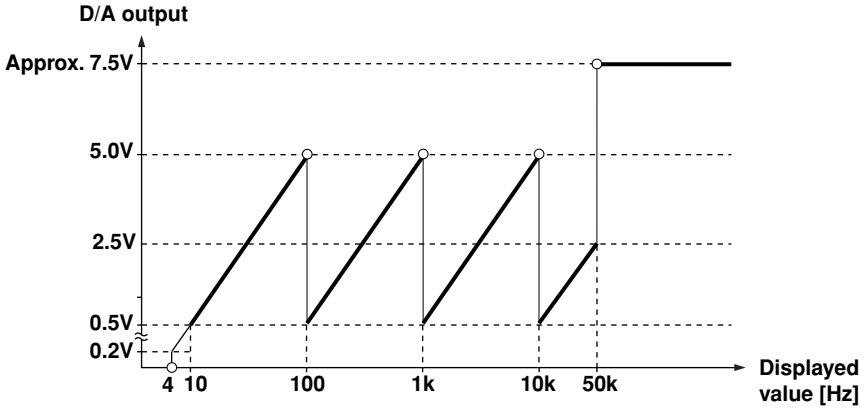
The D/A output of integrated values will be 5.0V FS when the rated range has been input consequently during the preset integration time (rated integration time).

Setting range : 000.00 (0 hrs 0 min) to 999.59 (999 hrs 59 min)

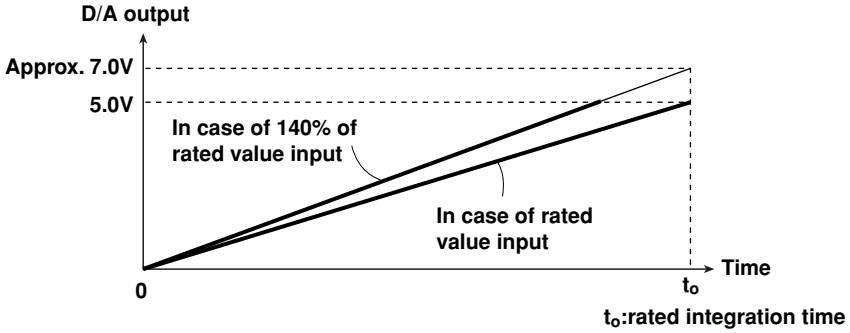
The initial value is 1. When 000.00 is set, the D/A output value will be 0V.

Relation between the output item and the D/A output voltage

• **Frequency**

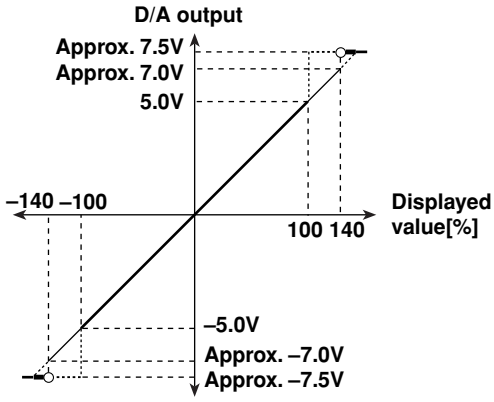


• **Integrated value**



• **Other items**

Displayed value	Output
140%	Approx. 7.0V
100%	5.0V
0%	0V
–100%	–5.0V
–140%	Approx. –7.0V



However, for PF and deg, points in the range from +5 to +7 V and from –5 to –7 V are not output.
If there is an error, the output will be about ±7.5 V. If the MATH setting is set to efficiency, the output will be +5 V for 100%.
For Vp and Ap, the output will be ±5 V when the value is three times the range rating. In addition, output will not be ±7.5 V when Vp and Ap are over the range.

10.4 Comparator Function (optional)

When the instrument is equipped with option /CMP you can compare the measured/computed/integrated/analysis values with previously set limits and these results can be output by contact relay.

Contact Relay Output

This instrument is equipped with four contact relays (4 ch) as follows. If the relay is not operating, the NC (Normally Closed) contact is closed. If the relay is operating, the NC contact is opened and the NO (Normally Open) contact is closed.

Relay specifications

- Contact rating : rated 24V/0.5A (max. 30V/0.5A)
- Minimum load : 10mV/10μA
- Operating life with load : approx. 500000 times (at contact rating)
- Operating life without load : approx. one hundred million times
- Contact Response time : less than 500ms

Note

Since this relay is subject to wear, it is excluded from the 3-year warranty.

CAUTION

Damage to the relays may occur when a voltage or current exceeding the specified range is applied to the contact output terminal.

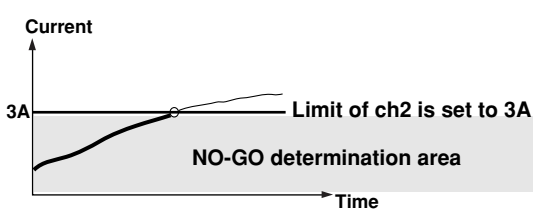
Comparator Mode

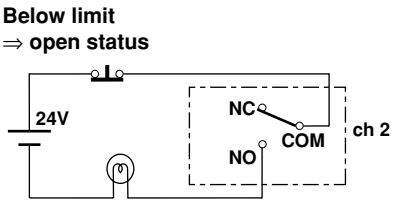
The following two comparator modes are available.

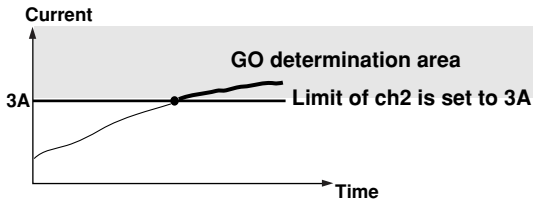
Single Mode

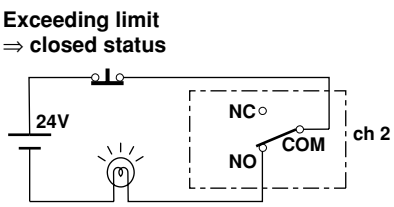
If the measured/computed/integrated/analysis values exceed the previously set limits, the relay contact will become NO. This mode is useful when you want to assign each of the four relays individually. Refer to the figure below.

When the current value is less than 3A: NO-GO will be determined and the circuit becomes open.
When the current value is 3A or more: GO will be determined and the circuit becomes closed.







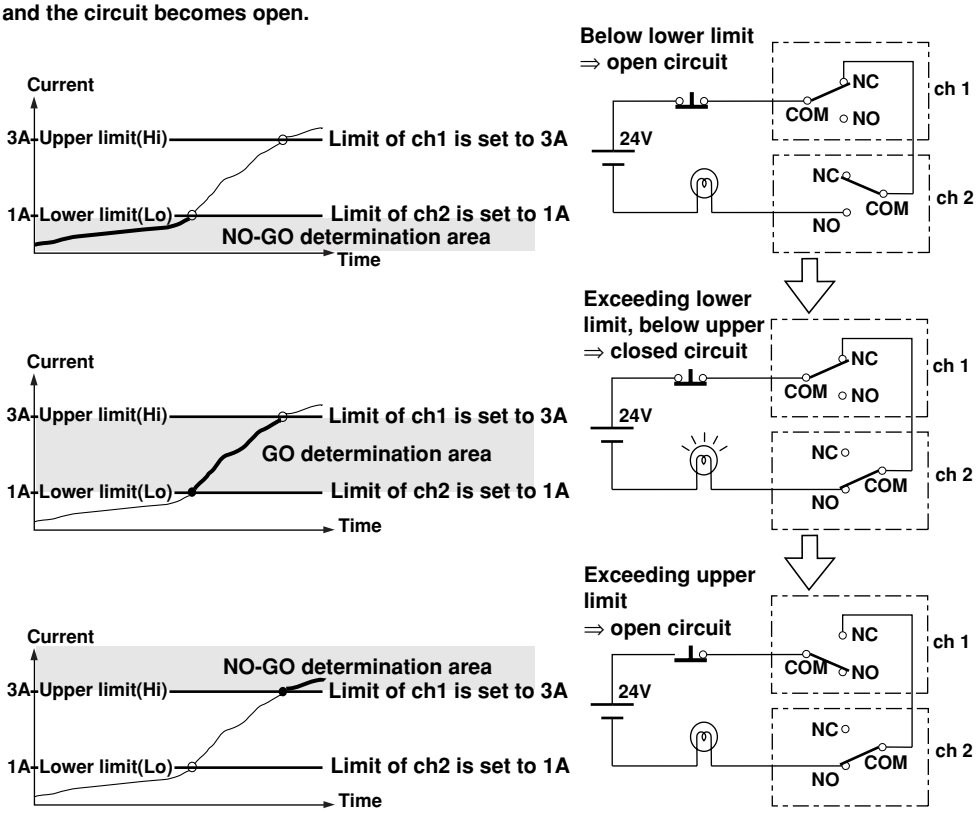


Dual Mode

This mode allows you to combine the limit values of two relays (e.g. the upper value (Hi) and the lower value (Lo)) to determine the contact status. The four relays will be fixed as two pairs of ch1 & ch2 and ch3 & ch4. Setting the limit values of a pair of relays (e.g. ch1 & ch2) can only be done at the same display function. The setting method, relay operation, etc. are the same as in the single mode, and when the measured/computed/integrated/analysis values exceed the preset limits, the contact status will become NO.

The following shows an example.

When the current value exceeds 1A, but is less then 3A: GO will be ditermined and the circuit becomes closed.
When the current value lies below 1A, or exceeds3A:NO-GO will be determined and the circuit becomes open.



Note

- In the dual mode, the combinations ch1&ch2, and ch3&ch4 are fixed. The combinations ch1&ch3 and ch2&ch4 are not possible.
- Within a pair you can set either channel as upper or lower limit.

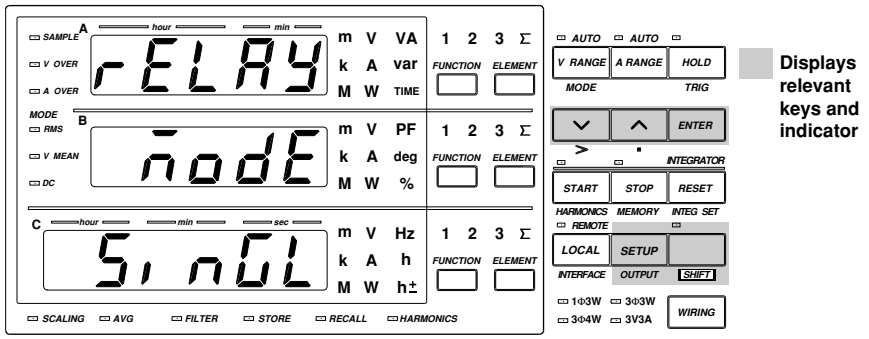
CAUTION

Make sure not to greatly vary the input signal when using the comparator function. Depending on the input signal used for determination, the instrument may display error codes (i.e. overrange) and this will change the output relays as follows. When using the output relay as a control signal, make sure to match these control signals with other equipments to eliminate erroneuous control.

Displayed error	Relay status
oL (over range)	The NC contact is closed.
oF (over flow)	The NC contact is closed.
dEGEr (phase angle error)	The NC contact is closed.
PFErr (power factor error)	The NC contact is closed.
ErrLo (frequency error)	The NC contact is closed.
ErrHi (frequency error)	The NO contact is closed for this case only.
FrqErr (frequency error in case of harmonic analysis)	The NC contact is closed.
—— (error when no data are present)	The NC contact is closed.

10.5 Setting the Comparator Mode (optional)

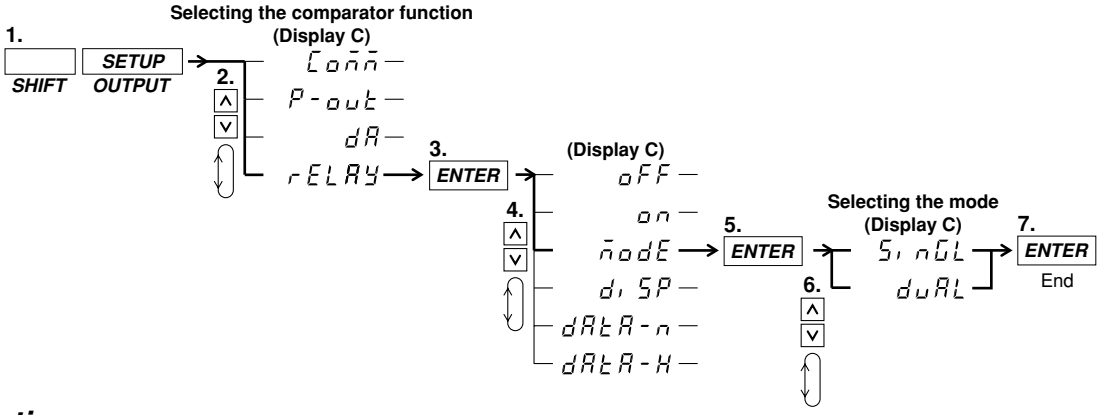
Relevant Keys



***Shows the operation panel of the WT130. For the differences between WT110 and WT130, refer to section 2.2, page 2-2, 2-3**

Operating Procedure

- **Perform operations following the thick line in the below menu.**
- **Press the ENTER key to confirm the selection or setting.**
- **When you want to leave the current menu during operation, press the key described under step 1. The confirmed settings made until that point will be kept.**



Explanation

Setting the Comparator Mode

The following two settings are available. For details, refer to pages 10-7, 10-8. The initial value is SinGL.

- SinGL: the comparator mode will be set to single mode;
- duAL : the comparator mode will be set to dual mode.

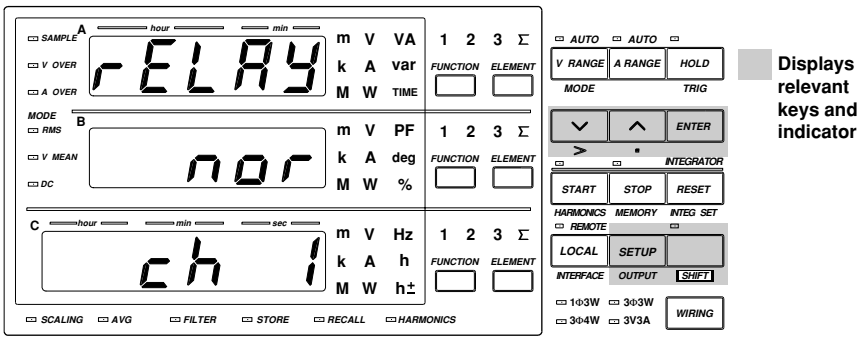
Note

- When you change the comparator mode after having set the comparator limit (refer to page 10-10), the situation will change as follows. Also verify the comparator limits again.
- When you change the mode to the dual mode after having set limits in the single mode, the limit of ch2 will take the value of the limit of ch1, and the limit of ch4 will take the value of the limit of ch3. When you return again to the single mode, the previous values of each channel will be restored.

Do not change the comparator mode, measurement mode or harmonic analysis ON/OFF, while the comparator function is in progress (ON). Similar to the Note above, changing the type of limit might result in unexpected statuses of the output relay.

10.6 Setting the Comparator Limit Values (optional)

Relevant Keys



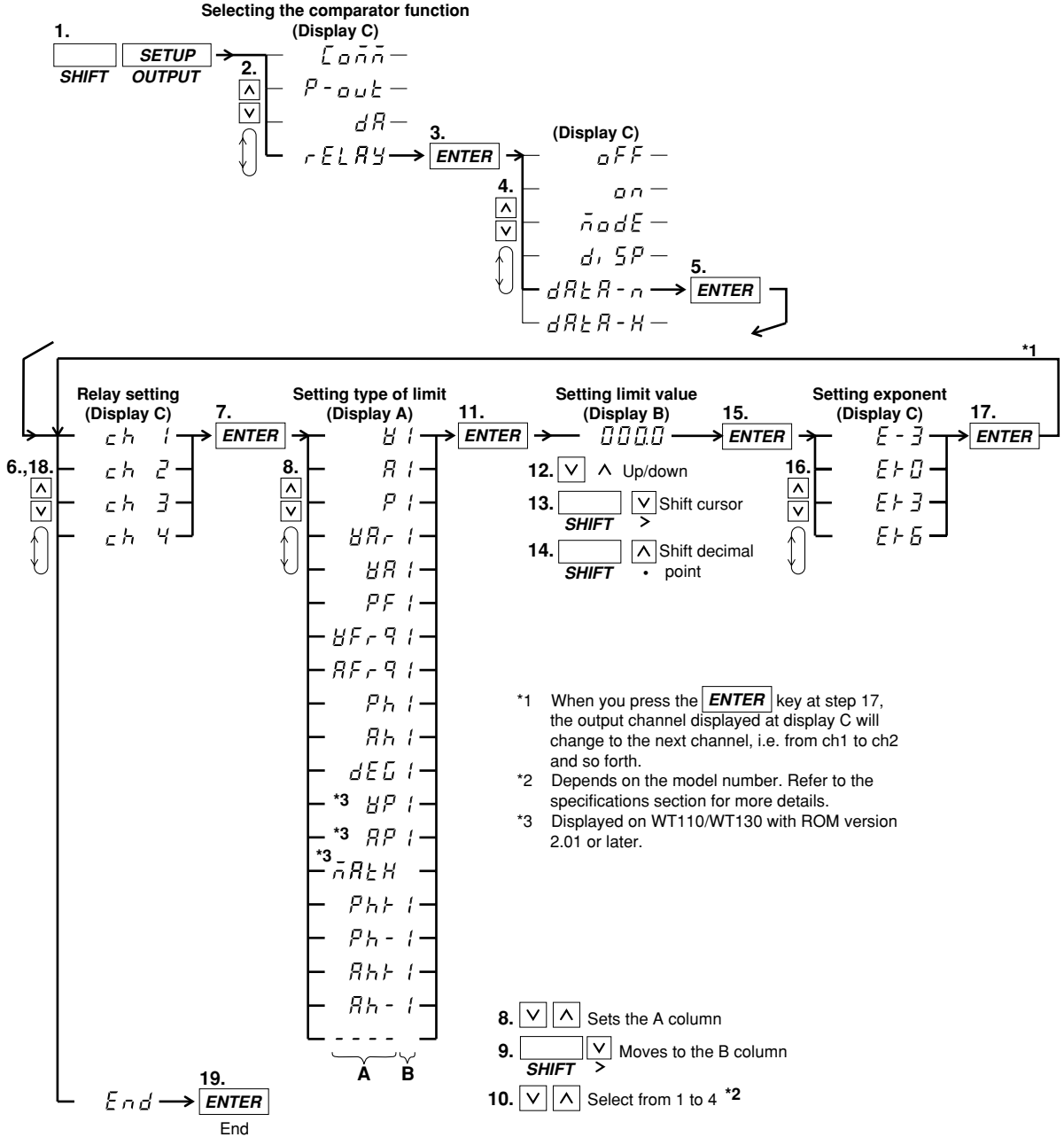
Displays relevant keys and indicator

*Shows the operation panel of the WT130. For the differences between WT110 and WT130, refer to section 2.2, page 2-2, 2-3

Operating Procedure

- Perform operations following the thick line in the below menu.
- Press the ENTER key to confirm the selection or setting.
- When you want to leave the current menu during operation, press the key described under step 1. The confirmed settings made until that point will be kept.

• Setting the Comparator Limit Values in case of Normal Measurement

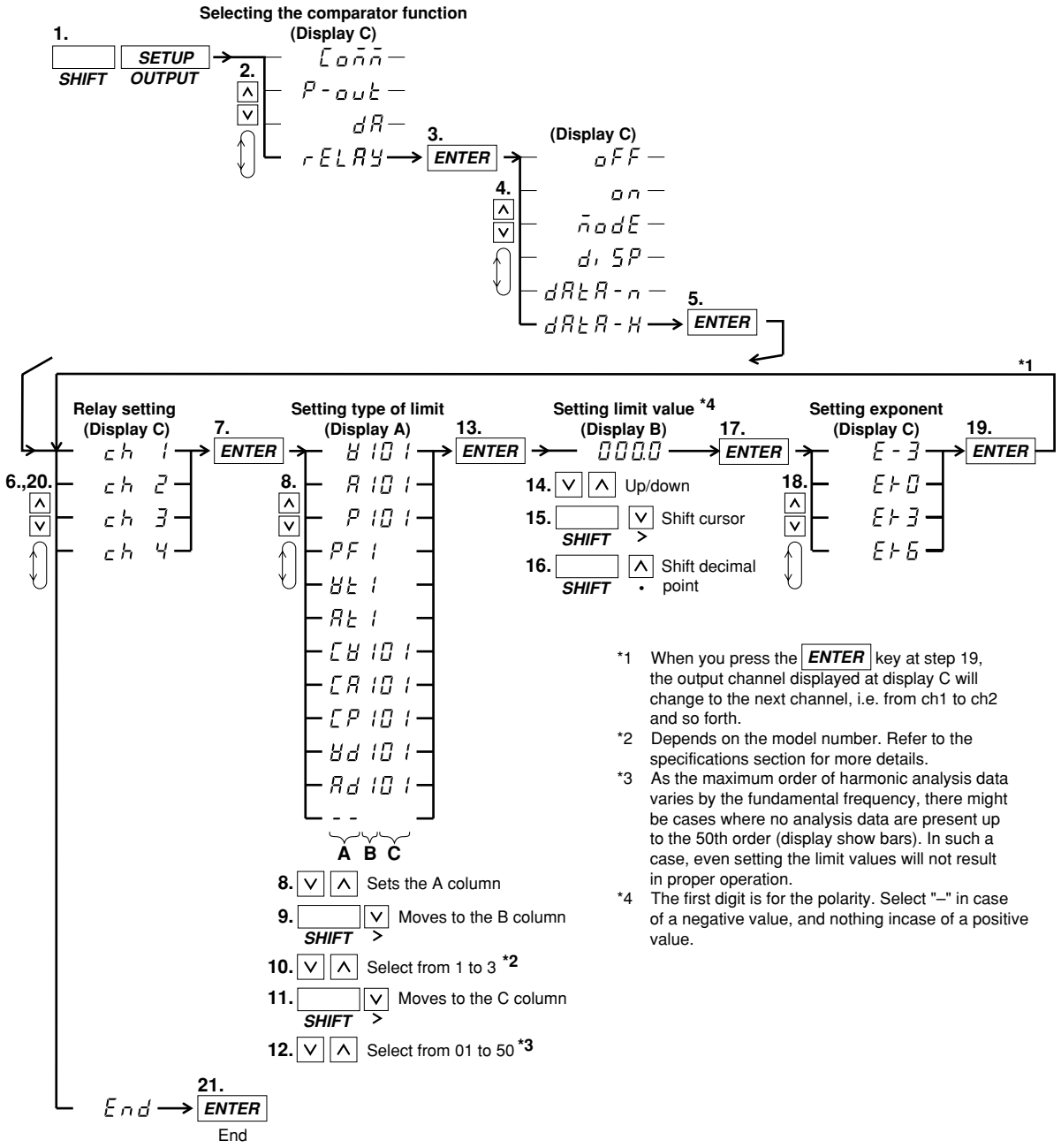


*1 When you press the ENTER key at step 17, the output channel displayed at display C will change to the next channel, i.e. from ch1 to ch2 and so forth.

*2 Depends on the model number. Refer to the specifications section for more details.

*3 Displayed on WT110/WT130 with ROM version 2.01 or later.

• **Setting the Comparator Limit Values in case of Harmonic Anaiysis**



*1 When you press the **ENTER** key at step 19, the output channel displayed at display C will change to the next channel, i.e. from ch1 to ch2 and so forth.

*2 Depends on the model number. Refer to the specifications section for more details.

*3 As the maximum order of harmonic analysis data varies by the fundamental frequency, there might be cases where no analysis data are present up to the 50th order (display show bars). In such a case, even setting the limit values will not result in proper operation.

*4 The first digit is for the polarity. Select "–" in case of a negative value, and nothing incase of a positive value.

Explanation

Setting the Comparator Limit Values in case of Normal Measurement

You can set the type of the limit and its value for each relay seperately.

- **Relay setting**

  Selects the relay (ch1 to ch4) for which the type of limit and its value will be set.

- **Setting the type of limit (corresponding to column A in the procedure)**

  The following selections are available. When the comparator mode is dual, ch1&ch2 and ch3&ch4 are pairs and the same type of limit should be set for the channels of one pair.
  V (voltage), A (current), P (active power), VAr (reactive power), VA (apparent power), PF (power factor), VFrq (voltage frequency), AFrq (current frequency), Ph (total Watt-hour Wh), Ah (total Ampere-hour), dEG (phase angle), VP(peak value of voltage)*2, AP(peak value of current)*2, MATH(computation)*2, Ph+ (positive watt hour value Wh+), Ph– (negative watt hour value Wh–), Ah+ (positive ampere hour value*1), Ah– (negative ampere hour value*1), – – – – (no data)

  *1 For details concerning the positive value of the ampere hour, refer to page 7-3.
  *2 Available on WT110/WT130 with ROM version 2.01 or later.

- **Setting the element (corresponds to column B in the operating procedure)**
  - WT110 (253401) no such element setting available;
  - WT130 (253502) element can be selected from 1, 3 or 4
  - WT130 (253503) element can be selected from 1, 2, 3 or 4

  The element number 4 represents ∑.

- **Setting the limit value**

  No element setting is available on the WT110.
  Setting range: 0.000 to ±9999
  Initial setting:

  ch1 : V (type) : 1 (element) : 600.0 (value) : E+0 (exponent) [600V voltage limit of element 1 for channel 1]
  ch2 : A (type) : 1 (element) : 20.00 (value) : E+0 (exponent) [20.00A current limit of element 1 for channel 2]
  ch3 : P (type) : 1 (element) : 1.200 (value) : E+3 (exponent) [1.2kW active power limit of element 1 for channel 3]
  ch4 : PF (type) : 1 (element) : 1.000 (value) : E+0 (exponent) [Power factor 1 limit of element 1 for channel 4]

- **Setting the exponent**

  The following selections are available. The initial value is as described above.
  E–3 (10^{-3}), E+0 (10^{0}), E+3 (10^{3}), E+6 (10^{6})

Setting the Comparator Limit Values in case of Harmonic Analysis

You can set the type of the limit and its value for each relay seperately.

- **Relay setting**

  Selects the relay (ch1 to ch4) for which the type of limit and its value will be set.

- **Setting the type of limit (corresponding to column A in the procedure)**

  The following selections are available. When the comparator mode is dual, ch1&ch2 and ch3&ch4 are pairs and the same type of limit should be set for the channels of one pair.
  V (voltage), A (current), P (active power), PF (power factor), Vt (harmonic distortion of voltage), At (harmonic distortion of current), CV (relative harmonic content of each voltage harmonic order), CA (relative harmonic content of each current harmonic order), CP (relative harmonic content of each active power harmonic order), Vd (voltage phase angle of each order), Ad (current phase angle of each order), – – – – (no data)

  * For details concerning the meaning of harmonic analysis values, refer to chapter 8.

- **Setting the element (corresponds to column B in the operating procedure)**
  - WT110 (253401) no such element setting available;
  - WT130 (253502) element can be selected from 1 or 3
  - WT130 (253503) element can be selected from 1, 2 or 3

Setting the harmonic order (corresponds to column C in the procedure)

Setting range: 01 to 50

Initial value: refer to the following.

The maximum order of harmonic analysis data varies by the fundamental frequency. Therefore, there might be cases where no analysis data are present up to the 50th order (and the display will show bars). In such a case, even if you set an harmonic order, determination will not be carried out. Therefore, before setting, verify the maximum order (chapter 15) and the fundamental frequency of the object of measurement.

- **Setting the limit value**

  No element setting is available on the WT110.

  Setting range : 0.000 to ±9999

  Initial setting :

  ch1 : V (type) : 1 (element) : 600.0 (value) : E+0 (exponent) [600V voltage limit of element 1 for channel 1]

  ch2 : A (type) : 1 (element) : 20.00 (value) : E+0 (exponent) [20.00A current limit of element 1 for channel 2]

  ch3 : P (type) : 1 (element) : 1.200 (value) : E+3 (exponent) [1.2kW active power limit of element 1 for channel 3]

  ch4 : PF (type) : 1 (element) : 1.000 (value) : E+0 (exponent) [Power factor 1 limit of element 1 for channel 4]

- **Setting the exponent**

  The following selections are available. The initial value is as described above.

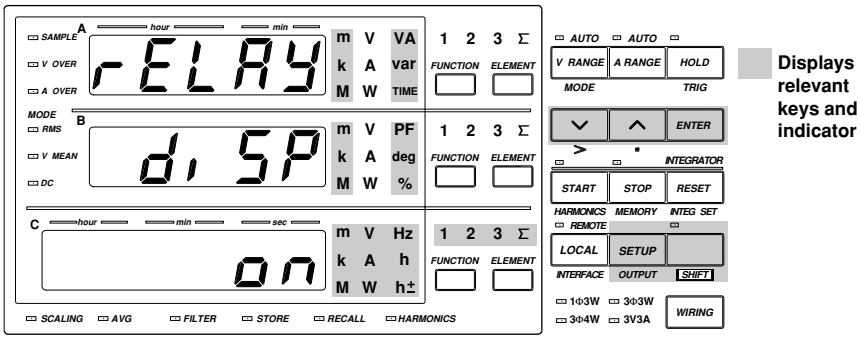
  E–3 (10^{-3}), E+0 (10^{0}), E+3 (10^{3}), E+6 (10^{6})

Note

- When you use limit values based on harmonic analysis data, make sure to set the harmonic analysis function to ON (page 8-5) before you set the comparator function ON (page 10-16).
- Although the four relays used in case of normal measurement and in case of harmonic analysis are the same, the contents of the settings will be kept for both seperately. For example, even after setting a limit for ch1 in case of harmonic analysis after previously having set a limit for ch1 in case of normal measurement, will result in keeping both values.
- The determination method does not change as a result of – (minus) limit values. For example, if a limit of –1 is set, the relay will not be activated when the input signal value reaches –2 coming from an even lower value, but will be activated when the input signal value becomes 0.
- Make sure to set the polarity of the phase angle as well, + for phase lead (and can be ignored), – for phase lag.

10.7 Comparator Display (optional)

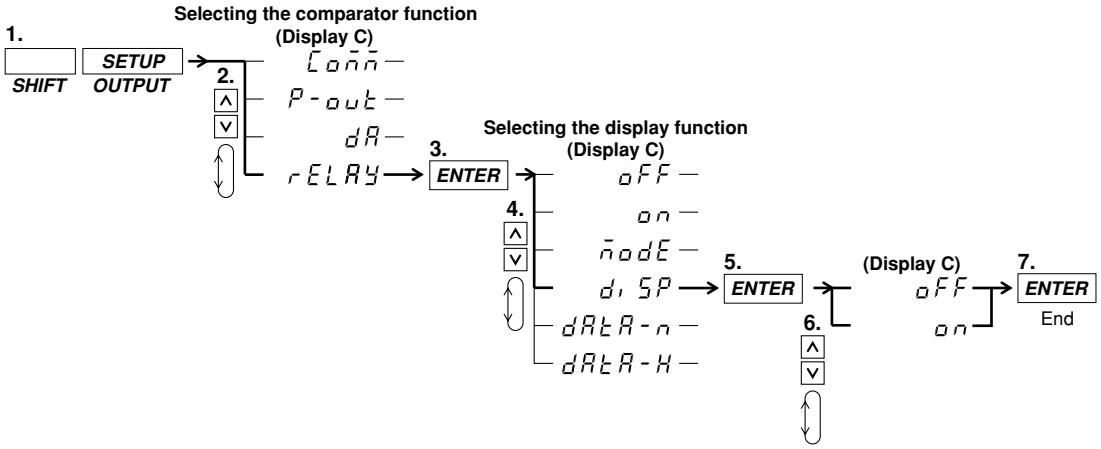
Relevant Keys



*Shows the operation panel of the WT130. For the differences between WT110 and WT130, refer to section 2.2, page 2-2, 2-3

Operating Procedure

- Perform operations following the thick line in the below menu.
- Press the ENTER key to confirm the selection or setting.
- When you want to leave the current menu during operation, press the key described under step 1 . The confirmed settings made until that point will be kept.

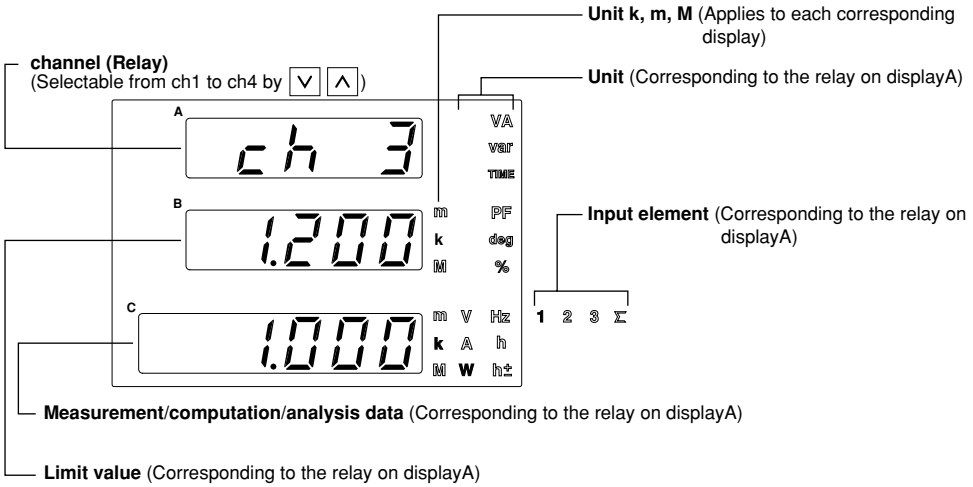


Explanation

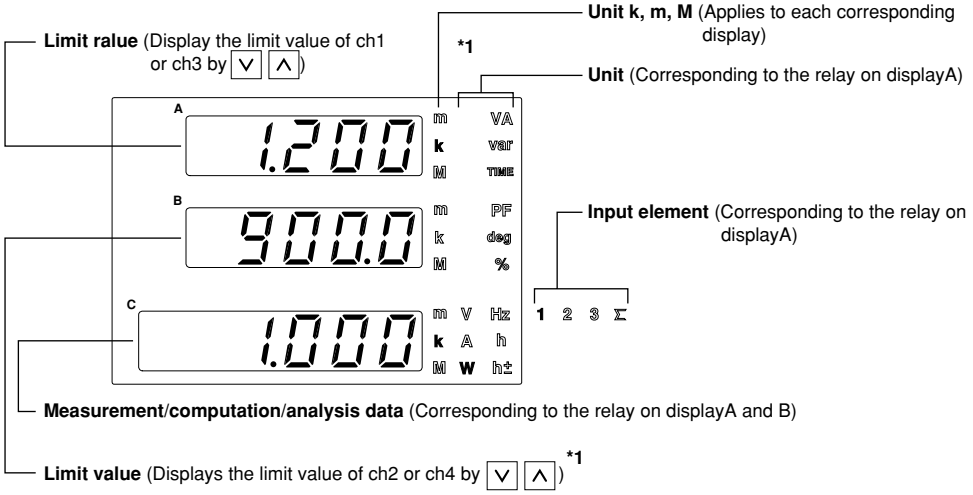
Comparator Display Function

This function allows you to verify the set limits together with measurement/computation/analysis data on the display when using the comparator function. The display is as follows, depending on whether the comparator function is set to single or dual mode.

- **Display in case the comparator function is set to single mode**



- **Display in case the comparator function is set to dual mode**



*1 The limit values on display A and B will show the pairs of ch1&ch2 and ch3&ch4 alternately by pressing the ∨ ∧ keys.

Comparator Display Function ON/OFF

This setting allows you to turn the above described display function ON or OFF.

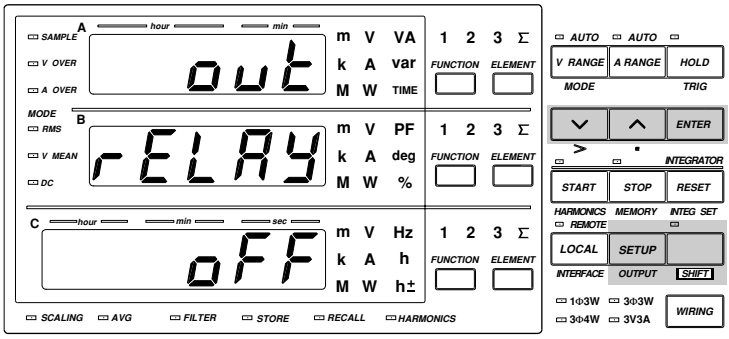
- oN : The comparator display will appear by pressing the ENTER key after selecting “on”;
- oFF : The normal measurement or harmonic analysis display will appear by pressing the ENTER key after selecting “oFF”.

Note

- Pressing the FUNCTION or ELEMENT key will result in an error. Other keys can be operated.
- Determination is done by internal data of the input signal, and not by displayed data. For example, when the limit is set to 10.00 and the internal data of the input signal coming from a lower value reaches 9.999, the relay will not be activated. Only when the internal data reaches a value of 10.000, the relay will be activated.

10.8 Turning the Comparator Function ON/OFF (optional)

Relevant Keys

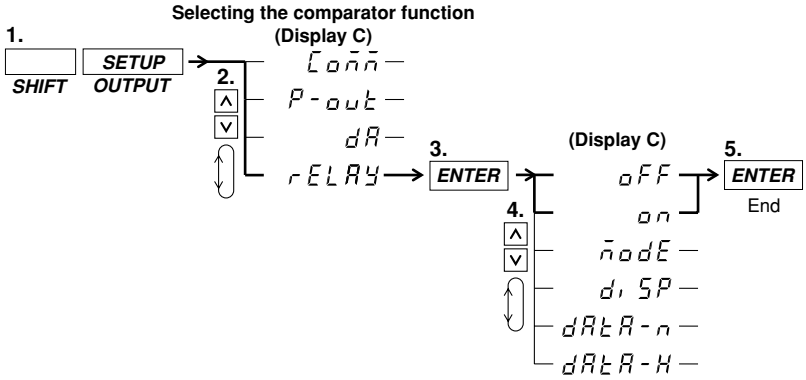


Displays relevant keys and indicator

***Shows the operation panel of the WT130. For the differences between WT110 and WT130, refer to section 2.2, page 2-2, 2-3**

Operating Procedure

- **Perform operations following the thick line in the below menu.**
- **Press the ENTER key to confirm the selection or setting.**
- **When you want to leave the current menu during operation, press the key described under step 1. The confirmed settings made until that point will be kept.**



Explanation

Turning the Comparator Function ON/OFF

After having set all the items described on the previous pages, turn the comparator function ON.

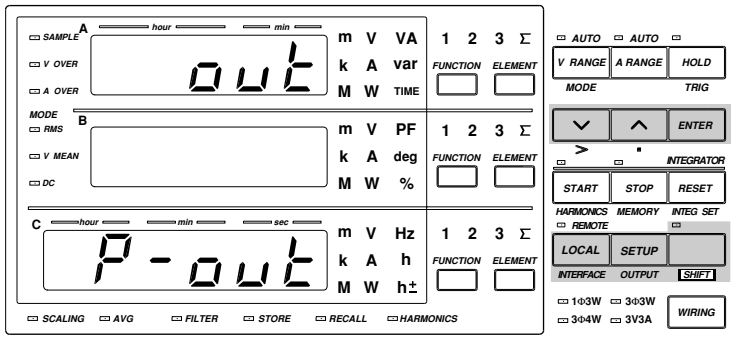
- oN : The comparator function will start by pressing the ENTER key after selecting “on”;
- oFF : The comparator function will stop by pressing the ENTER key after selecting “oFF”.

CAUTION

- After having turned ON the comparator function, do not change the comparator mode. Changing the type of limit might result in unexpected statuses of the output relay.
- Make sure not to greatly vary the input signal before turning the comparator function ON. Depending on the input signal used for determination, the instrument may display error codes (i.e. overrange) and this will change the output relays as described on page 10-8. When using the output relay as a control signal, make sure to match these control signals with other equipments to eliminate erroneuous control.

10.9 Outputting to an External Plotter / Printer

Relevant Keys



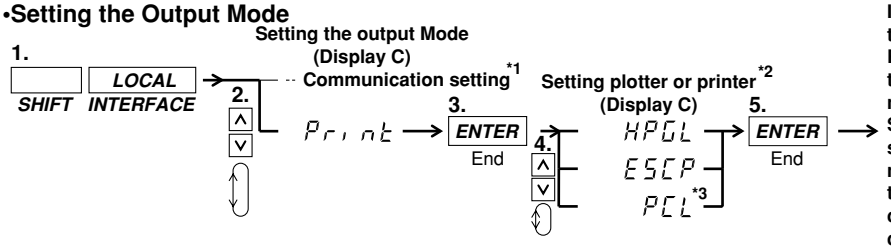
Displays relevant keys and indicator

***Shows the operation panel of the WT130. For the differences between WT110 and WT130, refer to section 2.2, page 2-2, 2-3**

Operating Procedure

- **Perform operations following the thick line in the below menu.**
- **Press the ENTER key to confirm the selection or setting.**
- **When you want to leave the current menu during operation, press the key described under step 1. The confirmed settings made until that point will be kept.**

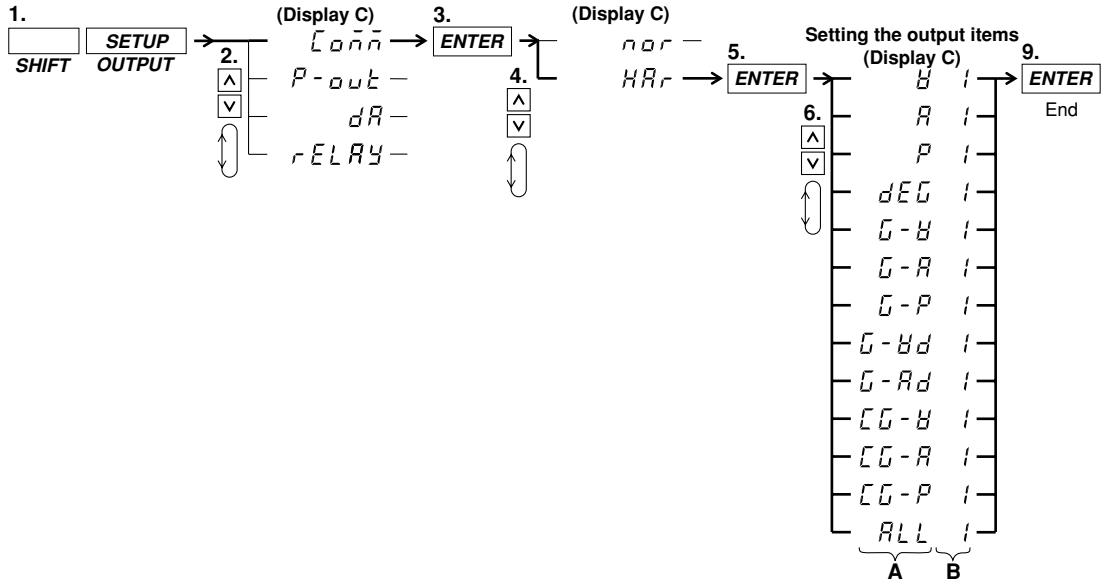
•Setting the Output Mode



If the communication interface that you purchased is an RS-232-C, the menu proceeds to the "Selecting handshaking method" menu of page 12-4. Set the relevant parameters such as the handshaking method, format, and baud rate, then press the *ENTER* key to complete the settings. If the communication interface is a GPIB, the procedure ends at step 5.

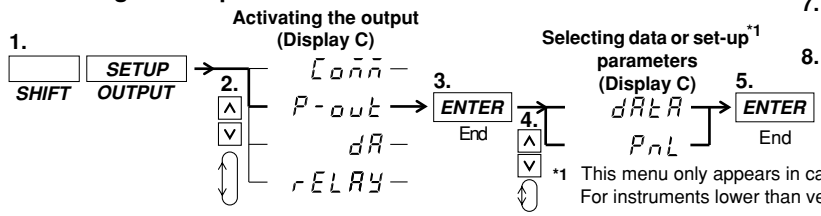
***1** Communication settings depend on your communication interface. Refer to Ch.11 or 12 for the menu.
***2** This menu only appears in case of version 1.11 and later. For instruments earlier than version 1.11, the setting ends at step 3.
***3** PCL is displayed on WT110/WT130 with version 2.21 or later.

• Setting the Output Items



6. ▽ △ Sets the A column
7. SHIFT + ▽ (>) Moves to the B column
8. ▽ △ Select from 1 to 3

• Activating the Output



***1** This menu only appears in case of version 1.11 and higher. For instruments lower than version 1.11, the setting ends at step 3.

Explanation

Setting the Output (Printing) Mode

This setting is to select whether you are printing out on a plotter or a printer.

HPGL : For printing on an external, HPGL - compatible plotter.

ESCP : For printing on an external, ESC / P - compatible printer.

PCL : For printing on an external, PCL5 (printer language of HP) - compatible printer. This mode is available on WT110/WT130 with version 2.21 or later.

Setting the Output Contents in case of Normal Measurement

All measured / computed data will be output.

Setting the Output Items and the Element in case of Harmonic Analysis

• Setting the Output Item (Column A)

One of the following items should be set, which then will be printed out on an external plotter/ ptinter. The initial value is V.

V : Prints the numerical values of the analysis value and relative harmonic content of the voltage;

A : Prints the numerical values of the analysis value and relative harmonic content of the current;

P : Prints the numerical values of the analysis value and relative harmonic content of the active power;

dEG : Prints the numerical values of the phase angle;

G-V : Prints the numerical values[*1] and the graph of the analyzed voltage values;

G-A : Prints the numerical values[*1] and the graph of the analyzed current values;

G-P : Prints the numerical values[*1] and the graph of the analyzed active power values;

G-Vd : Prints the numerical values[*1] and the graph of the phase angle between each voltage of the 2nd to 50th order and the fundamental (1st order);

G-Ad : Prints the numerical values[*1] and the graph of the phase angle between each current of the 2nd to 50th order and the fundamental (1st order);

CG-V : Prints the numerical values[*1] and the graph of the relative harmonic content of voltage;

CG-A : Prints the numerical values[*1] and the graph of the relative harmonic content of current;

CG-P : Prints the numerical values[*1] and the graph of the relative harmonic content of active power;

ALL : Prints the numerical values[*1] and the graph of the analysis values and relative harmonic content of voltage and current (V and A are both printed).

*1 HPGL/PCL plotters print both numerical values and the graph, but ESCP printers only print the graph.

• Setting the Element (Column B)

One of the following should be set. The output items corresponding to the set element will then be printed out on an external plotter. The initial value is 1. In case of the WT110, this setting is always 1.

1 : Select this when the output items of element 1 should be printed out;

2 : Select this when the output items of element 2 should be printed out; This setting is not available on model 253502.

3 : Select this when the output items of element 3 should be printed out.

Executing Output

After having connected the external plotter / printer to this instrument, execute the output of data.

dATA : All data selected as output items will be output.

PnL : All set-up parameters will be output.

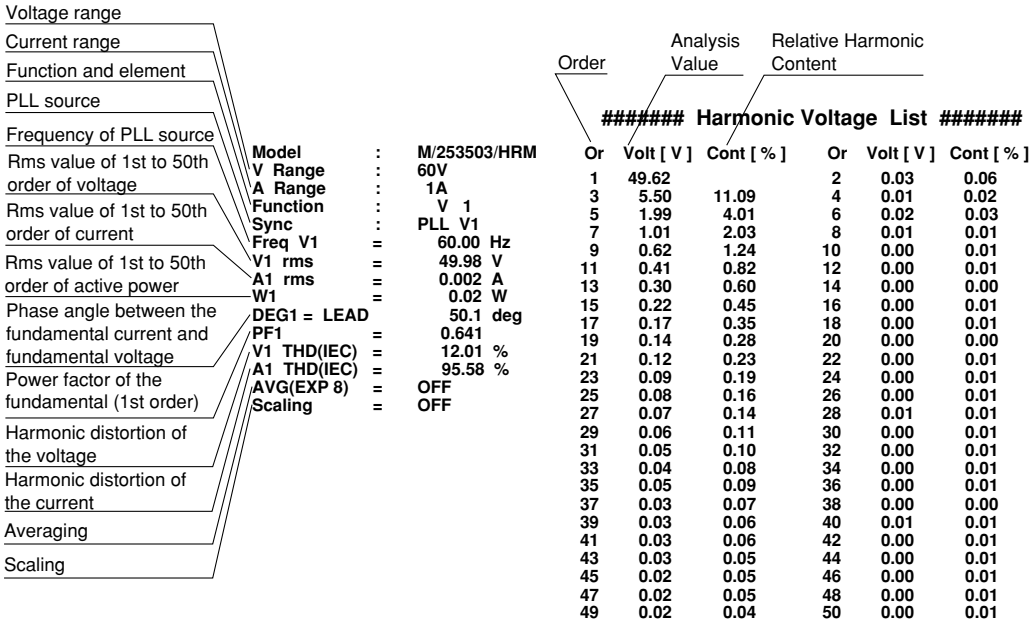
Note

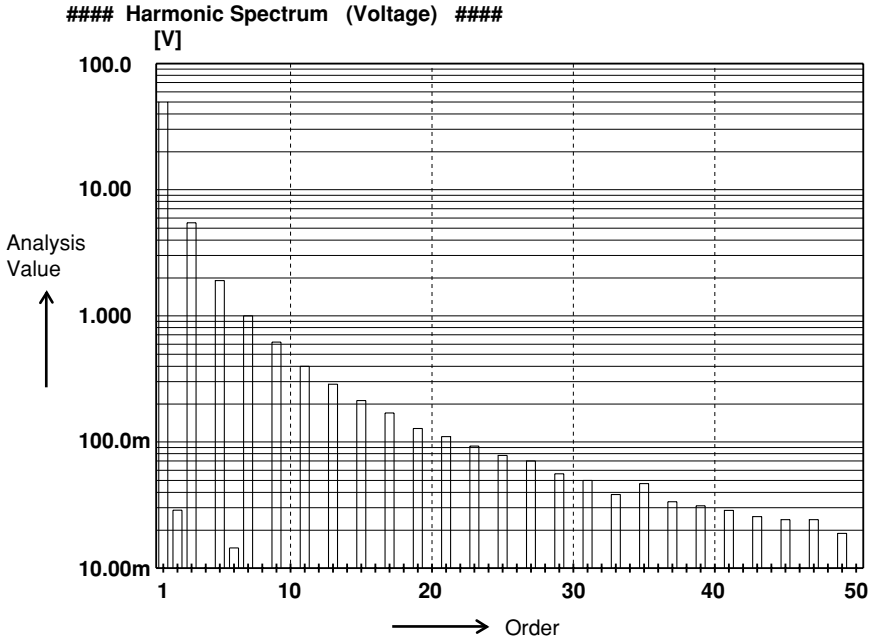
- When the output items are to be sent by communication interface and they are set to V, A, P or dEG, these items are then output. When the output item to be sent by communication is set to ALL, not only the V and A data are output, but P and dEG data as well. When the output item to be sent by communication is set to G-V to CG-P, the output data will not be the graph, but the numerical values.
- The orders are printed up to the maximum analysis order.
- When the fundamental frequency lies outside the measurement range of the harmonic analysis (display B will show FrqEr), an attempt to output will result in an error code.
- When you set an element which is not the element of measurement (column B), an attempt to output will result in an error code.
- When no analysis data are present, "——" will be printed.
- There are cases where the active power value becomes negative. The corresponding bargraph will be printed in thin print.
- When no plotter is connected, output time-out will result in an error code.

Example of Output to an External Plotter

• Output example in case of output item G-V of harmonic analysis data

(Slight differences may exist due to used plotter, etc.)





Output example of set-up parameters

```
WT110/130 Setup Lists
Version      : 1.11
Model        : 253503-C1/EX1/HRM/CMP

V Range      :  15   Vrms Manual
A Range      :  0.5  Arms Manual
Ext. Sensor (Elem 1)     = 50.00A
Ext. Sensor (Elem 2)     = 50.00A
Ext. Sensor (Elem 3)     = 50.00A

Display A    : Time  Element 1
Display B    : PF    Element 1
Display C    : A Hz  Element 3

Wiring       : 1 Phase 3 Wire
Filter       :  Off
Hold         :  On
Scaling      :  Off
PT Ratio          (Elem 1) =1.000
CT Ratio          (Elem 1) =1.000
Scaling Factor    (Elem 1) =1.000
PT Ratio          (Elem 2) =1.000
CT Ratio          (Elem 2) =1.000
Scaling Factor    (Elem 2) =1.000
PT Ratio          (Elem 3) =1.000
CT Ratio          (Elem 3) =1.000
Scaling Factor    (Elem 3) =1.000

Averaging                  : Off
Averaging Type             : Liner
Averaging Coefficient      :  8

Integrate Mode     : Manual
Integrate Timer    : 000:00
Rated Time (DA)    : 001:00

Store              :    Off
Store Interval     : 00:00:00
Recall             :    Off
Recall Interval    : 00:00:00

Sync. Source       :    PLL V1
Harmonics          :     Off
Display A Order    :      01
Harmonics Element  :  Element 1
Distortion Formula :     IEC

Comparator         :    Off
Comparator Mode    :  Single
Comparator Display :    Off
Comparator Channel :     1

Communication Command :  0
```

Voltage range
Current range
External sensor scaling values
Items shown
Wiring method
Filter ON/OFF
Hold ON/OFF
Scaling ON/OFF
Voltage(PT)ratio
Current(CT)ratio
Power value
Averaging ON/OFF
Type
Coefficient
Integration mode
Integration timer
Integration preset time
Storage ON/OFF
Interval
Recall ON/OFF
Interval
PLL source
Harmonics function ON/OFF
Order
Element
Distortion formula
Comparator function ON/OFF
Mode
Display ON/OFF
Channel
Comm.command

Output example of normal measurement data

```
                Element 1,  Element 2,  Element 3,  Sigma
V          0.88 ,     0.00 ,     0.09 ,    0.48
A           2.7m,     0.0m ,     0.0m ,    1.4m
W         -0.000 ,    0.000 ,    0.000 ,   -0.00
VA        0.002 ,     0.000 ,    0.000 ,   0.00
Var       0.002 ,     0.000 ,    0.000 ,   0.00
PF        -0.156 ,    PFErr ,    PFErr ,   -0.156
DEG        99.0 ,   dEGErr ,   dEGErr ,    99.0
HzA       ------- ,   ------- ,   ErrLo ,

Integrator          : Start
Integrator Time     : 000:05:55

                Element 1,  Element 2,  Element 3,  Sigma
Wh+     0.00m,     0.00m,     0.00m,    0.0000
Wh-    -0.03m,    -0.00m,    -0.00m,   -0.0000
Wh     -0.03m,    -0.00m,    -0.00m,   -0.0000
Ah+    0.245m,    0.000m,    0.000m,   0.245m
Ah-    0.000m,    0.000m,    0.000m,   0.000m
Ah     0.245m,    0.000m,    0.000m,   0.245m
```

Element
Voltage
Current
Active power
Apparent power
Reactive power
Power factor
Phase angle
Frequency
Integration status
Integration elapsed time
Watt-hour
Ampere-hour

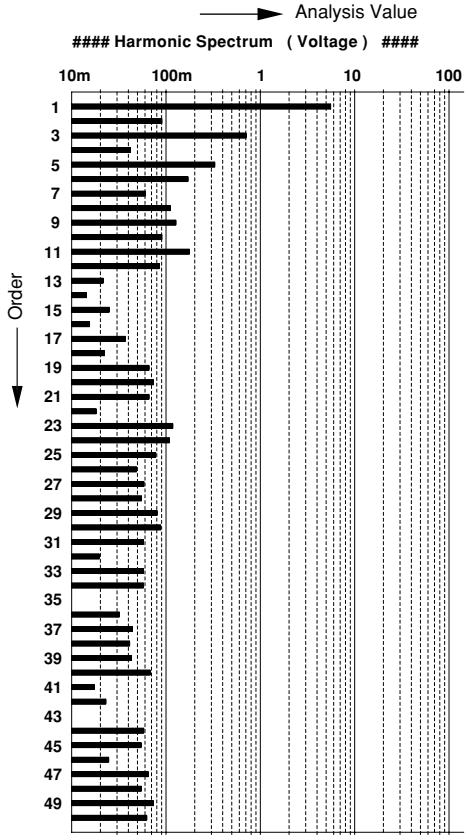
Output example of harmonic analysis data

Refer to the previous page for a description

```
Model       : M/253503/HRM
V Range     : 15 V
A Range     : 0.5A
Function    : V 1
Sync        : PLL V1
Freq V1     =     60.00 Hz
V1 rms      =      5.76 V
A1 rms      =      1.4  mA
W1          =   -0.001  W
DEG1   = LEAD  153.8  deg
PF1            = -0.897
V1 THD (IEC)   =   15.71%
A1 THD (IEC)   = - - - oF - - -
Avg    (EXP 8 ) = OFF
Scaling         = OFF

####### Harmonic Voltage List #######
```

Or	Volt [V]	Cont [%]	Or	Volt [V]	Cont [%]
1	5.69		2	0.09	1.60
3	0.68	12.02	4	0.04	0.74
5	0.32	5.63	6	0.16	2.77
7	0.06	1.05	8	0.11	2.01
9	0.12	2.15	10	0.09	1.65
11	0.17	2.96	12	0.08	1.47
13	0.02	0.39	14	0.01	0.25
15	0.02	0.43	16	0.01	0.25
17	0.04	0.63	18	0.02	0.41
19	0.07	1.15	20	0.07	1.31
21	0.07	1.15	22	0.02	0.31
23	0.11	1.93	24	0.10	1.84
25	0.08	1.39	26	0.05	0.85
27	0.06	1.04	28	0.06	0.97
29	0.08	1.44	30	0.09	1.59
31	0.06	1.03	32	0.02	0.36
33	0.06	1.08	34	0.06	1.06
35	0.00	0.02	36	0.03	0.57
37	0.04	0.77	38	0.04	0.72
39	0.04	0.74	40	0.07	1.24
41	0.01	0.26	42	0.02	0.40
43	0.01	0.14	44	0.06	1.04
45	0.05	0.94	46	0.02	0.43
47	0.07	1.18	48	0.05	0.94
49	0.07	1.30	50	0.06	1.09



11.1 Using the GP-IB Interface

This instrument is equipped with a GP-IB interface in accordance with your preference. This interface permits remote control from a controller such as a personal computer, and output of various data.

Overview of the GP-IB Interface

The table below shows functions that are available in each mode.

Mode	Function	
Addressable mode (mode A and mode B), 488.2 mode	Listener	Functions performed by key operations (except for LOCAL key and power ON/OFF) measured/computed/analysis data output request setting parameters output request error code output request
	Talker	measured/computed/analysis data output setting parameters output error code output status byte output
Talk-only mode	Talker	measured/computed/analysis data output

Addressable Mode A

Data is output when the data output request command "OD" is received. This mode enables transmission of data at a specified time.

Addressable Mode B

This mode does not require a measured data inquiry command. When data is requested by the controller (personal computer, etc.), the data is output as the display is updated when measurement is completed. Therefore, if an attempt is made to transmit data at intervals shorter than the display intervals, the controller is forced to wait until the next display interval.

488.2 Mode

This mode allows commands conforming to the IEEE St'd 488.2-1987 protocol to be used.

Talk-only Mode

This mode does not require a controller. Data is output at certain intervals. This interval can be set to any length. This mode is useful when the instrument is connected to a listener-only device such as a printer.

Print Mode

This mode is useful when harmonic analysis data are output to the external plotter/printer. For details, refer to page 10-17.

GP-IB Interface Specifications

- Electrical & mechanical specifications : conforms to IEEE st'd 488-1978
- Functional specifications : refer to the table below
- Code : ISO (ASCII) code
- Address setting : 0 to 30 listener and talker addresses, or talk-only can be selected using the front panel keys.
- Remote mode clear : remote mode can be cleared by pressing the LOCAL key on the front panel. However, this is not possible when Local Lockout has been set by the controller.

Function	Subset name	Description
source handshake	SH1	full source handshake capability
acceptor handshake	AH1	full acceptor handshake capability
talker	T5	basic talker capability, serial polling, nontalker on MLA (My Listen Address), talk-only capability
listener	L4	Basic listener capability, nonlistener to MTA (My Talk Address), no listen-only capability
service request	SR1	full service request capability
remote local	RL1	full remote/local capability
parallel poll	PR0	no parallel polling capability
device clear	DC1	full device clear capability
device trigger	DT1	full device trigger capability
controller	C0	no controller function

WARNING

The connectors used in this function have protective covers. When the covers are removed or when using connectors, the voltage ratings across the measuring input and the ground become as follows:

Voltage across A, ±(V and A side) input terminals and ground 400 Vrms max.
Voltage across V terminal and ground 600 Vrms max.

Put the protective cover on the connector when this function is not used.

11.2 Responses to Interface Messages

Responses to Interface Messages

IFC (Interface Clear)

Unaddresses talker and listener.

REN (Remote Enable)

Transfers the instrument from local control to remote control.

GTL (Go To Local)

Transfers the instrument from remote control to local control.

SDC (Selective Device Clear), DCL (Device Clear)

Cleasrs GP-IB input/output buffer, and resets an error. The set-up information and measurement state are not affected. DCL is applicable to all devices on the bus, whilst DSC is applicable to designated devices only.

GET (Group Execute Trigger)

Same function as the TRIG key.

LLO (Local Lockout)

Invalidates the LOCAL key on the front panel to inhibit transfer from remote control to local control.

Switching between Remote and Local Mode

When switched from local to remote mode

The REMOTE indicator will light up, and all panel keys except the LOCAL key cannot be operated. Set-up parameres entered in the local mode will be retained.

When switched from remote to local mode

The REMOTE indicator will extinguish and all panel keys can be operated. Set-up parameters entered in the remote mode will be retained.

Valid keys for remote control

Pressing the LOCAL key in remote control will switch the instrument to local control. However, this is not possible in case the Local Lockout has been set by the controller.

11.3 Status Byte Format (before the IEEE 488.2-1987 Standard)

DIO 8	DIO 7	DIO 6	DIO 5	DIO 4	DIO 3	DIO 2	DIO 1
Integration BUSY	**SRQ**	**ERROR**	**STORE/ RECALL BUSY**	**OVER**	**Syntax ERROR**	**Integration END**	**Computation END**

Integration Busy (DIO 8)

This bit is set to “1” when integration is in progress. This bit cannot be disabled by the IM command since it is a status bit. Even if this bit is set to “1”, SRQ will not be affected.

SRQ (DIO 7)

This bit is set to “1” when computation End (DIO 1), integration End (DIO 2), OVER (DIO 4) or Syntax error (DIO 3) occurs. When RQS is set to “1”, SRQ is set to True, issuing a service request to the controller. This bit is reset to “0” when a response is sent to the serial poll. To prevent the SRQ and status byte being affected by computation End, integration End, Over or Syntax error, this bit must be disabled by the IM command.
After an “IM15”, SRQ is affected by a computation End, integration End, Over, or Syntax error.
After an “IM1”, SRQ is affected only by a computation End.
In case of “IM4”, SRQ is affected only by a Syntax error.

ERROR (DIO 6)

When a Syntax error or Over occurs, this bit is set to “1” and the SRQ is set to True.

Store/Recall Busy (DIO 5)

This bit is set to “1” when storing/recalling of data is in progress. This bit cannot be disabled by the IM command since it is a status bit. Even if this bit is set to “1”, SRQ will not be affected.

Over (DIO 4)

This bit is set to “1” and SRQ is set to True when an overrange occurs in the measured data. However, this is not valid if the bit has been disabled by the IM command. This bit is reset after a response is made to the serial poll. The nature of Over can by identified by the OE command.

Syntax error (DIO 3)

This bit is set to “1” when a command error, parameter error or execution error occurs. The error No. can be identified by the OE command. This bit is reset after a response is made to the serial poll. However, this is not valid if the bit has been disabled be the IM command.

Integration End (DIO 2)

This bit is set to “1” when integration has been completed. The bit is reset when a response is made to the serial poll. However, this is not valid if the bit has been disabled by the IM command.

Computation End (DIO1)

This bit is set to “1” when computation has been completed and the display is updated. The bit is reset when a response is made to the serial poll. However, this is not valid if the bit has been disabled by the IM command.

11.4 Output Format for Normal Measured/Computed Data, Harmonic Analysis Data, Set-up Parameters and Error Codes

Output Format of Normal Measured/Computed Data

Data Format

Measured data normally consists of a 6-byte header and 11 bytes of data

Header	Data

Header Section

The header section consists of 6 bytes (h1 to h6).

h1	h2	h3	h4	h5	h6

h1 to h3: data type

V_ _	: voltage	A_ _	: Current	W_ _	: Active power
VA_	: Apparent power	Var	: Reactive power	PF_	: Power factor
HzV	: Voltage frequency	HzA	: Current frequency	Wh_	: Watt hour
Ah_	: Ampere hour	DEG	: Phase angle	Vpk	: Peak voltage value
Apk	: Peak current value	EFF	: Efficiency	CV1	: V1 crest factor
CV2	: V2 crest factor	CV3	: V3 crest factor	CA1	: A1 crest factor
CA2	: A2 crest factor	CA3	: A3 crest factor		
A+B	: (display A)+(display B)	A–B	: (display A)–(display B)		
A∗B	: (display A)∗(display B)	A/B	: (display A)/(display B)		
Wh+	: Positive watt hour	Wh–	: Negative watt-hour		
Ah+	: Positive ampere hour	Ah–	: Negative ampere hour		
HMS	: Elapsed time of integration	MEM	: Data number in case of recalling		

(Efficiency, crest factor, and the results of four arithmetic operations can be output on WT110/WT130 with ROM version 2.01 and later. However, different instruments have different restrictions on the output of these parameters.)

h4: Element

1: Element 1 2: Element 2 3: Element 3 4: Σ

h1-h4: data type (only when the computing equation is A/B^2 or A^2/B on WT110/WT130 with ROM version 2.01 or later)

A/B^2: (display A)/(display B)^2

A^2/B: (display A)^2/(display B)

h5: Data state

N: normal I: Overrange O: Computation overflow P: Peak overflow
E: No data

h6: Indicates data lag/lead in case of DEG data type. In case of other data types, _ (space) will occur.

G: Lag D: Lead _: Not detectable

Data Section

The data section consists of 11 bytes.

d1	d2	d3	d4	d5	d6	d7	d8	d9	d10	d11

d1 : polarity; _ (space) or – (minus)
d2 to d8 : mantissa, floating-point number of the maximum six digits
d9 to d11 : exponent; E-3→m, E+0, E+3 → k, E+6 → M

Data state in case of an overrange ("oL" is being displayed)

h1	h2	h3	h4	I	_	_	9	9	9	9	9	9	.	E	+	3

Data state in case of a computation overflow

("oF", "PFErr", "dEGEr", "ErrLo", "ErrHi" is being displayed)

h1	h2	h3	h4	O	_	_	8	8	8	8	8	8	.	E	+	0

Data state in case of no data (when the display is - - - - -)

"I" becomes "E" for data during overrange.

Elapsed time of integration

H	M	S	_	_	_	d1	d2	d3	d4	d5	d6	d7	d8	d9

d1 to d3 : Hour d4 : ":"
d5 to d6 : Minute d7 : ":"
d8 to d9 : Second

Output Format when Self Selected

Up to 14 normal measured/computed data can be output simultaneously, and the user is allowed to choose any output information type for those 14 data. Each output block is of the following format.

Line 1	Data number	Terminator	(The data number will only be output in case of recall)						
Line 2	ch.1	,	ch.2	,	ch.3	,	ch.4	Terminator	
Line 3	ch.5	,	ch.6	,	ch.7	,	ch.8	Terminator	
Line 4	ch.9	,	ch.10	,	ch.11	,	ch.12	Terminator	
Line 5	ch.13	,	ch.14	Terminator					
Line 6	END	Terminator							

Each output block usually consists of five lines (six in case of recall) including the block end line “END”. However, if all output types on a line are set to “no output”, this line will be omitted, reducing the number of output lines by one. For example, if all output items of ch.9 to ch12 are set to “no output”, line 4 in the above example will be omitted.
Furthermore, if any channel on a line is set to “no output”, all data following this channel on the line will be shifted forward. For example, if the ch.2 on line 1 is set to “no output”, data of ch.1 will be followed by data of ch.3.

Output Format in case of Normal Measurement

WT110 (253401)

Line 1	Data number	Terminator	(The data number will only be output in case of recall)						
Line 2	V1 data	Terminator							
Line 3	A1 data	Terminator							
Line 4	W1 data	Terminator							
Line 5	Frequency	,	Display C	Terminator					
Line 6	END	Terminator							

WT130 (253502)

Line 1	Data number	Terminator	(The data number will only be output in case of recall)						
Line 2	V1 data	,	V3 data	,	SV data	Terminator			
Line 3	A1 data	,	A3 data	,	SA data	Terminator			
Line 4	W1 data	,	W3 data	,	SW data	Terminator			
Line 5	Frequency	,	Display C	Terminator					
Line 6	END	Terminator							

Note

- When the frequency is set by either of the following methods, only one value is measured, and that value will be output.
  - by panel keys : by the FUNCTION key and ELEMENT key of display C (except WT110)
  - by communication command : by the “DC” or “EC” command.

  After setting the measurement object of frequency, even changing the display C to something different than VHz or AHz will not result in changing the object of measurement of frequency. When selecting the output items yourself and you set a frequency item which is not object of measurement, “999999.E+03” will be output.

WT130 (253503)

Line 1	Data number	Terminator	(The data number will only be output in case of recall)						
Line 2	V1 data	,	V2 data	,	V3data	,	SV data	Terminator	
Line 3	A1 data	,	A2 data	,	A3 data	,	SA data	Terminator	
Line 4	W1 data	,	W2 data	,	W3 data	,	SW data	Terminator	
Line 5	Frequency	,	Display C	Terminator					
Line 6	END	Terminator							

Default Output Format in case Integration Measurement

WT110 (253401)

Line 1	Data number	Terminator	(The data number will only be output in case of recall)	
Line 2	W1 data	Terminator		
Line 3	Wh1data	Terminator		
Line 4	Ah1data	Terminator		
Line 5	Frequency	,	Elapsed integration time	Terminator
Line 6	END	Terminator		

WT130 (253502)

Line 1	Data number	Terminator	(The data number will only be output in case of recall)			
Line 2	W1 data	,	W3 data	,	SW data	Terminator
Line 3	Wh1data	,	Wh3data	,	SWhdata	Terminator
Line 4	Ah1data	,	Ah3data	,	SAhdata	Terminator
Line 5	Frequency	,	Elapsed integration time	Terminator		
Line 6	END	Terminator				

WT130 (253503)

Line 1	Data number	Terminator	(The data number will only be output in case of recall)						
Line 2	W1 data	,	W2 data	,	W3 data	,	SW data	Terminator	
Line 3	Wh1data	,	Wh2data	,	Wh3data	,	SWhdata	Terminator	
Line 4	Ah1data	,	Ah2data	,	Ah3data	,	SAhdata	Terminator	
Line 5	Frequency	,	Elapsed integration time	Terminator					
Line 6	END	Terminator							

Output Format of Harmonic Analysis Data

Data Format

Harmonic analysis data normally consists of a 8-byte header and 11 bytes of data

Header	Data

Header Section

The header section consists of 8 bytes (h1 to h8).

h1	h2	h3	h4	h5	h6	h7	h8

h1 to h3 : data type

V__ : voltage A__ : Current W__ : Active power

DEG : Phase angle between the 1st order voltage and 1st order current

DGV : Phase angle between the 1st order voltage and the 2nd to 50st order voltage

DGA : Phase angle between the 1st order current and the 2nd to 50st order current

PF_ : Fundamental power factor (1st order)

HzV : Fundamental frequency of the voltage of the PLL source

HzA : Fundamental frequency of the current of the PLL source

THD : Harmonic distortion (either IEC or CSA)

CNT : Relative harmonic content

MEM : Data number in case of recalling

h4: Element

1: Element 1 2: Element 2 3: Element 3 4: Not applicable

h5: Data state

N: normal I: Overrange O: Computation overflow P: Peak overflow

E: No data

h6, h7: Order

01 to 50: Order of fundamental or higher harmonic (up to the maximum analysis order).

"__" (space) will be assigned in case of frequency, harmonic distortion, power factor or in case of all computed values of the 1st to 50th order.

h8: Indicates data lag/lead in case of DEG data type. In case of other data types, __ (space) will occur.

G: Lag D: Lead _: Not detectable

Data Section

The data section consists of 11 bytes.

d1	d2	d3	d4	d5	d6	d7	d8	d9	d10	d11

d1 : polarity; __ (space) or – (minus)

d2 to d8 : mantissa, floating-point number of the maximum six digits

In case of harmonic distortion and relative harmonic content :

d9 : %

d10 to d11 : __ (space)

In other cases :

d9 to d11 : exponent; E-3 → m, E+0, E+3 → k, E+6 → M

Output Format

The output format depends on the selected output items which can be selected by the “OH” command.

In case of voltage and current

Line 1	All computed values of the 1st to 50th order	,	harmonic distortion	Terminator
Line 2	Analysis value for fundamental (1st order)	,	Frequency	Terminator
Line 3	Analysis value for 2nd harmonic	,	Relative harmonic content for 2nd harmonic	Terminator
⋮	⋮	⋮	⋮	⋮
Line 51	Analysis value for 50th harmonic	,	Relative harmonic content for 50th harmonic	Terminator
Line 52	END	Terminator		

In case of active power

Line 1	All computed values of the 1st to 50th order	,	Power factor	Terminator
Line 2	Analysis value for fundamental (1st order)	,	Frequency	Terminator
Line 3	Analysis value for 2nd harmonic	,	Relative harmonic content for 2nd harmonic	Terminator
⋮	⋮	⋮	⋮	⋮
Line 51	Analysis value for 50th harmonic	,	Relative harmonic content for 50th harmonic	Terminator
Line 52	END	Terminator		

In case of phase angle

Line 1	Phase angle between fundamentals of voltage and current	,	Frequency	Terminator
Line 2	Phase angle between fundamental and 2nd harmonic of voltage	,	Phase angle between fundamental and 2nd harmonic of current	Terminator
Line 3	Phase angle between fundamental and 3rd harmonic of voltage	,	Phase angle between fundamental and 3rd harmonic of current	Terminator
Line 50	⋮	⋮	⋮	⋮
Line 51	Phase angle between fundamental and 50th harmonic of voltage	,	Phase angle between fundamental and 50th harmonic of current	Terminator
	END	Terminator		

In case of ALL setting

The data will be output in the sequence voltage → current → active power → phase angle → END <terminator>

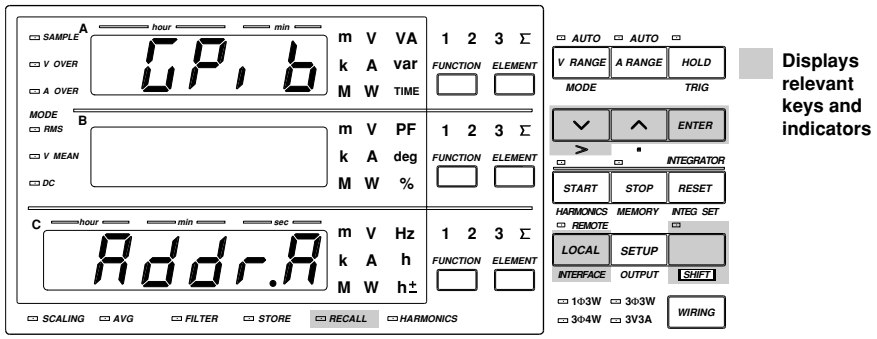
- The output format of each item is as described for each item above;
- The END line is not output for each item, but after finishing the entire output operation.

Output Format of Set-up Parameters and Error Codes

Refer to the explanations and examples of the “OS” or the “OE” commands described in Appendix 1.1.

11.5 Setting the Address/Addressable Mode

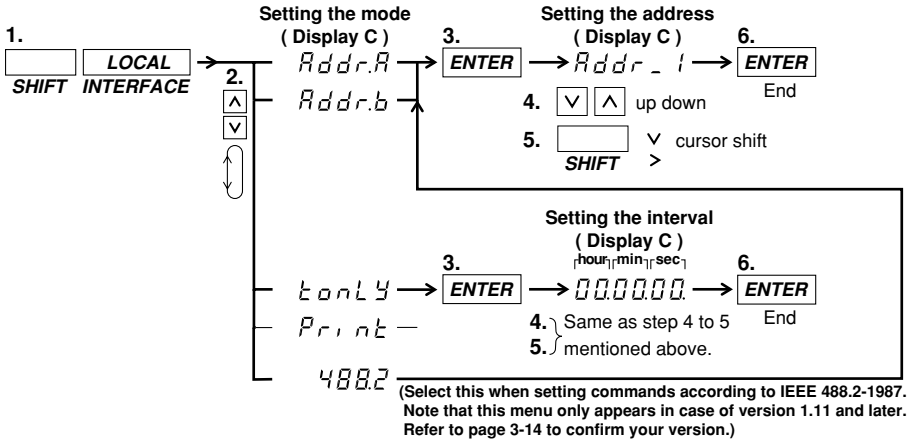
Relevant Keys



*** Shows the operation panel of the WT130. For the differences between WT110 and WT130, refer to section 2.2, page 2-2, 2-3**

Operating Procedure

- **Perform operations following the thick line in the below menu.**
- **Press the ENTER key to confirm the selection or setting.**
- **When you want to leave the current menu during operation, press the key described under step 1. The confirmed settings made until that point will be kept.**



Explanation

Mode Setting

Refer to page 11-1 for details.

Address Setting

A particular address is assigned to each device connected to the GP-IB interface so that each device can be recognized by every device. Therefore, an address must be assigned to this instrument when it is connected to a personal computer.

Address setting range: 0 to 30

The initial value is “1”. Initializating the instrument will not result in changing the address setting.

Talk-only Function

This function only allows the instrument to send data to other devices. If talk-only is off, the instrument can both send and receive data. In talk-only mode, the instrument cannot be controlled by the controller.

Terminator

When this instrument is used as a listener

Use “CR+LF”, “LF” or “EOI” as the receiving terminator.

When this instrument is used as a talker

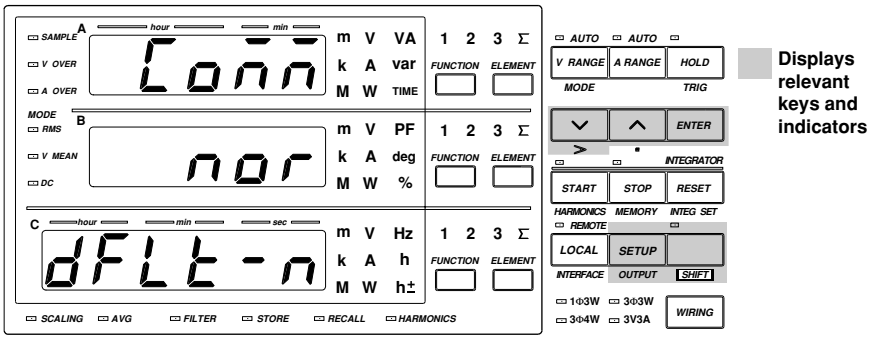
The sending terminator is set using the DL command. The initial setting is “CR+LF+EOI”.

Note

- It is not possible for this instrument to receive data if the “CR” terminator is sent from the controller. It is also not possible to set “CR” as the terminator which is to be sent from this instrument.

11.6 Setting the Output Items

Relevant Keys

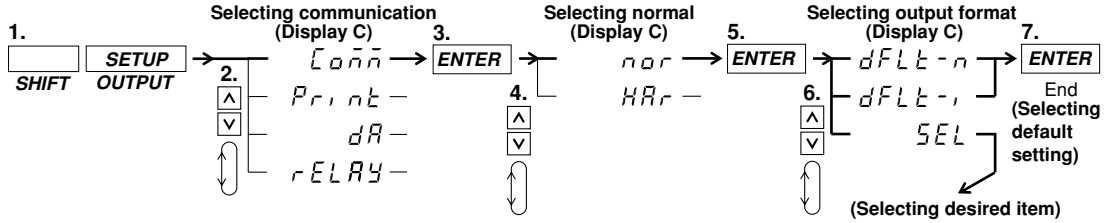


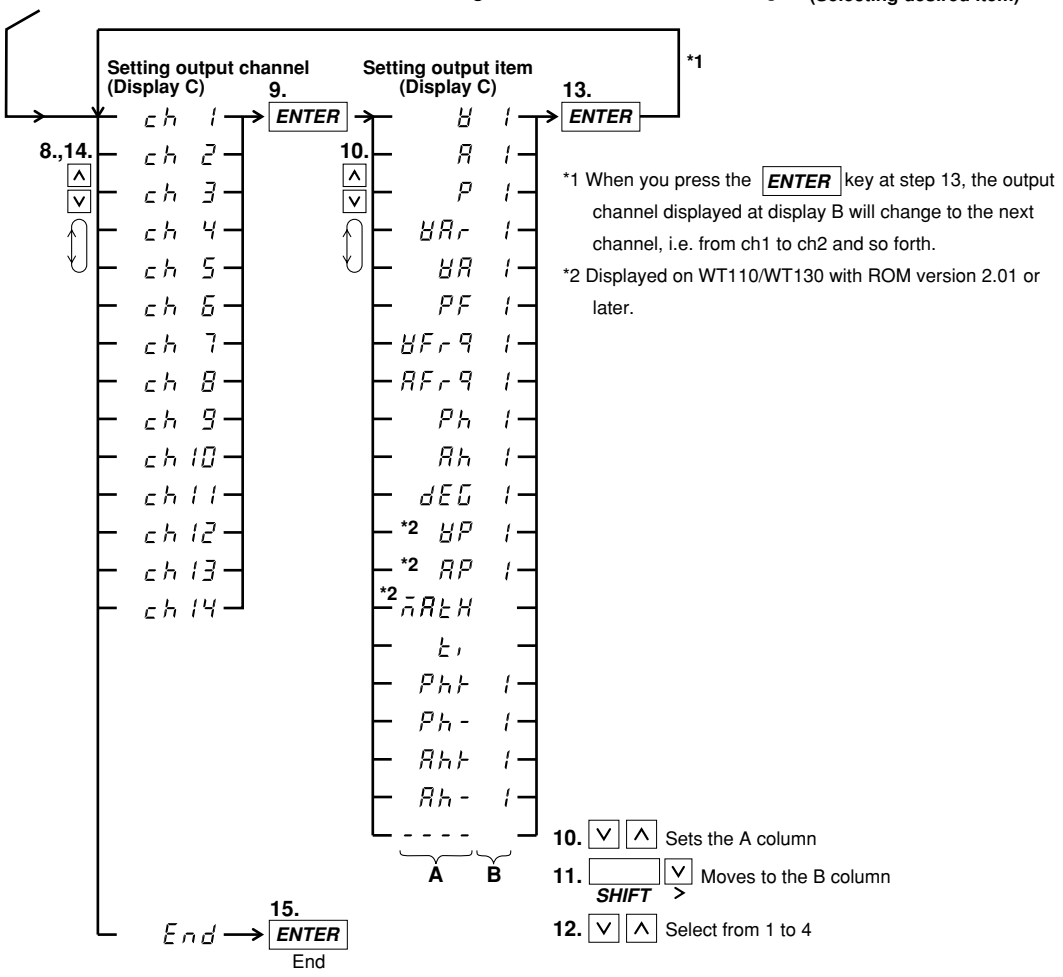
*** Shows the operation panel of the WT130. For the differences between WT110 and WT130, refer to section 2.2, page 2-2, 2-3**

Operating Procedure

- **Perform operations following the thick line in the below menu.**
- **Press the ENTER key to confirm the selection or setting.**
- **When you want to leave the current menu during operation, press the key described under step 1. The confirmed settings made until that point will be kept.**

• Setting the Output Item in case of Normal Measurement

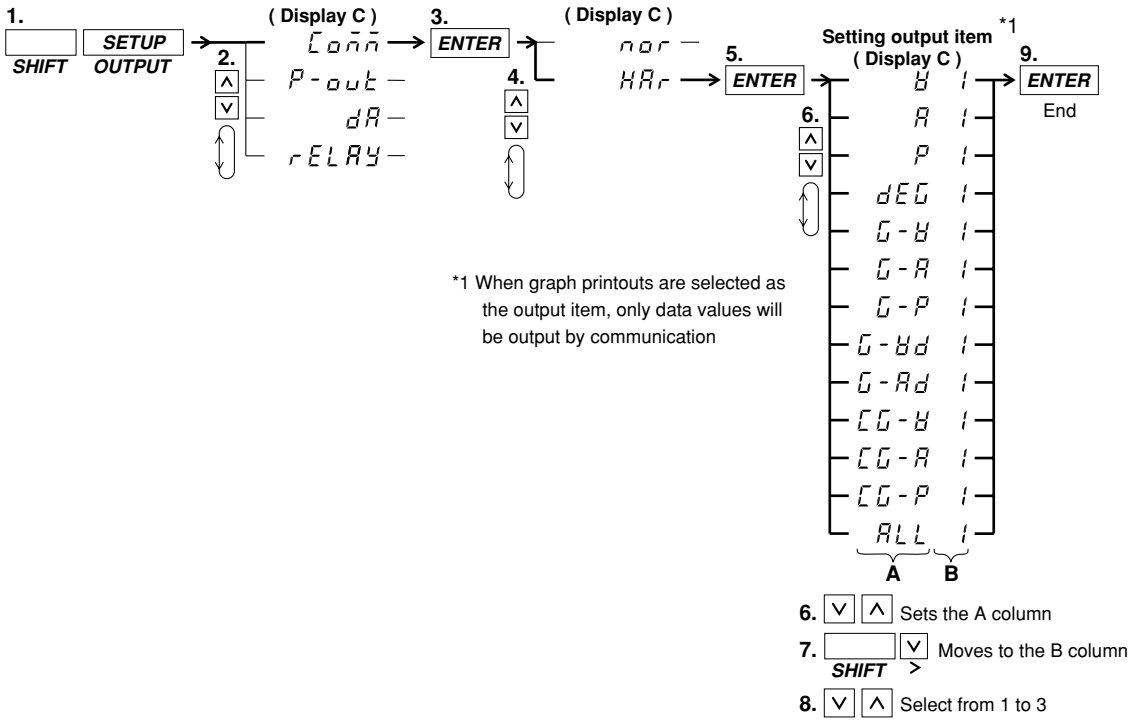




*1 When you press the ENTER key at step 13, the output channel displayed at display B will change to the next channel, i.e. from ch1 to ch2 and so forth.

*2 Displayed on WT110/WT130 with ROM version 2.01 or later.

Setting the Output Item in case of Harmonic Analysis



Explanation

Setting the Output Item in case of Normal Measurement

- **Selecting the Default Setting**

  Predefined items will be output by the communication function. The following types of default settings exist and they depend on the model. For more details, refer to page 11-5 and 11-6.

  Normal default setting : dFLt-n

  Consists of V (voltage), A (current), W (active power, the above menu shows P), frequency and displayed data of display C.

  Integration default setting : dFLt-i

  Consists of W (active power, the above menu shows P), Wh (watt hour), Ah (ampere hour), frequency, and integration time.

- **Selecting yourself**

  You can set any item to each of ch1 to ch14 output channels.

  Setting the channel

  Sets which channel (ch1 to ch14) will output the item.

  Setting the output item (corresponds to column A in the operating procedure)

  Any of the following items can be selected. The initial value is V.
  V (voltage), A (current), P (active power), VAr (reactive power), VA (apparent power), PF (power factor), VFrq (voltage frequency), AFrq (current frequency), Ph (total watt hour Wh), Ah (total ampere hour), dEG (phase angle),VP(peak value of voltage)*2, AP(peak value of current)*2, MATH(computation)*2, t1 (elapsed integration time), Ph+ (positive watt hour Wh+), Ph– (negative watt hour Wh–), Ah+ (positive ampere hour*1), Ah– (negative ampere hour*1), – – – – (no output)

  *1 For details regarding the positive ampere hour, refer to page 7-3.

  *2 Available on WT110/WT130 with ROM version 2.01 or later.

- **Setting the element (corresponds to column B in the operating procedure)**

  The element setting depends on the model and is as follows. The initial value is “1”.
  - WT110 (253401) no such element setting available;
  - WT130 (253502) element can be selected from 1, 3 or 4
  - WT130 (253503) element can be sleected from 1, 2, 3 or 4

  The element number 4 represents Σ.

Setting the Output Item in case of Harmonic Analysis

The setting is carried out in the same way as described in section 10.9. However, when output data by communication function, graphs will be printed, but only data values will be output. For details, refer to page 10-17, 10-18.

11.7 Commands (before the IEEE 488.2-1987 Standard)

For a detailed description of each command, refer to appendix 1.1.

	Command	Description
Wiring system	WRm (WiRing)	sets wiring system
Voltage range	RVm (Range Voltage)	sets voltage range
	AVm(Auto Voltage range)	sets voltage auto range
Current range	RAm(Range current(A))	sets current range
	AAm(Auto current(A) range)	sets current auto range
	SAm(Sensor Ampere)	sets external sensor
Display range	DR(Display Range)	sets external sensor
Measurement mode	MNm(MeaN)	sets external sensor
Filter	FLm(FiLter)	sets filter ON/OFF
Hold	HDm(sampling HolD)	holds display and output data
Trigger	E or ST or <GET>	trigger
Display	DAm(Display A function)	selects function to be displayed on display A
	DBm(Display B function)	selects function to be displayed on display B
	DCm(Display C function)	selects function to be displayed on display C
	EAm(Element display A)	selects element to be displayed on display A
	EBm(Element display B)	selects element to be displayed on display B
	ECm(Element display C)	selects element to be displayed on display C
Scaling	SCm(SCaling)	sets scaling ON/OFF
	KVm(K*Amplre)	sets the scaling value
	KAm(K*Wattage)	
	KWm(K*Voltage)	
Averaging	AGm(AveraGing)	sets averaging ON/OFF
	ATm(Averaging Type)	selects exponential averaging or moving averaging
	ACm(Averaging Coefficient)	sets attenuation constant or averaging number
MATH	MTm(MaThematics)	Sets computing equation
Integration	IS(Integrate Start)	starts integration
	IP(Integrate stoP)	stops integration
	IR(Integrate Reset)	resets integration
	ICm(Integrate Continuous)	sets integration mode
	TMm1,m2(integrate TiMer)	sets integration preset time
Data storage	SO(Store On)	starts storage
	SRm1,m2,m3(Store inteRval)	sets storage interval
Data recalling	ROm(Recall On)	starts recalling
	RRm1,m2,m3(recall inteRval)	sets recalling interval
Set-up parameters	SLm(panel Setting Load)	recalling set-up parameters
	SSm(panel Setting Save)	storing set-up parameters
	RC(Reset Command)	initialize set-up parameters
Communication commands	CMm(Communication coMmand)	sets command group to be used
	OD(Output Data)	requests output of measured data
	OFm1,m2,m3(Output Function)	sets output items
	OFDm(Output Function Default)	sets default output items
	OS(Output panal Setting)	requests output of setting parameters
	OE(Output Error code)	requests output of error code
	Hm(Header)	sets output data header
	DLm(DeLimiter)	sets output data delimiter
	IMm(Interrupt Mask)	sets status byte interrupt mask
/HAM (option)	HAm(Harmonics Analize)	sets harmonic analysis ON/OFF
	HEm(Harmonics Eiement)	sets harmonics element
	OR(harmonics ORder)	sets harmonics order
	OHm1,m2(Output Harmonics function)	sets communication or output block
	PSm(Pll Source)	sets PLL source
	DFm(Distortion Formula)	sets distortion formula
/DA (option)	OAm1,m2,m3(Output Analog)	sets output items yourself
	OADm(Output Analog Default)	sets default output items
	RTm1,m2,(integrate Rated Time)	sets integration time
/CMP (option)	YOm(relaY On)	sets comparator function ON/OFF
	YMm(relaY Mode)	sets comparator mode
	DYm(Display relaY)	sets display relay ON/OFF for comparator
	YCm(relaY Channel)	sets the relay channel
	OYm1,m2,m3,m4,m5 (Output relaY function)	sets the output relay function for normal measurement
	OYHm1,m2,m3,m4,m5,m6 (Output relaY Harmonic function)	sets the output relay function for harmonic analysis

Note

- If commands relating to options are used on instruments which do not have the options installed, "Error 11" is displayed. Also, there are no responses to inquiries.
- "MATH" is available on WT110/WT130 with ROM version 2.01 or later.

12.1 Using the RS-232-C Interface

This instrument is equipped with a RS-232-C interface in accordance with your preference. This interface permits remote control from a controller such as a personal computer, and output of various data.

Overview of the RS-232-C Interface

The table below shows functions that are available in each mode.

Mode	Function	
Normal mode	Reception	Functions performed by key operations (except for LOCAL key and power ON/OFF) measured/computed/analysis data output request setting parameters output request error code output request
	Transmission	measured/computed/analysis data output setting parameters output error code output status byte output
Talk-only mode	Transmission	measured/computed/analysis data output

Normal Mode

This mode is equivalent to the the addressable mode A of the GP-IB function, and enables reception of commands and transmission of data. Measured data is output on reception of the "OD" command.

488.2 Mode

This mode allows receiving of commands conforming to the IEEE St'd 488.2-1987 protocol.

Talk-only Mode

This mode is equivalent to the Talk-only mode of the GP-IB function. Only measured data can be output and commands cannot be received.
There is no equivalent to the addressable mode B of the GP-IB function.

Print Mode

This mode is useful when harmonic analysis data are output to the external plotter/printer. For details, refer to page 10-17.

RS-232-C Interface Specifications

Electrical characteristics	: conforms to EIA RS-232-C
Connection	: point-to-point
Communications	: full-duplex
Synchronization	: start-stop system
Baud rate	: 75, 150, 300, 600, 1200, 2400, 4800, 9600
Start bit	: 1 bit
Data length (word length)	: 7 or 8 bits
Parity	: Even, odd or no parity
Stop bit	: 1 or 2 bits
Hardware handshaking	: User can select whether CA, CB, CC and CD signals will always be True, or be used for control.
Software handshaking	: User can select whether to control only transmission or both transmission and reception using X-on and X-off signals. X-on (ASCII 11H) X-off (ASCII 13H)
Receive buffer size	: 64 bytes

WARNING

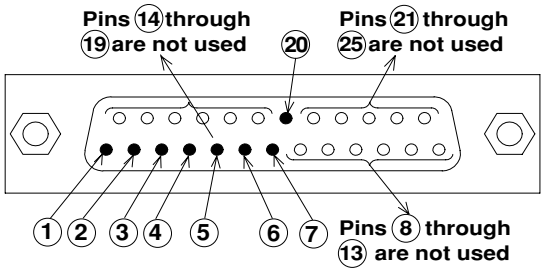
The connectors used in this function have protective covers. When the covers are removed or when using connectors, the voltage ratings across the measuring input and the ground become as follows:
Voltage across A, ±(V and A side) input terminals and ground 400 Vrms max.
Voltage across V terminal and ground 600 Vrms max.
Put the protective cover on the connector when this function is not used.

12.2 Connecting the Interface Cable

When connecting this instrument to a personal computer, make sure that the handshaking method, data transmission rate and data format selected for the instrument match those selected fro the computer. For details, refer to the following pages. Also make sure that the correct interface cable is used.

Connector and Signal Names

Numbers in the figure represent the Pin Nos.



RS-232-C Connector : DBSP-JB25S or equivalent

1	AA(GND : Protective Ground)	Grounded to the case of this instrument
2	BA(TXD : Transmitted Data)	Data transmitted to personal computer Signal direction: output
3	BB(RXD : Received Data)	Data received from personal computer Signal direction: input
4	CA(RTS : Request to Send)	Signal used to handshake when receiving data from personal computer Signal direction: output
5	CB(CTS : Clear to Send)	Signal used to handshake when transmitting data to personal computer Signal direction: input
6	CC(DSR : Data Set Ready)	Signal used to handshake when transmitting data to personal computer Signal direction: input
7	AB(GND : Signal Ground)	Ground for signals
20	CD(DTR : Data Terminal Ready)	Signal used to handshake when receiving data from personal computer Signal direction: output

Note

Pins 8 to 19 and 21 to 25 are not used.

Signal Direction

The figure below shows the direction of the signals used by the RS-232-C interface.

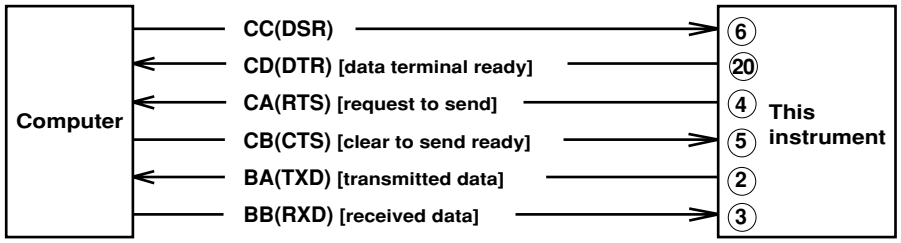


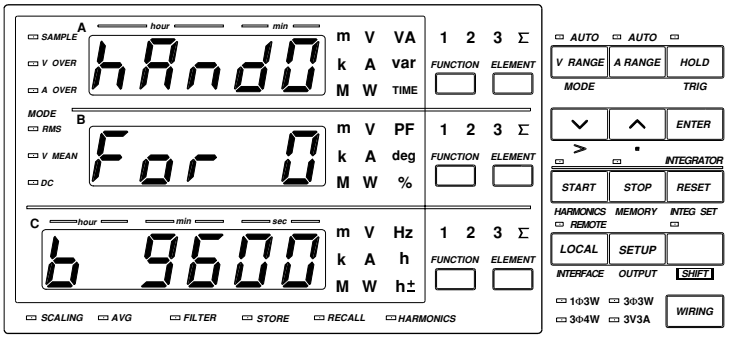
Table of RS-232-C Standard Signals and their JIS and CCITT Abbreviations

Pin No. (25-pin connector)	Abbreviations			Name
	RS-232-C	CCITT	JIS	
①	AA(GND)	101	FG	Protective ground
⑦	AB(GND)	102	SG	Signal ground
②	BA(TXD)	103	SD	Transmitted data
③	BB(RXD)	104	RD	Received data
④	CA(RTS)	105	RS	Request to send
⑤	CB(CTS)	106	CS	Clear to send
⑥	CC(DSR)	107	DR	Data set ready
⑳	CD(DTR)	108/2	ER	Data terminal ready
22	CE(RI)	125	CI	Ring indicator
8	CF(DCD)	109	CD	Data channel received carrier detect
21	CG(-)	110	SQD	Data signal quality detect
23	CH/CI(-)	111	SRS	Data signal rate select
24/15	DA/DB(TXC)	113/114	ST1/ST2	Transmitter signal element timing
17	DD(RXC)	115	RT	Receiver signal element timing
14	SBA(-)	118	BSD	Secondary transmitted data
16	SBB(-)	119	BRD	Secondary received data
19	SCA(-)	120	BRS	Secondary request to send
13	SCB(-)	121	BCS	Secondary clear to send
12	SCF(-)	122	BCD	Secondary received carrier detect

Circles indicate pins used for the RS-232-C interface of this instrument

12.3 Setting the Mode, Handshaking Method, Data Format and Baud Rate

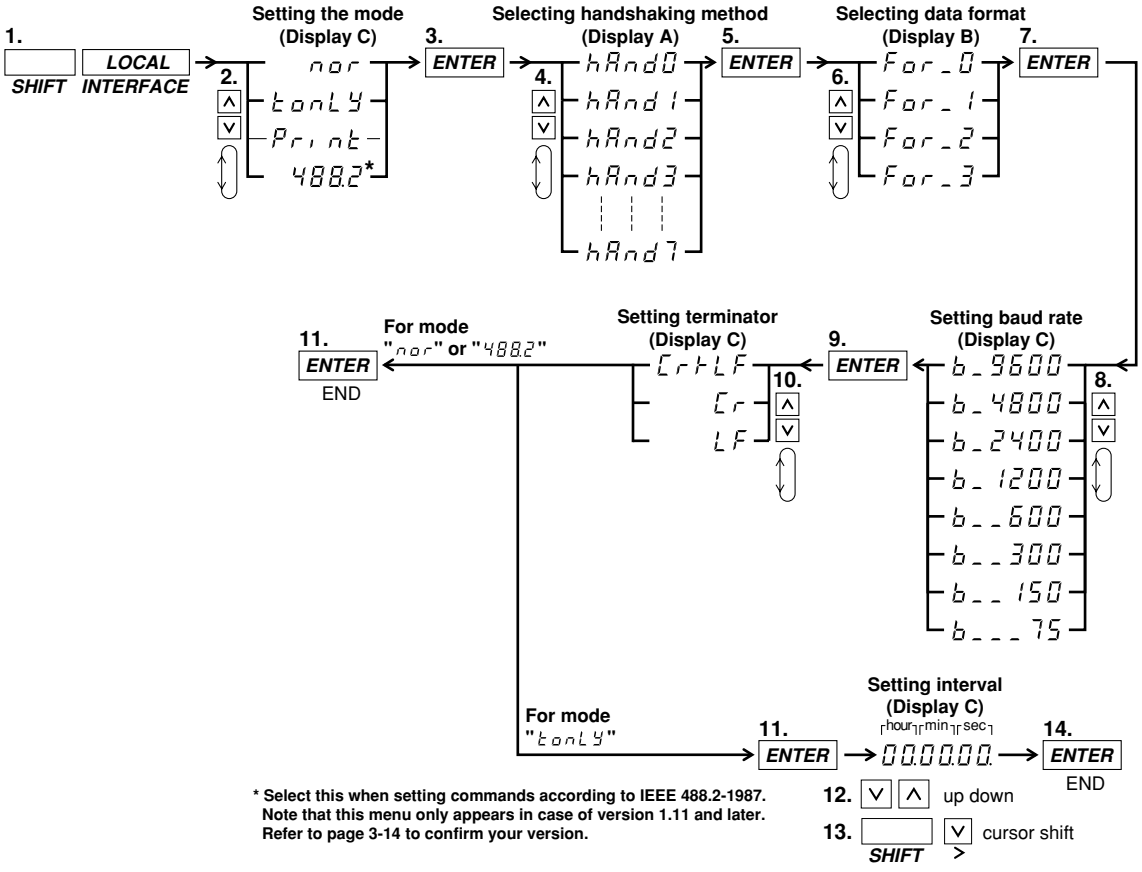
Relevant Keys



*Shows the operation panel of the WT130. For the differences between WT110 and WT130, refer to section 2.2, page 2-2, 2-3

Operating Procedure

- Perform operations following the thick line in the below menu.
- Press the ENTER key to confirm the selection or setting.
- When you want to leave the current menu during operation, press the key described under step 1. The confirmed settings made until that point will be kept.



* Select this when setting commands according to IEEE 488.2-1987. Note that this menu only appears in case of version 1.11 and later. Refer to page 3-14 to confirm your version.

Explanation

Mode Setting

Refer to page 12-1 for more details.

Handshaking

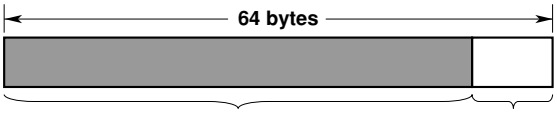
To use an RS-232-C interface to transfer data between this instrument and a computer, it is necessary to use certain procedures by mutual agreement to ensure the proper transfer of data. These procedures are called “handshaking”. Various handshaking systems are available depending on the computer to be used; the same handshaking system must be used for both computer and this instrument. This instrument allows you to choose any handshaking method from the following eight using the panel keys.

Handshaking method combinations (a circle indicates that the function is available)

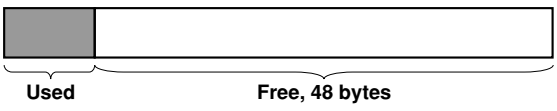
Mode selection no.	Data sending control (Control method when sending data to computer)				Data receiving control (Control method when receiving data from computer)			
	Software handshake	Hardware handshake		No handshake	Software handshake	Hardware handshake		No handshake
	Sending stops when X-off is received, and sending is resumed when X-on is received.	Sending stops when CB (CTS) is False, and sending is resumed when CB is True.	Sending stops when CC (DSR) is False,and sending is resumed when CC is True.		X-off is sent when received data buffer becomes 3/4-full, and X-on is sent when received data buffer becomes 1/4-full.	CD(DTR) is set to False when received data buffer becomes 3/4-full, and is set to True when received data buffer becomes 1/4-full.	CA(RTS) is set to False when received data buffer becomes 3/4-full, and is set to True when received data buffer becomes 1/4-full.	
0				o				o
1	o				o			
2	o					o		
3	o						o	
4		o				o		
5		o					o	
6			o			o		
7			o				o	

Precautions Regarding Data Receiving Control

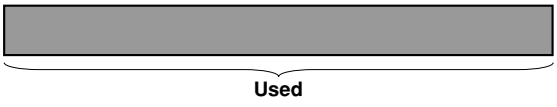
When handshaking is used to control received data, data may still be sent from the computer even if the free space in the receive buffer drops below 16 bytes. In this case, after the receive buffer becomes full, the excess data will be lost, whether handshaking is in use or not. Data storage to the buffer will start again when there is free space in the buffer.



When handshaking is in use,reception of data will stop when the free space in the buffer drops to 16 bytes since data cannot be passed to the main program fast enough to keep up with the transmission.



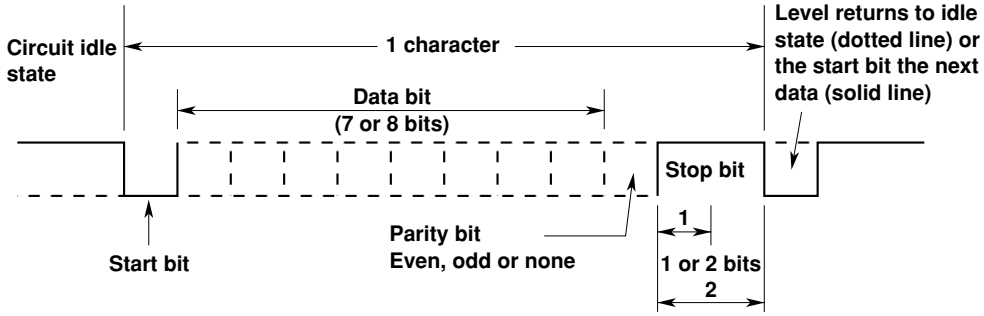
After reception of data stops, data continues to be passed to the internal program. Reception of data starts again when the free space in the buffer inceases to 48 bytes.



Whether handshaking is in use or not, if the buffer becomes full, any additional data received is no longer stored and is lost.

Data Format

The RS-232-C interface of this instrument performs communications using start-stop synchronization. In start-stop synchronization, one character is transmitted at a time. Each character consists of a start bit, data bits, a parity bit, and a stop bit. Refer to the figure below.



The table below shows the data format combinations supported.

Preset value	Start bit	Data length	Parity	Stop bit
0	1	8	No	1
1	1	7	Odd	1
2	1	7	Even	1
3	1	7	No	2

Baud Rate

The baud rate can be selected from 75, 150, 300, 600, 1200, 2400, 4800 or 9600.

About the Terminator

Data can be received with either "CR+LF" or "LF" terminator. For transmission terminator, you can select from "CR+LF," "LF," and "CR."

Interval

In case of the talk-only mode, this setting specifies the interval to send data.
Setting range : 00.00.00 (0hr 0min 0sec) to 99.59.59 (99 hrs 59min 59sec)
Initial value : 00.00.00

Note

The error code 390 may appear depending on the status of this instrument. In such a case, lower the baud rate.

12.4 Format and Commands of Output Data (before the IEEE488.2-1987 Standard)

Output Format

The format of output data is the same as for the GP-IB interface. Refer to page 11-4 for more details.

Commands

The commands used for the RS-232-C interface are identical to those used for the GP-IB interface, except for the following commands.

DL/DL?

Sets or inquires about output data terminator.

Syntax DLm <terminator>

"m" indicates terminator

m= 0 : CR + LF

1 : LF

2 : CR

Query DL?<terminator>

Example DL1

Note

If a value outside the setting range is set, an error code will appear.

The interface message function of the GP-IB interface is assigned to the following commands at the RS-232-C interface.

<ESC>S

Equivalent to GP-IB's serial poll function. Status byte is output when the S command is received following reception of the <ESC> code (1BH).

<ESC>R

Equivalent to GP-IB's remote/local control function. The instrument is placed in remote status and panel keys become invalid when the R command is received following reception of the <ESC> code (1BH). Press the LOCAL key to exit from the remote status.

<ESC>L

Equivalent to GP-IB's remote/local control function. When the instrument is in remote status, the instrument will be placed in local status when the L command is received following reception of the <ESC> code (1BH).

<ESC>C

Equivalent to GP-IB's device clear function. The communication devices of this instrument are initialized when the C command is received following reception of the <ESC> code (1BH).

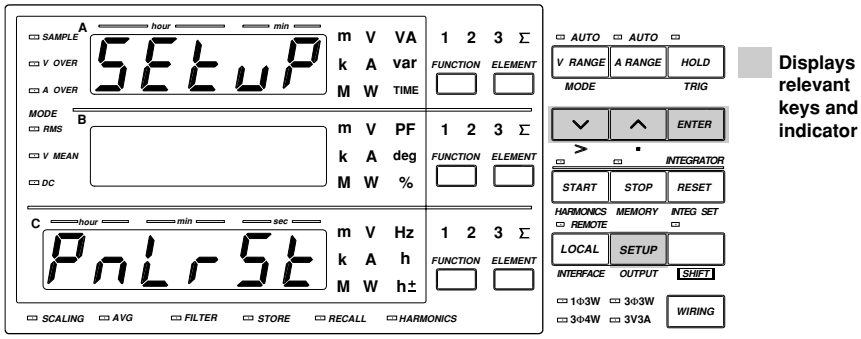
13.1 Back-up of Set-up Parameters

In order to protect set-up parameters in case of a power failure and such, this instrument is equipped with a lithium battery which protects these parameters. The following set-up parameters are being kept.

Wiring method
Voltage range
Current range
Measurement mode of voltage and current
Data hold
Filter ON/OFF
Scaling ON/OFF
PT/CT scaling value
External sensor scaling value
Averaging ON/OFF
Averaging type
Averaging sample number/attenuation constant
Computing Equation of MATH function (applies to WT110/WT130 with ROM version 2.01 or later)
Display function/element for each display
Integration mode
Integration timer preset time
Integration value
Integration elapsed time
Data stored in internal memory
Storage interval
Recalling interval
Output items for plotter/communication
Harmonic analysis ON/OFF (only when equipped with the harmonic analysis option)
PLL source (only when equipped with the harmonic analysis option)
D/A output items (only when equipped with the D/A output option)
D/A integration preset time (only when equipped with the D/A output option)
Comparator determination function (only when equipped with the comparator option)
Comparator determination limit value (only when equipped with the comparator option)
Communication output mode
Delimiter
Header
Output interval in case of talk-only
GP-IB address (when GP-IB is installed)
Handshaking method (when RS-232-C is installed)
Data format (when RS-232-C is installed)
Baud rate (when RS-232-C is installed)

13.2 Initializing Set-up Parameters

Relevant Keys

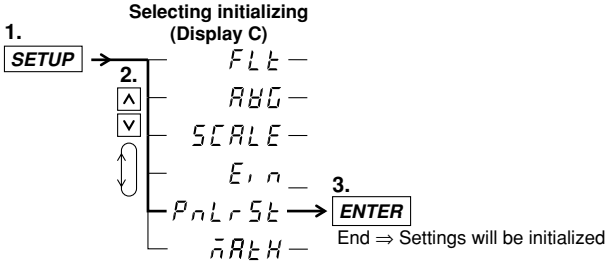


Displays relevant keys and indicator

***Shows the operation panel of the WT130. For the differences between WT110 and WT130, refer to section 2.2, page 2-2, 2-3**

Operating Procedure

- **Perform operations following the thick line in the below menu.**
- **Press the ENTER key to confirm the selection or setting.**
- **When you want to leave the current menu during operation, press the key described under step 1. The confirmed settings made until that point will be kept.**



Explanation

Initializing Set-up Parameters

Set-up parameters will be initialized as soon as the ENTER key is being pressed in the procedure described above. The initial settings are as follows.

Item	Initial setting
Display A	Display function: V, element: 1
Display B	Display function: A, element: 1
Display C	Display function: W, element: 1
Filter	OFF
Measurement range	Auto range
Measurement mode	RMS
Wiring method (only WT130)	1F3W
Hold	OFF
PC/CT scaling value	P: 1.000, C: 1.000, F: 1.000 scaling ON/OFF: OFF
External sensor scaling value	50.00A
Averaging	Averaging type: exponential, attenuation constant: 8 Averaging ON/OFF: OFF
MATH computing equation	WT110: Voltage crest factor WT130: Efficiency
Frequency	VHz
Integration	Reset condition, integration mode: manual Integration preset time: 0hr, 0min
Harmonic analysis (option)	PLL source: V1, harmonic distortion factor computation format: IEC, element: 1 Harmonic analysis function ON/OFF: OFF
Storage/recalling	Interval: 0hr 0min 0sec, storage/recalling ON/OFF: OFF
D/A output (option)	Output items: normal measurement items, integration preset time: 1hr, 0min
Comparator (option)	Mode: single, determination function: (V1, A1, P1, PF1) Limit value: refer to page 10-12, 10-13, display function ON/OFF: OFF
Data output	Communication, item: normal measurement setting
GP-IB	Addressable mode: A, address: 1, status byte:15, delimiter: 0
RS-232-C	Normal mode, handshaking mode: 0, format: 0, Baud rate: 9600, delimiter: 0, status byte: 15

Note

- Be careful since measurement data will be lost when initializing. However, measurement data or set-up parameters stored in the internal memory will be kept.
- "MATH computing equation" applies to WT110/WT130 with ROM version 2.01 or later.

14.1 Adjustments

When the measurement values are erroneous, adjust this instrument using the following procedures.

Required Equipments

AC Voltage/Current Standard (0.02%, 30 to 300V, 1 to 10A/60Hz)
  recommended: Yokogawa 9100
    or 2558 (if you want to carry out adjustments with an accuracy higher than the one 2558 is providing, fine adjust the output using the Digital Multi Meter (DMM) 1271)
DMM (0.5%)
  recommended: Yokogawa 7552

Adjusting

Preparations

• Preparing this instrument

1 Turn ON the power while pressing the SHIFT key. Release the SHIFT key after all LED's have lit up.
2 Press the ENTER key.
  "rAnGE" will appear on display C. Press the ∧ or ∨ key and the display will change to "Ein" (in case of the external input option), "dA" (in case of the D/A option) or "End". The "rAnGE" mode is for adjustments of voltages or currents, while the "dA" mode is for adjustments of the D/A output. This instrument has no need for adjustment of power.
3 Select "rAnGE" and press the ENTER key. Then let the instrument warm up for at least 30 minutes.

• Preparing the AC voltage/current standard and DMM

4 Allow a warm-up time of at least one hour for the AC voltage/current standard and, if necessary, DMM.

Operating Keys

The keys to be used for carrying out adjustments, are as follows.

ENTER : Press this key to confirm every adjustment of each range.
SHIFT : Returns to the previous screen when aborting adjustment. However, since the adjustments will not be displayed, turn the power OFF and ON again.
RESET : Returns to normal measurement. However, all adjusted data will become invalid.
A RANGE : Press this key to proceed to the following range without adjusting the current range. When adjusting the D/A output, press this key to move the new input value to the right.
V RANGE : Press this key to return to the previous range without adjusting the current range. When adjusting the D/A output, press this key to move the new input value to the left.

Adjusting the Voltage Range

1 Select "rAnGE" as described in the preparation above, press the ENTER key, and the display will become as follows.
  Display A rAnGE
  Display B 30.00V
  Display C displays measurement value for five seconds.
2 Connect the voltage output of the AC voltage/current standard to the voltage input terminal of this instrument. Connect the H terminal of the standard to the V terminal of this instrument, and connect the L terminal of the standard to the ± terminal of this instrument. In case of the WT130, bundle all V terminals together and bundle all ± terminals together.
3 Set the output voltage of the standard to 30.00V and output this voltage.

4 Press the ENTER key after the value on display C stabilizes. (Even in a stabilized condition, drifting within ± 2 digits limit may occur.)
5 Display B will change to “300.0” V.
6 Set the output voltage of the standard to 300.0V.
7 Press the ENTER key after the value on display C stabilizes. (Even in a stabilized condition, drifting within ± 2 digits limit may occur.)
8 Turn the output of the standard OFF.
This completes the adjustment of the voltage range. The current range will be adjusted next. If the current range is not to be adjusted, press the SHIFT key here.

Adjusting the Current Range

1 After having completed adjusting the 300V voltage range, display B will show “1.000” A.
2 Connect the current output of the AC voltage/current standard to the current input terminal of this instrument. Connect the H terminal of the standard to the A terminal of this instrument, and connect the L terminal of the standard to the ± terminal of this instrument. In case of the WT130, connect the current terminal of each input element horizontally. That is connect the H terminal of the standard to the A terminal of element 1, the ± terminal to the A terminal of element 2, the ± to the A terminal of element 3, followed by connecting the ± terminal to the L terminal of the standard.
3 Set the output of the standard to 1.000A and output this current.
4 Press the ENTER key after the value on display C stabilizes. (Even in a stabilized condition, drifting within ± 1 digit limit may occur.)
5 Display B will change to “10.00” A.
6 Set the output of the standard to 10.000A.
7 Press the ENTER key after the value on display C stabilizes. (Even in a stabilized condition, drifting within ± 1 digit limit may occur.)
8 Turn the output of the standard OFF.
9 Press the SHIFT key and display C will change to “rAnGE”. This completes the range adjustments. When you press the RESET key instead of the SHIFT key, the carried out adjustments will become invalid.

In case the External Input Option is installed (/EX1 or /EX2)

1 Select “Ein” in step 2 of Preparing this instrument (see previous page) and press the ENTER key.
2 Display B will change to “10.00” V (or “200.0” mV).
3 Connect the voltage output of the AC voltage/current standard to the voltage input terminal of this instrument. Connect the H terminal of the standard to the EXT terminal of this instrument, and connect the L terminal of the standard to the ± terminal of this instrument. In case of the WT130, bundle all EXT terminals together and bundle all ± terminals together.
4 Set the output voltage of the standard to 10.000V (or 200.00mV) and output this voltage.
5 Press the ENTER key after the value on display C stabilizes. (Even in a stabilized condition, drifting within ± 2 digits limit may occur.)
6 Press the SHIFT key and display C will change to “Ein”. This completes the external input adjustments. When you press the RESET key instead of the SHIFT key, the carried out adjustments will become invalid.

Note

The displayed value of the external input will become 50.000A by the rated range.

Adjusting the D/A Output

• Preparations

1 Connect the pin No. of the output connector corresponding to the channel to be adjusted to the H terminal of the DMM, and connect pin No. 12 and 24 of the output connector to the L terminal.
2 Set the range of the DMM to 20V.
3 After "dA" appears on display C (using the ∧ or ∨ key), press the ENTER key.

• Adjusting

After having carried out the above described preparations, the displays will show the following. Display A will be blinking.

display A: ch 1
display B: 5.000
display C: 5.0000

1 Select the channel to be adjusted on display A by pressing the ∧ or ∨ key, and then press the ENTER key. The head digit of display C will start blinking. From that point a voltage of approx. +5V will be output from the connector.
2 Press the V RANGE or A RANGE key to move the blinking digit of display C. Then, using the ∧ or ∨ key, adjust the blinking value to the value displayed at the DMM.
3 After having adjusted all digits of display C, press the ENTER key. "–5.000V" will appear on display C, and a voltage of approx. –5 V will be output from the connector.
4 Carry out step 2 once again.
5 After having adjusted all digits of display C, press the ENTER key.
6 Change the channel indication on display A from "ch1" to "ch2". Carry out steps 1 to 5 to adjust channel 2.
7 Carry out steps 1 to 5 to adjust all channels.
8 Press the SHIFT key and display C will change to "dA". This completes the D/A output adjustments. When you press the RESET key instead of the SHIFT key, the carried out adjustments will become invalid.

After Finishing Adjustments

After having finished all adjustments, turn the power OFF and ON again.

Communication Commands to Carry Out Adjustments

Command	Description
CAL1	Enters the range adjustment mode
CAL2	Enters the external input range adjustment mode
CAL3	Enters the D/A output adjustment mode
CAL0	Finishes adjustment (and returns to normal measurement mode)
CR0	Switches to 30V range in range adjustment mode
CR1	Switches to 300V range in range adjustment mode
CR2	Switches to 1A range in range adjustment mode
CR1	Switches to 10A range in range adjustment mode
CHm	Switches the channel in D/A output adjustment mode m = 1 to 12
CDm,n	Enters the actual output value in D/A output adjustment mode m = 1 to 12, n = actual output value
DO0	Outputs +5V in D/A output adjustment mode
DO1	Outputs –5V in D/A output adjustment mode
OD	Requests the output of measurement data, and sets the output format to normal measurement default
ENT	Corresponds to the ENTER key operation, confirming the adjustment value.
CAN	Corresponds to the RESET key operation, ignoringthe adjustments.
END	Corresponds to the SHIFT key operation, keeping the adjustments.

Note

- In case of D/A adjustment, change the channel using the CHm command, then carry out DO0 or DO1 command, and the request output using the CDm,n command. After the CDm,n command is being executed by +5V or –5V, make sure to confirm by the ENT command.
- After the display has been stabilized in the range adjustment mode or external input range adjustment mode, execute the ENT command.

14.2 Calibration

Required Equipment

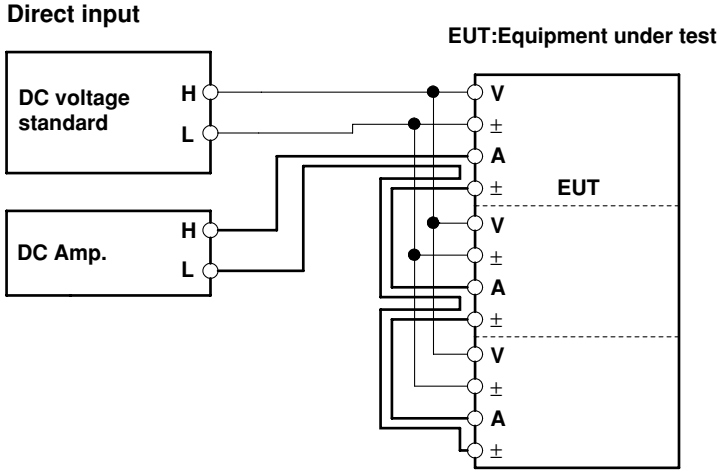
DC Voltage/Current Standard
    recommended: Yokogawa 2552, 2550
AC Voltage/Current Standard
    recommended: Yokogawa 2558
        or 9100 (up to 400Hz)
        or Fluke 5200A + 5215A or 5200A + 5220A
Digital Power Meter
    recommended: Yokogawa WT2000 or 2531
2ch Synchronizer
    recommended: Yokogawa FG120

Calibration of DC Voltage, Current and Power

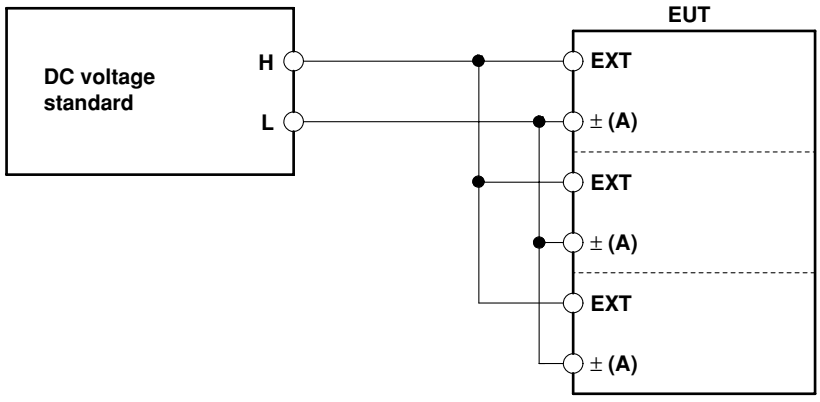
Wiring

Connect the DC voltage and DC current standard as follows. In case of the WT130, voltages are connected parallel, and currents in series.

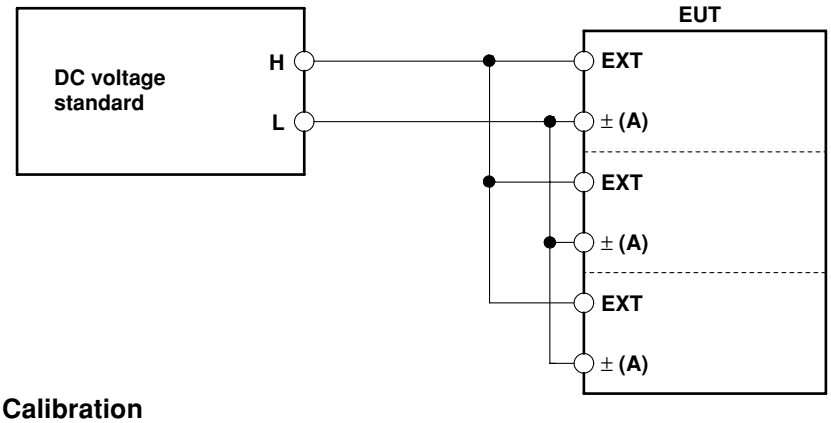
• Direct input



• External sensor input (equipped with option /EX1)



• External sensor input (equipped with option /EX2)



Calibration

Regarding the combination of voltage and current ranges, we recommend applying the following.

- Test the current ranges with the voltage range set to 150V;
- Test the voltage ranges with the current range set to 5A.

Of course testing can be carried out using other combinations as well.

1 Set the voltage or current range of this instrument to the testing range.
2 Set the output voltage of the DC voltage standard to the rated range value of this instrument, and output the voltage.
3 Set the output current of the DC current standard to the rated range value of this instrument, and output the current.
4 Fine adjust the output setting value of the voltage standard so that the voltage or current value displayed on this instrument shows the rated range.
5 Read the output voltage or current setting value of the voltage standard and treat this as the reference.
6 Verify that the power factor value displayed on this instrument shows the rated value. The product of the voltage setting value and the current setting value of the voltage standard is the calibrated power factor value.

Note

Before carrying out the calibration described above, verify that this instrument performs within its accuracy specifications.

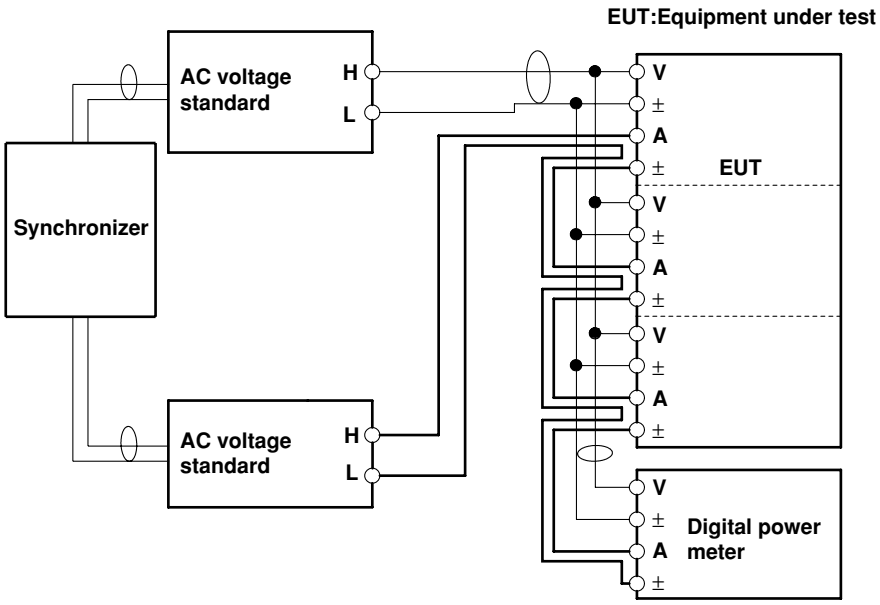
- Set the output of the DC voltage standard to the rated range of this instrument, read this voltage or current value on the display on this instrument and verify that this value lies within this instrument's accuracy.
- Set the output of the DC voltage standard to the rated range of this instrument, read the power factor value on the display on this instrument and verify that this value lies within this instrument's accuracy.

Calibration of AC Voltage, Current and Power

Wiring

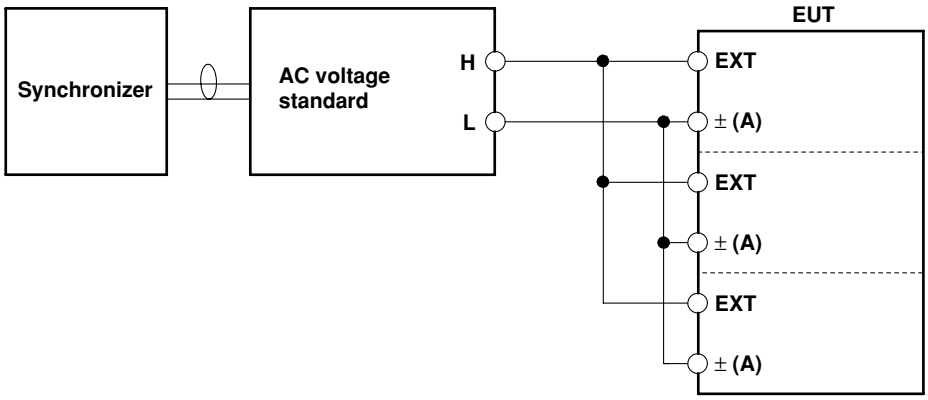
Connect the Digital Power meter, Synchronizer and the AC voltage and AC current standard as follows.

• **Direct input**

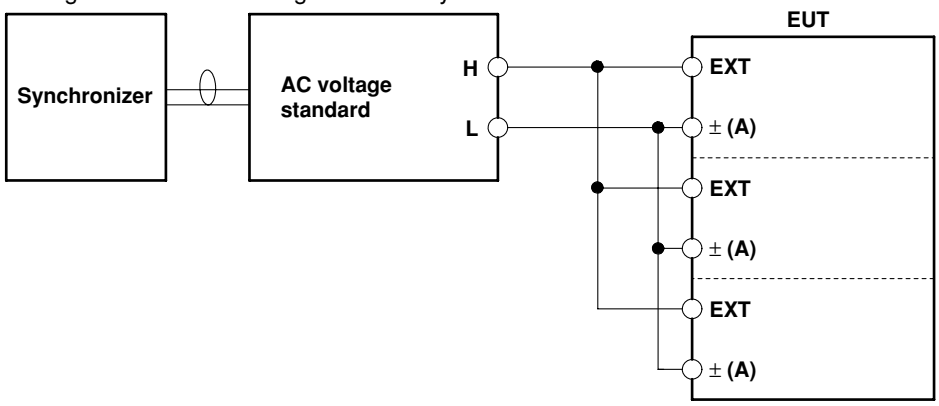


• **External sensor input (equipped with option /EX1)**

Change as follows for wiring currents only.



• **External sensor input (equipped with option /EX2)**
Change as follows for wiring currents only.



Preparation

Set the frequency of the AC voltage standard and of each channel of the synchronizer to 60Hz. Then, while not exceeding the maximum values of the external synchronization inputs of the voltage and current standard, rise the output level of the synchronizer until the standards are synchronized. Make sure that the phase angle between each channel of the synchronizer is 0 degrees.

Calibrating

1 Set the voltage or current range of this instrument to the range to be calibrated.
2 Set the output voltage of the AC voltage standard to the rated range of this instrument, and output the voltage.
3 Set the output current of the AC current standard to the rated range of this instrument, and output the current.
4 Fine adjust the output values of the standard so that the displayed voltage or current value on this instrument show the rated range.
5 Read the output voltage or current value, and keep it as a reference.
6 Verify that the displayed power value corresponds to the rated value. The product of the voltage value and the current value is the reference value of the power.

Note

- Before starting the above described calibration, verify that the accuracy of this instrument lies within the specifications.
  - Adjust the output of the standard to the rated range value of this instrument, then read the displayed voltage or current value on this instrument and verify that this value lies within the specifications.
  - Slightly change the phase angle of ch2 of the synchronizer (current signal) so that the displayed power value becomes the rated value. Then read the displayed power value on this instrument and verify that this value lies within the specifications (power factor = 1).
  - Change the phase of ch2 of the synchronizer so that the displayed power value becomes zero. Then read the displayed power value on this instrument and verify that this value lies within the specifications (power factor = 0).
- When calibrating the harmonic analysis, match the phase so that the displayed power value becomes the calibrated value.
- When calibrating using a frequency of more than 60Hz, set the same frequency for the synchronizer and the standard. In such a case, use a voltage/current standard which surely has a sufficient accuracy regarding the output frequency. This means to use measuring equipment with an accuracy of 3 to 4 times the specified higher accuracy of this instrument.

Calibration of D/A Output

Preparation

1 Connect the AC voltage standard to the voltage terminal of this instrument. The wiring method is the same as when adjustments are carried out (see page 14-3). However, calibration of the WT130 can also be carried out when only element 1 is connected.
2 Set the D/A output of this instrument to V1 for each channel.

Calibrating

1 Connect the DMM to ch1 of the output terminal in the same way as when carrying out adjustments.
2 Set the voltage range of this instrument to a suitable range.
3 Set the output voltage of the voltage standard so that positive rated values are generated.
4 Then read the value of the DMM and verify that this value lies within the specifications.
5 Connect the DMM to ch2 of D/A output and carry out steps 3 and 4. Repeat this for all D/A channels.
6 Set the output voltage of the voltage standard so that negative rated values are generated.
7 Repeat steps 4 and 5 and verify all channels.
8 Turn the output of the voltage standard OFF.

Verifying the Comparator Output Function

Preparation

1 Connect the voltage standard to the voltage terminal of this instrument.
2 Set the range of this instrument to 15V.
3 Set the comparator output to V1 for each channel.
4 Set the comparator setting value to 10V for each channel.

Calibrating

1 Set the output of the voltage standard so that the displayed value on this instrument becomes 9.99V, and output this voltage.
2 Measure the resistance values between all terminals of the comparator output (between NO and COM or between NC and COM) using the DMM. Verify that the resistance between NO and COM is at least 50MΩ, and that the resistance between NC and COM is at most 0.1Ω.
3 Set the output of the voltage standard so that the displayed value on this instrument becomes 10.01V, and output this voltage.
4 Measure the resistance values between all terminals of the comparator output (between NO and COM or between NC and COM) using the DMM. Verify that the resistance between NO and COM is at most 0.1Ω, and that the resistance between NC and COM is at least 50MΩ.
5 Turn the output of the voltage standard OFF.

Calibration of the Harmonic Analysis Function

Connection

Use the same instruments as in case of AC power measurement and connect them in the same way (refer to page 14-6 and 14-7).

Preparation

1 Set the voltage range of this instrument to 15V, and the current range to 1A.
2 Turn the harmonic analysis function ON.

Calibrating Currents

1 Set the ch1 of the synchronizer to 60Hz, ch 2 to 900Hz (15 times) and output these frequencies.
2 Set the frequency of the voltage standard to 60Hz, the output voltage to 15V and output the voltage.
3 Set the frequency of the current standard to 900Hz, the output current to 1A and output the current.
4 Set the displayed number on display A of this instrument to 15.
5 Set the display function of display B to A and verify that the displayed value lies within the specifications. In case of the WT130, verify each element 1, 2, and 3.
6 If required, change the ch2 setting of the synchronizer and the frequency of the current standard, and verify another number.
7 Turn the output of the voltage and current standard OFF.

Calibrating Voltages

1 Set the ch1 of the synchronizer to 900Hz (15 times), ch 2 to 60Hz and output these frequencies.
2 Set the frequency of the current standard to 60Hz, the output current to 1A and output the current.
3 Set the frequency of the voltage standard to 900Hz, the output voltage to 15V and output the voltage.
4 Set the displayed number on display A of this instrument to 15.
5 Set the display function of display B to V and verify that the displayed value lies within the specifications. In case of the WT130, verify each element 1, 2, and 3.
6 If required, change the ch1 setting of the synchronizer and the frequency of the current standard, and verify another number.
7 Turn the output of the voltage and current standard OFF.

Verification of Functions

Auto Range Operation

1 Set the voltage or current range of this instrument to Auto range. In case of no voltage or current input, the voltage range will become 15V, and the current range will become 0.5A automatically.
2 Press the V RANGE key to verify the 15V range and then press this key once more.
3 Press the A RANGE key to verify the 0.5A range and then press this key once more.
4 Connect the output terminal of the voltage standard (either AC or DC) to the voltage input terminal of this instrument, and connect the current standard to the current input terminal.
5 Set the output voltage of the voltage standard to 600V and output this voltage.
6 Verify that the display shows "——" as the measured voltage value for approx. 1.5 seconds and then changes to 600V.
7 Turn the output of the voltage standard OFF.
8 Set the output current of the current standard to 20A and output this current.
9 Verify that the display shows "——" as the measured current value for approx. 1.5 seconds and then changes to 20A.
10 Turn the output of the current standard OFF.

14.3 In Case of Malfunctioning

Check These Items First

If the instrument does not operate properly even if the actions given in the table below are performed, contact your nearest sales representative. Addresses may be found on the back cover of this manual. When contacting your representative, inform the ROM version No. which is displayed on display B on power-up.

Symptom	Items to check	Reference page
Nothing is displayed when the power is turned ON.	· Is the power cord properly connected to the power connector of this instrument and the AC outlet? · Is the input power voltage within the allowed range? · Has the fuse blown? (for WT130 only)	3-12,3-13 14-13
Displayed data is odd.	· Is there a possibility of noise? · Are measurement leads connected correctly? · Is the filter OFF? · Are the ambient temperature and humidity within the allowed range?	3-2,3-4, 3-5 to 3-11, 3-15,4-1, 4-3
Keys do not function properly.	· Is the REMOTE indicator LED off?	11-2
Instrument cannot be controlled via GP-IB interface.	· Does the GP-IB address specified in the program match the address set up in the instrument? · Does the interface meet the IEEE standard 488-1978 electrical and mechanical requirements?	11-1,11-9
Instrument cannot be controlled via the RS-232-C interface.	· Are the instrument and controller using the same communication settings?	12-1 to 12-3

14.4 Error Codes and Corrective Actions

Error Codes for Operation and Measurement

Error Code	Description	Corrective Action	Reference page
11	Received a command not used by this instrument.	Check for error in the command sent.	11-12
12	Parameter value specified is outside the allowed range.	Correct the value.	App. 2
13	Attempted to execute a key operation or received a communications command, while integration was running or was interrupted, that cannot be executed or received in such a state.	Check whether integration is in progress or is interrupted.	7-8, 11-12
14	Attempted to set auto range while external sensor range is selected.	It is not possible to set auto range while external sensor range is selected.	4-5
15	Attempted to execute a command or key operation that was protected.	Check whether the command or key operation is correct.	-
16	Attempted to execute a key operation or received a communications command, while harmonic analysis was being performed or was interrupted, that cannot be executed or received in such a state.	Check whether harmonic analysis is in progress or is interrupted.	8-5
17	Print output time-out.		10-18
18	No data to be printed or not in the printing mode.		10-17
19	Attempted to execute a key operation or received a communications command, while storing/recalling of data being performed.		-
30	Invalid file data.		-
31	File is damaged.		-
32	No data stored in the internal memory.	Store data in the internal memory or select the proper file to be stored.	Ch. 9
33	No space to store data in the internal memory.		9-2
41	· Attempted to start integration while there is an overflow condition. · Attempted to start integration after integration time has reached its preset value.	Reset integration.	7-5
42	Attempted to start integration while integration is in progress.		7-8
43	Measurement stopped due to overflow during integration or due to a power failure.		7-8
44	Attempted to stop integration even though integration was not in progress.		7-8
45	Attempted to reset integration even though integration was not in progress or integration mode was not selected.		7-6
46	Attempted to start integration while measurement of peak overflow was in progress or during an overrange condition.		2-4
47	Attempted to start integration in continuous integration mode when integration preset time was set to "0".	Set a correct preset time.	7-4
50	A/D conversion time-out.		-
51	Measurement data overflow occurred. "oL" is displayed.		2-4
52	Voltage peak overflow occurred. V OVER indicator lights up.		2-4
53	Current peak overflow occurred. A OVER indicator lights up.		2-4

54	Power factor exceeded "2" during measurement of power factor.		6-1
55	"PFErr" was displayed at the end of power factor computation during measurement of phase angle.		6-1, 6-2
56	Input level was too low or below measurement range during measurement of frequency. "Err-Lo" is displayed.		5-3
57	Measured frequency exceeded the measurement range. "Err-Hi" is displayed.		5-3
58	Computation overflow occurred. "oF" is displayed.		2-4
59	Harmonic analysis becomes "FrqEr".		8-2
390	Overrun error.	Lower the baud rate.	12-6

Error Codes regarding Self Diagnosis

Error Code	Description	Corrective Action
60	Data failure of set-up parameters backup. (set-up parameters are set to default)	-
61	EEPROM (element 1) failure.	Service is required.
62	EEPROM (element 2) failure.	Service is required
63	EEPROM (element 3) failure.	Service is required.
64	EEPROM (D/A board) failure.	Service is required.
65	A/D converter (element 1) failure.	Service is required.
66	A/D converter (element 2) failure.	Service is required.
67	A/D converter (element 3) failure.	Service is required.
68	Data file failure (measurement data, set-up parameter file failure)	File will be initialized automatically.
69	Lithium battery voltage drop.	Service is required.
71	DSP communications failure.	Service is required.
75	DSP1 program RAM failure.	Service is required.
76	DSP2 program RAM failure.	Service is required.
77	DSP3 program RAM failure.	Service is required.
79	ROM checksum error.	Service is required.
80	RAM read/write check error.	Service is required.
81	DSP1 data RAM error.	Service is required.
82	DSP2 data RAM error.	Service is required.
83	DSP3 data RAM error.	Service is required.
84	DSP1 sample clock failure.	Service is required.
85	DSP2 sample clock failure.	Service is required.
86	DSP3 sample clock failure.	Service is required.
90	Incorrect board combination.	Service is required.
91	Incorrect board combination.	Service is required.

14.5 Replacing the Fuse (for WT130)

When replacing the fuse of the WT130, carry out the procedure described below.

WARNING

- The fuse used must be of the specified rating (current, voltage, type) in order to prevent a fire hazard.
- Make sure to turn OFF the power switch and to unplug the power cord from its source before replacing the fuse.
- Never short-circuit the fuse holder.

Fuse Ratings

The fuse used in the WT130 has the following specifications.

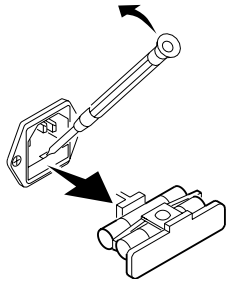
100V/200V Common

Maximum rated voltage : 250V
Maximum rate current : 0.5A
Type : Time-lag
Approved standard : UL/VDE
Parts number : A1346EF

Replacing Procedure

Replace the fuse as follows.

1 Turn the power switch OFF.
2 Unplug the power cord from the power connector.
3 Place the tip of a flat-blade screwdriver in to the slot of the fuse holder, and move the screwdriver in the direction of the arrow to remove the fuse holder.
4 Remove the blown fuse.
5 Insert a new fuse into the holder, then install the holder in place.



Note

The fuse used in the WT110 can not be replaced by the user, because of the fuse inside the case. If you believe the fuse is blown, please contact your nearest YOKOGAWA representative listed on the back cover of this manual. The ratings of the fuses used inside the case are indicated below.

Location	Max. rated voltage	Max. rated current	Type	Approved standard	Part No.
Main board	250 V	1 A	Time lag	UL/VDE	S9564VK

Chapter 15 Specifications

15.1 Input

Item	Voltage (V)	Current (A)
Input circuit type	Floating input	
	Resistive voltage divider	Shunt input
Rated inputs (range rms)	15/30/60/150/300/600V	Direct input: 0.5/1/2/5/10/20 A External input (optional): 2.5/5/10 V or 50/100/200 mV
Input impedance	Input resistance approx.2MΩ, Input capacitance approx.13 pF	Direct input: approx. 6 mΩ + approx. 0.1 μH External input: 2.5/5/10 V - approx. 100 kΩ; 50/100/200 mV - approx. 20 kΩ
Instantaneous maximum allowable input for 20 ms, 1 cycle	The peak is 2.8 kV or the RMS value is 2.0 kV, whichever is less.	The peak is 450 A or the RMS value is 300 A, whichever is less. External input: Peak value is 10 times the range or less.
Instantaneous maximum allowable input for 1 s	The peak is 2.0 kV or the RMS value is 1.5 kV, whichever is less.	The peak is 150 A or the RMS value is 40 A, whichever is less. External input: Peak value is 10 times the range or less.
Continuous maximum allowable input	The peak is 1.5 kV or the RMS value is 1.0 kV, whichever is less.	The peak is 100 A or the RMS value is 30 A, whichever is less. External input: Peak value is 5 times the range or less.
Continuous maximum common mode voltage (at 50/60 Hz)	600 Vrms (when the protective cover for the output connector is used)CAT II, 400 Vrms (when the protective cover for the output connector is removed)CAT II	
Common mode rejection ratio at 600 Vrms between input terminals and case	50/60 Hz, better than -80 dB (±0.01% of range maximum) Voltage input terminals : short, Current input terminals : open Reference value: 50 kHz max. ±{(maximum range rating)/(range rating) × 0.001 × f% of range} or less; 0.01% or more; the unit f: kHz	
Input terminals	Binding posts	Direct input: Large binding posts, External input: Safety terminals
A/D conversion	Simultaneous sampling of voltage and current inputs; Resolution: 12 bits; Maximum conversion rate: approx. 22μs (approx. 45 kHz)	
Range switching	Range can be selected manually, automatically or by communication control.	
Automatic range switching	Range up: When the measured value exceeds 110% of the rated range or the peak value exceeds approximately 300% of the rated range Range down: When the measured value becomes less than 30% of the rated range and the peak value is less than approximately 300% of the subordinate range	
Measurement mode switching	The following modes can be set manually or by communication control: RMS: True RMS measurement for both voltage and current; V MEAN: Rectified Mean Calibrated to an RMS sine wave measurement for voltage, and true RMS measurement for current; DC: Mean value measurement for voltage and current	

15.2 Measurement Functions

Item	Voltage/current	Effective power
Method	Digital sampling method, summation averaging method	
Frequency range	DC, 10 Hz to 50 kHz	
Crest factor	"3" at rated input	
Display accuracy Accuracy (within 3 months after calibration) (Conditions) Temperature: 23 ±5°C Humidity: 30% to 75% R.H. Supply voltage: Specified Voltage ±5% Input waveform: Sine wave Common mode voltage: 0 V DC Filter: ON at 200 Hz or less Scaling: OFF This accuracy are guaranteed by YOKOGAWA calibration system. Note: The unit f in accuracy expressions is kHz.	DC : ±(0.2 % of rdg + 0.2% of rng)* 10Hz ≤ f < 45Hz : ±(0.3% of rdg + 0.2% of rng) 45Hz ≤ f ≤ 66Hz : ±(0.15% of rdg + 0.1% of rng) 66Hz < f ≤ 1kHz : ±(0.3% of rdg + 0.2% of rng) 1kHz < f ≤ 10kHz : ±(0.2% of rdg + 0.3% of rng) ±{(0.05 × f)% of rdg} 10kHz < f ≤ 20kHz : ±(0.5% of rdg + 0.5% of rng) ±[{0.15 × (f-10)}% of rdg] Reference value 20kHz < f ≤ 50kHz : ±(0.5% of rdg + 0.5% of rng) ±[{0.15 × (f-10)}% of rdg] * DC: ±0.2% of range is added if the 0.5/1 A range is selected.	DC : ±(0.3% of rdg + 0.3% of rng)* 10Hz ≤ f < 45Hz : ±(0.5% of rdg + 0.3% of rng) 45Hz ≤ f ≤ 66Hz : ±(0.25% of rdg + 0.1% of rng) 66Hz < f ≤ 1kHz : ±(0.5% of rdg + 0.3% of rng) 1kHz < f ≤ 10kHz : ±(0.3% of rdg + 0.5% of rng) ±{(0.08 × f)% of rdg} 10kHz < f ≤ 20kHz : ±(0.8% of rdg + 0.8% of rng) ±[{0.19 × (f-10)}% of rdg] Reference value 20kHz < f ≤ 50kHz : ±(0.8% of rdg + 0.8 % of rng) ±[{0.25 × (f-10)}% of rdg] * DC: ±0.2% of range is added if the 0.5/1 A range is selected.
Effect of power factor Note: The φ is the phase angle between the voltage and current, and the f is frequency.	———	cosφ = 0 45 Hz ≤ f ≤ 66 Hz:add ±0.25% of range Reference data (up to 50kHz): add ±{(0.23 + 0.4 × fkHz)% of range} 1 > cosφ > 0 add the product of tanφ and the effect on cosφ = 0.
Effective input range	With the input range at 10% to 110%, the above specified accuracy is valid. With the input range at 110% to 130%, the above specified reading accuracy increased 0.5 times is added to the accuracy.	
Accuracy (within 12 months after calibration)	The above specified reading accuracy increased 0.5 times is added to the accuracy (within 3 months after calibration).	
Temperature coefficient	±0.03% of range/°C at 5 to 18°C, 28 to 40°C	
Display update rate	4 times/s	

15.3 Frequency Measurement

Input: V1, V2, V3, A1, A2, A3
Operating principle: Reciprocal counting method
Frequency ranges: 10 Hz to 50 kHz
Accuracy: ±(0.1% of rdg + 1 digit)
Minimum input is more than 30% of rated range.
When an input frequency is less than 200Hz, FILTER must be ON to obtain the specification accuracy.
Minimum input frequency is more than 20% of frequency measurement range.

15.4 Communication

Communication Specifications (GP-IB & RS-232-C)
GP-IB:
Electrical specifications: IEEE St'd 488.2-1987
Mechanical specifications: IEEE St'd 488.2-1987
Interface function: SH1, AH1, T5, L4, SR1, RL1, PP0, DC1,DT1, C0
RS-232-C:
Transmission mode: Start stop synchronization
Baud rate: 75, 150, 300, 600, 1200, 2400, 4800, 9600 bps

15.5 Computing Functions

		Effective Power (W)	Apparent Power (VA)	Reactive Power (var)	Power Factor (PF)	Phase Angle (deg)
Computation	1-phase 2-wire	W	$VA=V\times A$	$\sqrt{(VA)^2-W^2}$	$\frac{W}{VA}$	$=\cos^{-1}(\frac{W}{VA})$
	1-phase 3-wire	W_i $_{i=1, 3}$ $\Sigma W=W_1+W_3$	$VA_i=V_i\times A_i$ $_{i=1, 3}$ $\Sigma VA=VA_1+VA_3$	$var_i=\sqrt{(VA_i)^2-W_i^2}$ $_{i=1, 3}$ $\Sigma var=var_1+var_3$	$PF_i=\frac{W_i}{VA_i}$ $_{i=1, 3}$ $\Sigma PF=\frac{\Sigma W}{\Sigma VA}$	$\varphi_i=\cos^{-1}(\frac{W_i}{VA_i})$ $_{i=1, 3}$ $\Sigma\varphi=\cos^{-1}(\frac{\Sigma W}{\Sigma VA})$
	3-phase 3-wire (two power meter method)	W_i $_{i=1, 3}$ $\Sigma W=W_1+W_3$	$VA_i=V_i\times A_i$ $_{i=1, 3}$ $\Sigma VA=\frac{\sqrt{3}}{2}(VA_1+VA_3)$	$var_i=\sqrt{(VA_i)^2-W_i^2}$ $_{i=1, 3}$ $\Sigma var=var_1+var_3$	$PF_i=\frac{W_i}{VA_i}$ $_{i=1, 3}$ $\Sigma PF=\frac{\Sigma W}{\Sigma VA}$	$\varphi_i=\cos^{-1}(\frac{W_i}{VA_i})$ $_{i=1, 3}$ $\Sigma\varphi=\cos^{-1}(\frac{\Sigma W}{\Sigma VA})$
	3-phase 3-wire (three power meter method)	W_i $_{i=1,2,3}$ $\Sigma W=W_1+W_3$	$VA_i=V_i\times A_i$ $_{i=1,2,3}$ $\Sigma VA=\frac{\sqrt{3}}{3}(VA_1+VA_2+VA_3)$	$var_i=\sqrt{(VA_i)^2-W_i^2}$ $_{i=1,2,3}$ $\Sigma var=var_1+var_3$	$PF_i=\frac{W_i}{VA_i}$ $_{i=1,2,3}$ $\Sigma PF=\frac{\Sigma W}{\Sigma VA}$	$\varphi_i=\cos^{-1}(\frac{W_i}{VA_i})$ $_{i=1,2,3}$ $\Sigma\varphi=\cos^{-1}(\frac{\Sigma W}{\Sigma VA})$
	3-phase 4-wire	W_i $_{i=1,2,3}$ $\Sigma W=W_1+W_2+W_3$	$VA_i=V_i\times A_i$ $_{i=1,2,3}$ $\Sigma VA=VA_1+VA_2+VA_3$	$var_i=\sqrt{(VA_i)^2-W_i^2}$ $_{i=1,2,3}$ $\Sigma var=var_1+var_2+var_3$	$PF_i=\frac{W_i}{VA_i}$ $_{i=1,2,3}$ $\Sigma PF=\frac{\Sigma W}{\Sigma VA}$	$\varphi_i=\cos^{-1}(\frac{W_i}{VA_i})$ $_{i=1,2,3}$ $\Sigma\varphi=\cos^{-1}(\frac{\Sigma W}{\Sigma VA})$
Computating Range		Depends on the selected V and A ranges	Depends on the selected V and A ranges	Same as apparent power (var ≤ 0)	-1 to 0 to 1	-180 to 0 to 180
Display resolution		10000	10000	10000	±1.000	±180.0
Computing accuracy (for the value operated from the measured value)		—	±0.005% of VA range	±0.005% of var range	±0.0005	Resolution (power factor ±0.0005)

Note 1: The apparent power (VA), reactive power (var), power factor (PF), and phase angle (deg) measurements in this instrument are computed digitally from the voltage, current and effective power. If the input is non-sinusoidal, the measured values may differ from those obtained with instruments employing different measurement principles.

Note 2: When the current or voltage is less than 0.5% of the range, the VA and var will be displayed as 0, and PF/deg will be displayed as an error.

Note 3: The Lead and Lag are displayed for V and A input at 50% or more. The detected lead/lag accuracy is ±5 degrees over the frequency range of 20 Hz to 2 kHz.

15.6 Display Functions

Display type: 7-segment LED
Number of displays: 3

DISPLAY	Displayed Value	Maximum Reading
A	V, A, W, VA, var (each element), elapsed integration time	V, A, W : 9999
B	V, A, W, PF, deg (each element), % (contents ratio in %, THD)	Wh, Ah : 999999
C	V, A, W, V · AHz, ±Wh, ±Ah (each element) Vpk*, Apk*, MATH*	V, AHz : 9999

* Vpk, Apk, and MATH are supported only for ROM versions 2.01 or later.

Unit: m, k, M, V, A, W, VA, var, Hz, h±, deg, %
Display update rate: 4 times/s
Response time: Approximately 0.5 s (time for displayed value to settle within accuracy specifications of final value after step change from 0% to 100% or 100% to 0% of rated range)
Display scaling function: Significant digits: Selected automatically according to significant digits in the voltage and current ranges
Reassign ratio: 0.001 to 1000
Averaging function: The following two algorithms can be selected:
Exponential averaging
Moving averaging
Response can be set; for exponential averaging, the attenuation constant can be selected and for moving averaging, the number of averages (N) can be set to 8, 16, 32, or 64.
Peak over range display: The alarm LED will light up when the RMS value is greater than 140% of the range or the peak value is greater than 300% of the range.

15.7 Integrator Function

Display resolution: Depending on elapsed time value, the resolution will be changed.
Maximum display: –99999 to 999999 MWh (or MAh)
Modes: Standard integration mode (timer mode)
Continuous integration mode (repeat mode)
Manual integration mode
Timer: When the timer is set, integration will be stopped automatically.
Setting range: 000 h:00 min to 999 h:59 min (000 h:00 min will be shown when manual integration mode is selected automatically.)
Count overflow: If the integration count flows above 999999 MWh (or MAh) or below –99999 MWh (or MAh), integration stops and the elapsed time is held on the display.
Accuracy: ±(display accuracy + 0.2% of rdg) However, only when the input signal is continuous.
Timer accuracy: ±0.02%
Remote control: Start, stop, and reset can be remotely controlled by external contact signals.
However, the /DA4 or /DA12 options must be installed.

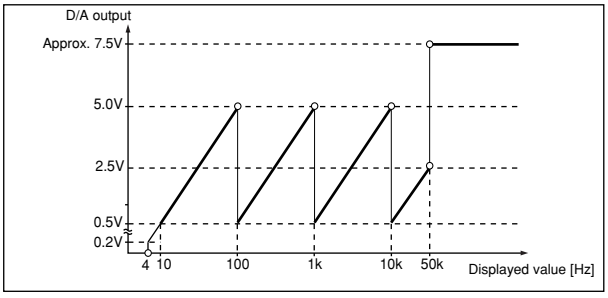
15.8 Internal Memory Function

Measurement data
Number of data that can be stored:
WT110 (253401): 600 blocks
WT130 (253502): 300 blocks
WT130 (253503): 200 blocks
Each block has following data:
measurement setting mode, measurement ranges, V, A, W, Wh+, Wh-, Ah+, Ah-, elapsed time and frequency
Writing intervals: 250 ms and 1 s to 99 h: 59 min: 59 s
Reading intervals: 250 ms and 1 s to 99 h: 59 min: 59 s (both intervals can be set on a second basis)
Panel setup information: Four-pattern information can be written/read.

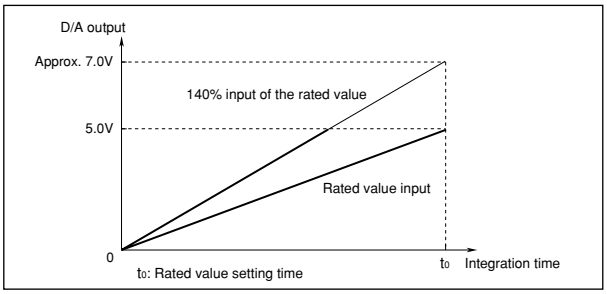
15.9 D/A Converter (optional)

Output voltage: ±5 VDC FS (approximately ±7.5 V maximum) at rated value or range Number of output channels: 12 when the /DA12 option is installed; 4 when the /DA4 option is installed
Output data selection: Can be selected for each channel.
Accuracy: ±(Display accuracy + 0.2% of range)
Update rate: Identical to display update interval
Temperature coefficient: ±0.05% of f.s./ °C

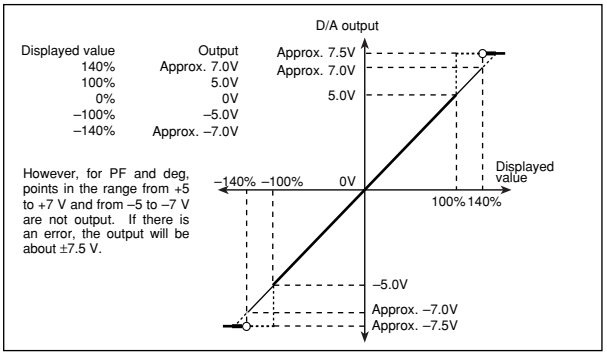
• Frequency



• Integration



• Other items



15.10 External Input (optional)

Either /EX1 or /EX2 can be selected as a voltage-output-type current sensor.
/EX1: 2.5/5/10 V
/EX2: 50/100/200 mV
Specifications: Refer to item “Input.”

15.11 Comparator Output (optional)

Output method: Normally open and normally closed relay contact outputs (one pair)
Number of output channels and channel setup: 4 (Can be set for each channel.)
Contact capacity: 24 V/0.5 A
D/A output (4 channels): Refer to item “D/A Output (Optional).”

15.12 External Control and Input Signals (in combination with the D/A converter and comparator options)

External Control and Input/Output signals
EXT-HOLD, EXT-TRIG, EXT-START, EXT-STOP, EXT-RESET, INTEG-BUSY
(However, the /DA4 or /DA12 options must be installed. Only EXT-HOLD and EXT-TRIG are available if the /CMP option is installed.)
Input level:-
TTL negative pulse

15.13 General Specifications

Warm-up time: Approx. 30 min.
Ambient temperature and humidity range: 5 to 40°C, 20% to 80% R.H. (no condensation)
Operating altitude: 2000m or below
Insulation resistance:
Between voltage input terminals and case
Between current input terminals and output terminals
Between voltage input terminals and current input terminals
Between voltage input terminals of each element
Between current input terminals of each element
Between voltage input terminals and power plug
Between current input terminals and power plug
Between case and power plug
Above: 50 MW or more at 500 V DC
Withstanding voltage:
Between voltage input terminals and case
Between current input terminals and output terminals
Between voltage input terminals and current input terminals
Between voltage input terminals of each element
Between current input terminals of each element
Between voltage input terminals and power plug
Between current input terminals and power plug
Above: AC 3700 V for 1 minute at 50/60 Hz
Between case and power plug: AC 1500 V for 1 minute at 50/60 Hz
Power supply: Any power supply voltage between 100 and 240 V; frequency: 50/60 Hz
Vibration test condition:
Sweep test - Frequency: 8 to 150 Hz sweep, all 3 directions for 1 minute
Endurance test - Frequency: 16.7 Hz, all 3 directions; amplitude of 4 mm for 2 h
Impact condition:
Impact test: Acceleration at 490 m/s², all 3 directions
Free-fall test - Height: 100 mm, 1 time for each 4 sides
Power consumption:
WT110: 30 VA maximum; WT130: 50 VA maximum (Power supply : 240V)
WT110: 20 VA maximum; WT130: 32 VA maximum (Power supply : 100V)
External dimensions:
WT110: Approx. W × H × D : 213 × 88 × 350 (mm), 8-3/8 × 3-1/2 × 13-3/4 (inch)
WT130: Approx. W × H × D : 213 × 132 × 350 (mm), 8-3/8 × 5-3/16 × 13-3/4 (inch)
Weight:
WT110: Approx. 3.0 (kg), 6.6 (lbs)
WT130: Approx. 5.0 (kg), 11.0 (Lbs)
Accessories:
Power cord: UL/CSA, VDE, SAA or BS standard 1 pc
Spare fuse (for WT130 only)
24-pin connector
User’s Manual
Rubber feed
Emission*
Complying Standard:EN55011-Group1, Class A
This is a Class A product for industrial environment. In a domestic environment, this product may cause radio interference in which cause the user may be required to take adequate measures.
Cable Condition:
Measuring Input
WT100
To bundle the wires between source and load with Ferrite Core (A1179MN).
WT130
To bundle the wires between source and load for each phase and to separate the input signal wires by less than 50 mm between each phase and neutral line.
External Senser Input (installed /EX1 or /EX2 option)
500 mm max
External Input/Output Signals (installed /DA4, /DA12, /CMP option)
To use shielded wires
Immunity*
Complying Standard: EN50082-2:1995
Susceptibility Under Immunity Condition
Measuring Input : ±5 % of range max
DA Output : ±40 % of range max
Testing Condition
Voltage : range 150 V Input, 100 V/50 Hz
Current : range 1 A Input, 1 A/50 Hz
Safety standard*
Complying Standard :EN61010
Overvoltage Category II
Pollution degree 2

* Applies to products manufactured after Jan. 1997 having the CE Mark. For all other products, please contact your nearest YOKOGAWA representative as listed on the back cover of this manual.

15.14 Total Harmonic Analysis Function (optional)

Method: synchronization to the fundamental frequency by using a phase locked loop (PLL) circuit
Frequency range: Fundamental frequency between 40 Hz and 440 Hz
Maximum reading: 9999
Items to be analyzed: V1, V2, V3, A1, A2, A3, W1, W2, W3, deg1, deg2, deg3
Each harmonic components, Total Vrms, Total Arms, Total effective power, PF of the fundamental, Phase-angle of fundamental, For each harmonic phase-angle related to the fundamental, Total harmonic distortion ratio in %, and contents ratio in %.
However, a simultaneous analysis can be made for a specified input module.
Sampling speed/method:
The sampling speed depends on the fundamental frequency to be input:

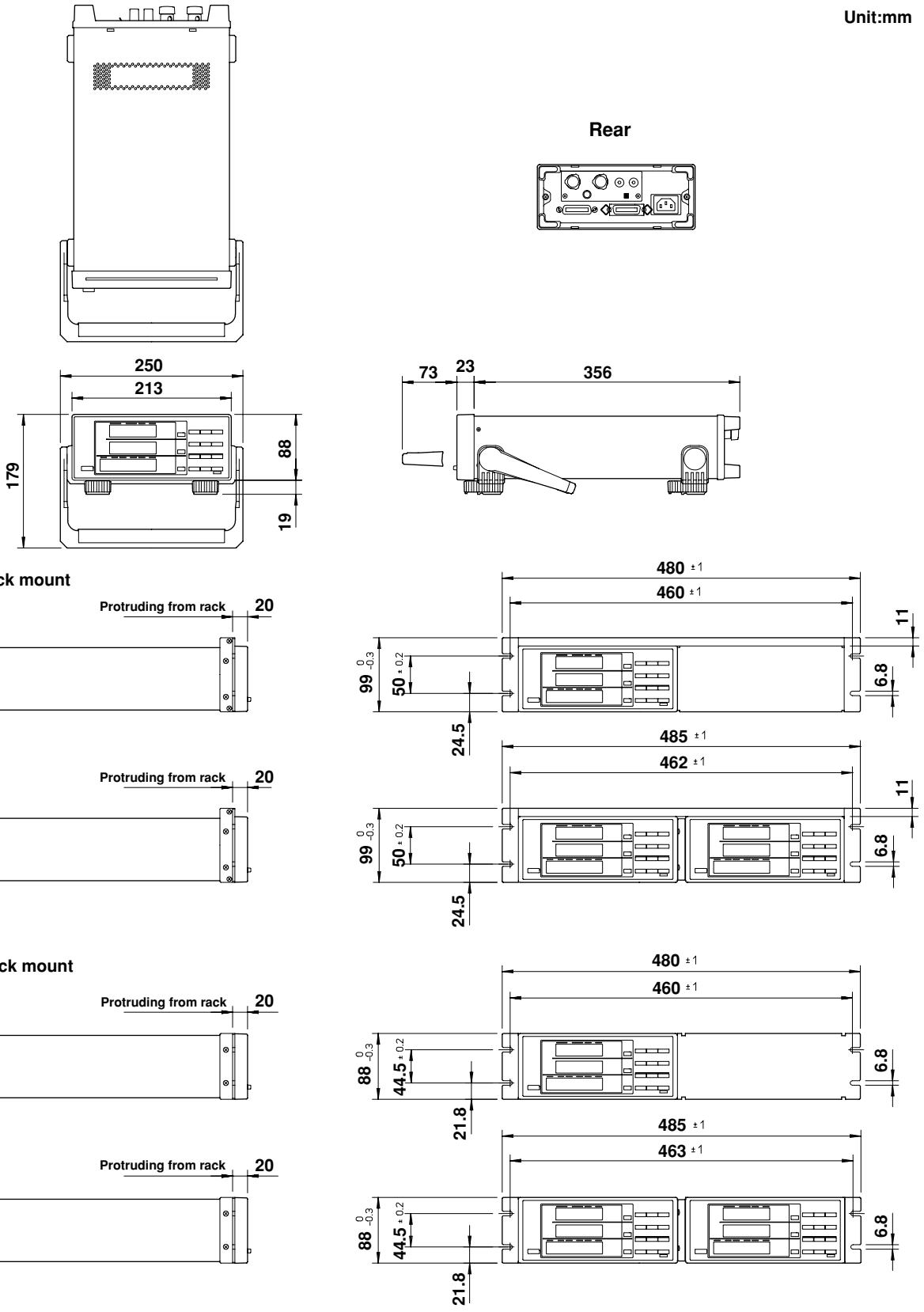
Input frequency range	Sampling frequency	Window up to the n'th harmonic	Order
40≤f<70Hz	f×512Hz	1 period of f	50
70≤f<130Hz	f×256Hz	2 period of f	50
130≤f<250Hz	f×128Hz	4 period of f	50
250≤f<440Hz	f×64Hz	8 period of f	30

FFT number of points : 512 points FFT
FFT calculation accuracy: 32 bits
Window: Rectangular window
Display update interval: Approx. 3 s
Accuracy: ±0.2% of range is added to the normal display accuracy.

15.15 External Dimensions

WT110(253401)

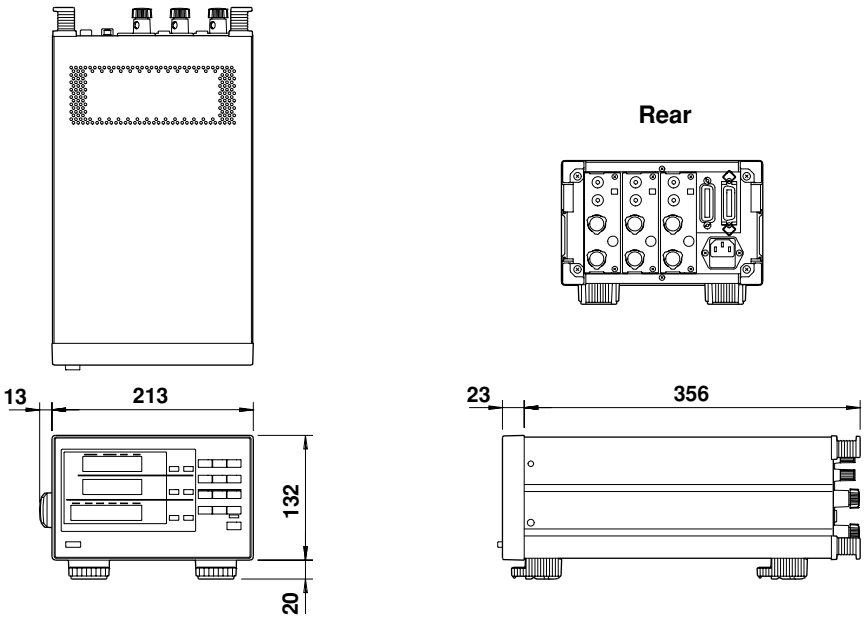
Unit:mm



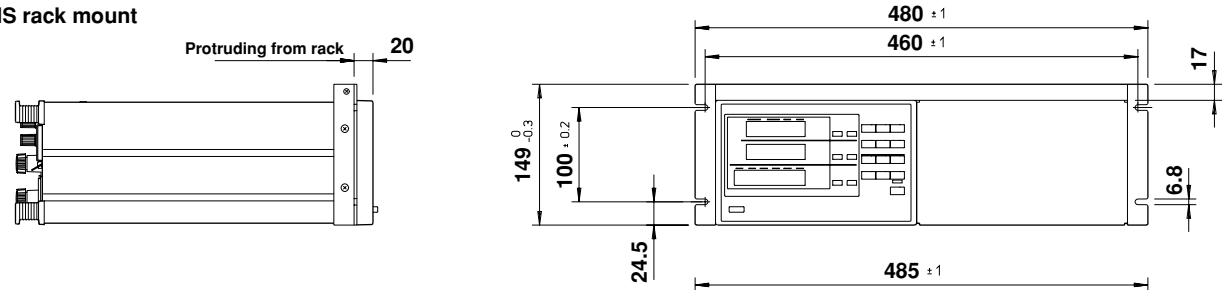
Unless other wise specified, tolerance is ±3% (However, tolerance is ±0.3mm when below 10mm)

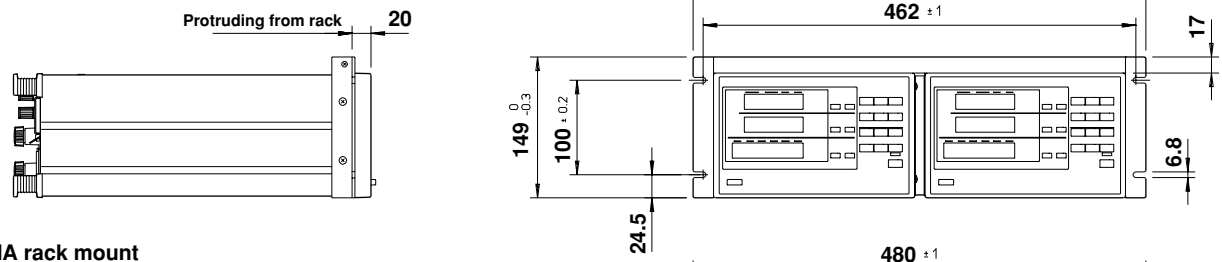
WT130(253502, 253503)

Unit:mm

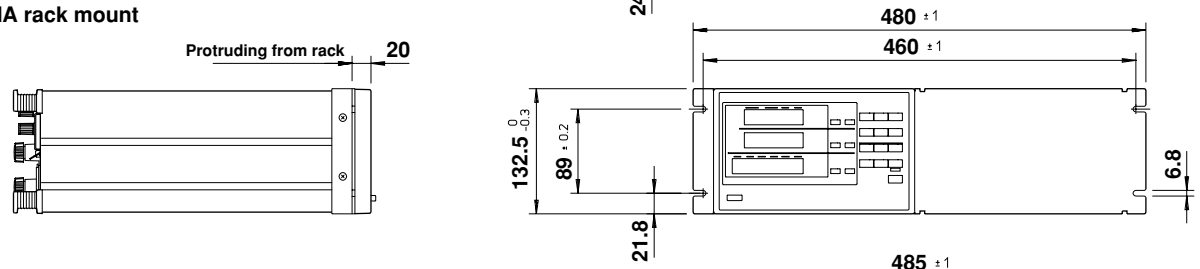


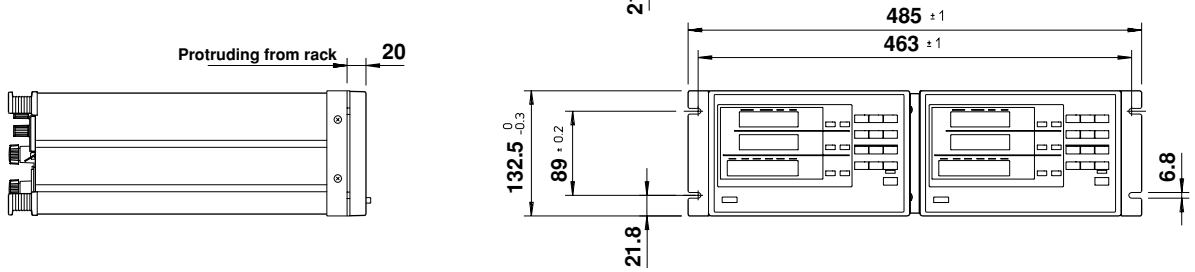
JIS rack mount





EIA rack mount





Unless other wise specified, tolerance is ±3% (However, tolerance is ±0.3mm when below 10mm)

Appendix 1.1 Commands

AA/AA? **Sets the current auto range ON or OFF/ inquires about the current setting.**

Syntax AAm <terminator>
"m" indicates auto range ON/OFF
m=0 :auto range OFF (fixed range)
1 :auto range ON
Query AA? <terminator>
Example AA0
Description
- Parameter error 12 will occur if "m" is set to an illegal value.
- Auto range is not allowed while integration is in progress; execution error 13 will occur.
- If the range is changed during auto range mode, manual range mode will be validated instead of auto range mode.
- If integration is started during auto range mode, auto range mode will be invalidated.
- Auto range mode is not allowed if the external sensor range is selected; execution error 14 will occur.
- While recalling is in progress, execution error 19 will occur.

AC/AC? **Sets attenuation constant/inquires about the current setting. The constant set is used as the attenuation constant for exponential averaging, or as the number of data for moving averaging.**

Syntax ACm <terminator>
"m" indicates attenuation constant
m=1 :8
2 :16
3 :32
4 :64
5 :128
8 :256
Query AC? <terminator>
Example AC1
Description
- Parameter error 12 will occur if "m" is set to an illegal value.
- While recalling or storing is in progress, execution error 19 will occur.

AG/AG? **Determines whether or not averaging should be performed/inquires about the current setting.**

Syntax AGm <terminator>
"m" indicates if averaging is ON or OFF
m=0 :OFF
1 :ON
Query AG? <terminator>
Example AG1
Description
- Parameter error 12 will occur if "m" is set to an illegal value.
- Averaging cannot be set to ON while integration is in progress; Error 13 will occur.
- While recalling or storing is in progress, execution error 19 will occur.

AT/AT? **Sets averaging type (exponential or moving)/inquires about the current setting.**

Syntax ATm <terminator>
"m" indicates averaging type
m=0 :Exponential averaging
1 :Moving averaging
Query AT? <terminator>
Example AT1
Description
- Parameter error 12 will occur if "m" is set to an illegal value.
- While recalling or storing is in progress, execution error 19 will occur.

AV/AV? **Sets the voltage auto range ON or OFF/ inquires about the voltage setting**

Syntax AVm <terminator>
"m" indicates auto range ON/OFF
m=0 :auto range OFF (fixed range)
1 :auto range ON
Query AV? <terminator>
Example AV0
Description
- Auto range is not allowed while integration is in progress; execution error 13 will occur.
- If the range is changed during auto range mode, manual range mode will be validated instead of auto range mode.
- If integration is started during auto range mode, auto range mode will be invalidated.
- While recalling is in progress, execution error 19 will occur.

CM/CM? **Selects WT110/130 scaling values simultaneously or individual setting command group, or 2533E setting command group for command data which come after this command/inquires about the current setting.**

Syntax CMm <terminator>
"m" indicates command group used.
m=0 :WT110/130 command/output format group (scaling value simultaneous setting command group)
1 :command/output format group by element (scaling value individual setting command group)
2 :2533E command/output group
Query CM? <terminator>
Example CM1
Description
- Parameter error 12 will occur if "m" is set to an illegal value.
- The output format of the WT110/130 is the same for m=0 or 1.

DA/DA? **Sets the function for display A/inquires about the current setting.**

Syntax DAm <terminator>
"m" indicates one of the following functions.
- in case of normal measurement
m=1 :voltage (V)
2 :current (A)
3 :power (W)
4 :reactive power (var)
5 :apparent power (VA)
15 :Integration time (TIME)
- in case of harmonic analysis
m=1 :Each relative harmonic content of 1st to 50 (or 30) th order of voltage (V)
2 :Each relative harmonic content of 1st to 50 (or 30) th order of current (A)
3 :Each relative harmonic content of 1st to 50 (or 30) th order of active power (W)
28 : harmonic analysis order (order)

Query DA? <terminator>
Example DA1
Description
- Parameter error 12 will occur if "m" is set to an illegal value.

DB/DB? **Sets the function for display B/inquires about the current setting.**

Syntax DBm <terminator>
"m" indicates one of the following functions.
- in case of normal measurement
m=1 :voltage (V)
2 :current (A)
3 :power (W)

6 :power factor (PF)
11 :phase angle (deg)
• in case of harmonic analysis
m=1 :Analysis value of each component of voltage (V)
2 :Analysis value of each component of current (A)
3 :Analysis value of each component of active power (W)
6 :power factor (PF)
16 :harmonic distortion factor of voltage (V THD)
17 :harmonic distortion factor of current (A THD)
19 :Relative harmonic content of each voltage component (V %)
20 :Relative harmonic content of each current component (A %)
21 :Relative harmonic content of each active power component (W %)
22 :Phase angle between each voltage of the 2nd to 50 (or 30) th order and the fundamental (1st order) voltage.
23 :Phase angle between each current of the 2nd to 50 (or 30) th order and the fundamental (1st order) current.

Query DB? <terminator>
Example DB1
Description • Parameter error 12 will occur if "m" is set to an illegal value.

DC/DC? **Sets the function for display C/inquires about the current setting**

Syntax DCm <terminator>
"m" indicates one of the following functions.
• in case of normal measurement
m=1 :voltage (V)
2 :current (A)
3 :power (W)
7 :Input voltage frequency (V Hz)
8 :Input current frequency (A Hz)
9 :watt hour (Wh)
10 :ampere hour (Ah)
12 :Peak voltage value (Vpk)*
13 :Peak current value (Apk)*
14 :Computation result (MATH)*
24 :positive watt hour (Wh+)
25 :negative watt hour (Wh–)
26 :positive ampere hour (Ah+)
27 :negative ampere hour (Ah–)
* Applies to WT110/WT130 with ROM version 2.01 or later
• in case of harmonic analysis
m=1 :Rms value of the 1st to 50 (or 30) th order of voltage (V)
2 :Rms value of the 1st to 50 (or 30) th order of current (A)
3 :Rms value of the 1st to 50 (or 30) th order of active power (W)
7 :Input voltage frequency (V Hz)
8 :Input current frequency (A Hz)

Query DC? <terminator>
Example DC1
Description • Parameter error 12 will occur if "m" is set to an illegal value.

DF/DF? **Sets the computation method for harmonic distortion (THD)/inquires about the current setting.**

Syntax DFm <terminator>
"m" indicates the computation method for harmonic distortion (refer to page 8-4)
m=0 :IEC
1 :CSA

Query DF? <terminator>
Example DF0
Description • Parameter error 12 will occur if "m" is set to an illegal value.
• While recalling or storing is in progress, execution error 19 will occur.

DL/DL? **Sets the terminator for communication output data/inquires about the current setting.**

Syntax DL <terminator>
"m" indicates terminator

	GP-IB	RS-232-C
m=0 :	CR+LF+EOI	CR+LF
1 :	LF	LF
2 :	EOI	CR

Query DL? <terminator>
Example DL0
Description • Parameter error 12 will occur if "m" is set to an illegal value.

DR/DR? **Displays the current range.**

Syntax DRm <terminator>
"m" indicates the range.
m=0 :cancels the range display and returns to measurement display
1 :displays voltage, current and shunt value of element 1 on display A, B and C respectively.
2 :displays the shunt value of element 1, 2 and 3 on display A, B and C respectively (WT130 only).

Query DR? <terminator>
Example DR0
Description • Parameter error 12 will occur if "m" is set to an illegal value.

DY/DY? **Sets the display for comparator ON/OFF, or inquires about the current setting.**

Syntax DYm <terminator>
"m" indicates display for comparator ON/OFF
m=0 :cancels the display for comparator
1 :sets the display for comparator ON

Query DY? <terminator>
Example DY1
Description • Parameter error 12 will occur if "m" is set to an illegal value.

EA/EA? **Sets the element for display A/inquires about the current setting.**

Syntax EA m <terminator>
"m" indicates element.
m=1 :Element 1
2 :Element 2 (for model 253503 only)
3 :Element 3 (for WT130 only)
4 :Σ (for WT130 only)

Query EA? <terminator>
Example EA1
Description • Parameter error 12 will occur if "m" is set to an illegal value.

EB/EB? **Sets the element for display B/inquires about the current setting.**

Syntax EB m <terminator>
"m" indicates element.
m=1 :Element 1
2 :Element 2 (for model 253503 only)
3 :Element 3 (for WT130 only)
4 :Σ (for WT130 only)

Query EB? <terminator>
Example EB1
Description • Parameter error 12 will occur if "m" is set to an illegal value.

EC/EC? **Sets the element for display C/inquires about the current setting.**

Syntax EC m <terminator>
"m" indicates element.
m=1 :Element 1
2 :Element 2 (for model 253503 only)
3 :Element 3 (for WT130 only)
4 :∑ (for WT130 only)
Query EC? <terminator>
Example EC1
Description ∑ Parameter error 12 will occur if "m" is set to an illegal value.

E,ST,<interface message GET>
Generates a trigger.

Syntax E <terminator>
ST <terminator>
<interface message GET>
Description
- This command is valid only during sample hold mode.

FL/FL? **Determines whether or not filter is used/ inquires about the current setting.**

Syntax FL m <terminator>
"m" indicates whether filter is ON or OFF.
m=0 :OFF
1 :ON
Query FL? <terminator>
Example FL1
Description
- Parameter error 12 will occur if "m" is set to an illegal value.
- Filter cannot be switched ON or OFF while integration is in progress; error 13 will occur.
- While recalling or storing is in progress, execution error 19 will occur.

HD/HD? **Determines whether or not output data should be updated/inquires about the current setting.**

Syntax HD m <terminator>
"m" indicates the sampling mode.
m=0 :Updates the data at each sampling rate.
1 :Hold
Query HD? <terminator>
Example HD0
Description
- Parameter error 12 will occur if "m" is set to an illegal value.

H/H? **Determines whether or not to add a head to measured data output via communication/inquires about the current setting.**

Syntax H m <terminator>
"m" indicates whether a header is added or not.
m=0 :No header added
1 :Header added
Query H? <terminator>
Example H0
Description
- Parameter error 12 will occur if "m" is set to an illegal value.

HA/HA? **Determines whether or not to turn ON the harmonic analysis function/inquires about the current setting.**

Syntax HA m <terminator>
"m" indicates whether the harmonic analysis function or normal measurement function is set.
m=0 :Normal measurement
1 :Harmonic analysis
Query HA? <terminator>
Example HA1
Description
- Parameter error 12 will occur if "m" is set to an illegal value.
- When integration is in progress or being aborted, harmonic analysis cannot be performed; error 13 will occur.
- Integration cannot be started when the harmonic analysis function is in progress; error 16 will occur.
- While recalling or storing is in progress, execution error 19 will occur.

HE/HE? **Determines the element of the harmonic analysis function/inquires about the current setting.**

Syntax HE m <terminator>
"m" indicates the element of the harmonic analysis function.
m=1 :Element 1
2 :Element 2 (for model 253503 only)
3 :Element 3 (for WT130 only)
Query HE? <terminator>
Example HE1
Description
- Parameter error 12 will occur if "m" is set to an illegal value.
- While recalling or storing is in progress, execution error 19 will occur.

IC/IC? **Sets the integration mode/inquires about the current setting.**

Syntax IC m <terminator>
"m" indicates one of the following integration modes.
m=0 :Normal integration mode
1 :Continuous integration mode
Query IC? <terminator>
Example IC1
Description
- Parameter error 12 will occur if "m" is set to an illegal value.
- Changing the integration mode is not allowed while integration is in progress; execution error 13 will occur.
- If continuous integration mode is selected, make sure that the timer preset time is set to a value larger than "0".
- If normal integration mode is selected, set the timer preset time to any desired value.
- While recalling or storing is in progress, execution error 19 will occur.

IM/IM? **Specifies which causes will be allowed to generate a status byte/inquires about the current setting.**

Syntax IM m <terminator>
"m" is assigned as follows (0 ≤ m ≤ 15).
m=1 :Computation end
2 :Integration end
4 :Syntax error
8 :OVER
Query IM? <terminator>
Example IM15
Description
- Parameter error 12 will occur if "m" is set to an illegal value.
- If more than one of these causes is to be allowed, set "m" to the sum of their individual "m" values. For instance, if all causes are to be allowed, set "m" to 15 (=1+2+4+8).

IP **Stops integration.**

Syntax IP <terminator>
Description
- If an attempt is made to stop integration when integration has already been interrupted (stopped), execution error 44 will occur.
- While recalling or storing is in progress, execution error 19 will occur.

IR **Resets integration.**

Syntax IR <terminator>
Description
- If an attempt is made to reset integration while integration is in progress, execution error 45 will occur.
- While recalling or storing is in progress, execution error 19 will occur.

IS **Starts integration.**

Syntax IS <terminator>

Description
- If an attempt is made to start integration when integration is already in progress, execution error 42 will occur.
- If a voltage or current peak overflow, or overrange takes place when an attempt is made to start integration, execution error 46 will occur, and integration will not be started.
- While recalling or storing is in progress, execution error 19 will occur.

KV/KV?, KA/KA?, KW/KW?
Sets the scaling constant/inquires about the current setting.
KV is used for voltage measurement, KA for current measurement, and KW for power measurement.

Syntax When CM0 is set:
KVn <terminator>
KAn <terminator>
KWn <terminator>
When CM1 is set:
KVm,n <terminator>
KAm,n <terminator>
KWm,n <terminator>
"m" indicates element.
m=0 : All elements (Setting not allowed during inquiry)
1 :Element 1
2 :Element 2 (for model 253503 only)
3 :Element 3 (for WT130 only)
"n" indicates scaling value.
$0.001 \leq n \leq 1000$

Query When CM0 is set:
KV? <terminator>
KA? <terminator>
KW? <terminator>
When CM1 is set:
KV1? <terminator>
KA2? <terminator>
KW3? <terminator>

Example When CM0 is set:
KV1.000
KA1.000
KW1.000
When CM1 is set:
KV1,1.000
KA2,1.000
KW3,1.000

Description
- Parameter error 12 will occur if "m" is set to an illegal value.
- "n" must be floating-point or integer.
- Error 12 will occur when an inquiry is made if the scaling values set for each element by CM0 differ from each other.
- While recalling or storing is in progress, execution error 19 will occur.

MN/MN? **Sets the measurement mode for voltage and current/inquires about the current setting.**

Syntax MN m <terminator>
"m1" indicates the measurement mode.
m1=0 : RMS
1 : V MEAN (MEAN in case of voltage, RMS in case of current)
2 :DC

Query MN? <terminator>

Example MN0

Description
- Parameter error 12 will occur if "m" is set to an illegal value.
- Changing of the measurement mode is not allowed while integration is in progress; execution error 13 will occur.
- While recalling or storing is in progress, execution error 19 will occur.

MT/MT? **Sets the computing equation of MATH function/inquires about the current setting.**

Syntax MTm<terminator>
m indicates the computing equation.
m=0 : Efficiency (available only on the WT130)
1 : Crest factor of the voltage input waveform of input element 1
2 : Crest factor of the voltage input waveform of input element 2 (available only three-phase four-wire model of the WT130)
3 : Crest factor of the voltage input waveform of input element 3 (available only on the WT130)
4 : Crest factor of the current input waveform of input element 1
5 : Crest factor of the current input waveform of input element 2 (available only three-phase four-wire model of the WT130)
6 : Crest factor of the current input waveform of input element 3 (available only on
7 : display A + display B
8 : display A – display B
9 : display A X display B
10 : display A / display B
11 : display A / (display B)^2
12 : (display A)^2 / display B

Query MT?<terminator>

Example MT0

Description
- This command applies to WT110/WT130 with ROM version 2.01 or later.

OA/OA? **Sets D/A output items/inquires about the current settings.**
Up to 4 or 12 measured data can be selected and output as analog signal from the D/A converter.

Syntax OA m1,m2,m3 <terminator>
"m1" indicates D/A output channel, and must be set within the following range.
$1 \leq m1 \leq 12$ or 4
"m2" indicates output item no.
m2=0 :No output
1 :Voltage (V)
2 :Current (A)
3 :Power (W)
4 :Reactive power (var)
5 :Apparent power (VA)
6 :Power factor (PF)
7 :Input voltage frequency (V Hz)
8 :Input current frequency (A Hz)
9 :Watt-hour (Wh)
10 :Ampere-hour (Ah)
11 :Phase angle (deg)
12 : Peak voltage value (Vpk)*
13 : Peak current value (Apk)*
14 : Computation result (MATH)*
24 :Positive watt-hour (Wh+)
25 :Negative watt-hour (Wh–)
26 :Positive ampere-hour (Ah+)
27 :Negative ampere-hour (Ah–)
* Applies to WT110/WT130 with ROM version 2.01 or later
"m3" indicates element.
m=1 :Element 1
2 :Element 2 (for model 253503 only)
3 :Element 3 (for WT130 only)
4 :∑ (for WT130 only)

Query OA1? <terminator>
Example OA1,3,2
Description
- Parameter error 12 will occur if any of "m1", "m2" and "m3" is set to an illegal value.
- If computation result is selected and the MATH computing equation is set to anything other than efficiency (MT0),the D/A output is fixed to 0 (V).
- "No output" and "computation result" have no relation to the element, but when using them with the "OA" command, set m3=1.

OAD/OAD? Initializes D/A output items/inquires about the current settings. Two sets of default settings are available: one is for normal measurement and the other is for integration. The same initialization can also be performed using a key operation.

Syntax OAD m <terminator>
"m" indicates default no.
m=2 :Select mode
0 :Default for normal measurement
1 :Default for integration
Query OAD? <terminator>
Example OAD1
Description
- Parameter error 12 will occur if "m" is set to an illegal value.
- Select mode (OAD2) is validated when the OA command is executed if "m" has been set to "0" (default for normal measurement) or "1" (default for integration).

OD Requests output of measurement data.

Syntax OD <terminator>
Description
- The OD command should be used only in addressable mode A. If the OD command is used in addressable mode B, execution error 11 will occur. Setting the addressable mode should be done using a key operation.

OE Requests output of error codes via communications.

Syntax OE <terminator>
Example ERR11 <terminator>
Error codeDescription
11 Command error
12 Parameter error
13 Attempted to change settings which cannot be changed while integration was in progress.
14 Attempted to set auto range mode while external sensor range was selected.
15 Attempted to execute a command that was protected.
16 Attempted to execute a command that was protected while harmonic analysis was being performed.
17 Time-out in print output.
18 Not in printing mode, or no data available.
19 Attempted to execute commands while recalling/storing is in progress.
30 File data failure
31 File is damaged.
32 Not stored in internal memory.
33 No data to be stored in internal memory.
41 Attempted to start integration when integration had been stopped due to an irregularity.
42 Attempt made to start integration during integration.
43 Measurement stopped due to overflow during integration or due to a power failure.
44 Attempt made to stop integration while integration was interrupted.
45 Attempt made to reset integration while integration was in progress.
46 Attempt made to start integration when peak overflow was detected.
51 Measurement data overflow occurred. "-oL" is displayed.
52 Voltage peak overflow occurred
53 Current peak overflow occurred
54 Power factor exceeded "2". "PFErr" is displayed.
55 "degErr" was displayed.
56 Frequency input level was too low or below measurement range. "ErrLo" is displayed.
57 Frequency was above the measurement range. "ErrHi," is displayed.
58 Computation overflow occurred. "—oF—" is displayed.
59 When harmonic analysis is carried out, "FrqEr" is displayed

OF/OF? Sets communication output information types/inquires about the current settings. Up to 14 measured data can be selected and output.

Syntax OF m1,m2,m3 <terminator>
"m1" indicates communication output channel, and must be set within the following range.
1 ≤ m1 ≤ 14
"m2" indicates output type no.
m2=0 :No output
1 :Voltage (V)
2 :Current (A)
3 :Power (W)
4 :Reactive power (var)
5 :Apparent power (VA)
6 :Power factor (PF)
7 :Input voltage frequency (V Hz)
8 :Input current frequency (A Hz)
9 :Watt-hour (Wh)
10 :Ampere-hour (Ah)
11 :Phase angle (deg)
12 : Peak voltage value (Vpk)*
13 : Peak current value (Apk)*
14 : Computation result (MATH)*
15 :Integration time
24 :Positive watt-hour (Wh+)
25 :Negative watt-hour (Wh–)
26 :Positive ampere-hour (Ah+)
27 :Negative ampere-hour (Ah–)
* Applies to WT110/WT130 with ROM version 2.01 or later
"m3" indicates element, and must be set within the following range.
1 ≤ m3 ≤ 4
Query OF1? <terminator>
Example OF1,3,2
Description
- Parameter error 12 will occur if "m1", "m2" or "m3" is set to an illegal value.
- "No output," "computation range," and "integration time" have no relation to the element, but when using them with the "OF" command, set m3=1.

OFD/OFD? Initializes communication output information type/inquires about the current settings. Two sets of default setting are available: one is for normal measurement and the other is for integration.

Syntax OFD m <terminator>
"m" indicates default no.
m=2 :Select mode (valid only for the inquiry command)
0 :Default for normal measurement
1 :Default for integration
Query OFD? <terminator>
Example OFD1
Description
- Parameter error 12 will occur if "m" is set to an illegal value.

• Select mode (OFD2) is validated when the OF command is executed if "m" is set to "0" (default for normal measurement) or "1" (default for integration).
• If you select default for normal measurement, the output of channel 13 is the information on the frequency target function that is currently measured, and the output of channel 14 is the information displayed on display C. If you change either the frequency measurement target or display information of display C, the output also changes.

OH/OH? **Sets communication output information types in case of harmonic analysis/ inquires about the current settings.**

Syntax OH m1,m2 <terminator>
"m1" indicates output type no.
• in case of print mode
m1=1 :(V) outputs voltage analysis value and relative harmonic content as a numerical value
2 :(A) outputs current analysis value and relative harmonic content as a numerical value
3 :(W) outputs active power analysis value and relative harmonic content as a numerical value
4 :(deg) outputs the phase angle as a numerical value
5 :(GV) outputs voltage analysis value as numerical value and graph
6 :(GA) outputs current analysis value as numerical value and graph
7 :(GW) outputs active power analysis value as numerical value and graph
8 :(GVD) outputs the phase angle between the 2nd to 50 (or 30) th order voltage and the fundamental (1st order) as numerical value and graph
9 :(GAD) outputs the phase angle between the 2nd to 50 (or 30) th order current and the fundamental (1st order) as numerical value and graph
10 :(CGV) outputs the relative harmonic content of voltage as numerical value and graph
11 :(CGA) outputs the relative harmonic content of current as numerical value and graph
12 :(CGW) outputs the relative harmonic content of active power as numerical value and graph
13 :(ALL) outputs the relative harmonic content and analysis value of both voltage and current
• in case of any other mode
m1=1 :(V) outputs voltage analysis value and relative harmonic content as a numerical value
2 :(A) outputs current analysis value and relative harmonic content as a numerical value
3 :(W) outputs active power analysis value and relative harmonic content as a numerical value
4 :(deg) outputs the phase angle between the first order voltage(current) and the 2nd to 50 (or 30) th voltage(current) as a numerical value
5 :(GV) outputs voltage analysis value and relative harmonic content as numerical value
6 :(GA) outputs current analysis value and relative harmonic content as numerical value
7 :(GW) outputs active power analysis value and relative harmonic content as numerical value
8 :(GVD) outputs the phase angle between the first order voltage(current) and the 2nd to 50 (or 30) th voltage(current) as a numerical value
9 :(GAD) outputs the phase angle between the first order voltage(current) and the 2nd to 50 (or 30) th voltage(current) as a numerical value
10 :(CGV) outputs the analysis value of voltage and relative harmonic content as numerical value
11 :(CGA) outputs the analysis value of current and relative harmonic content as numerical value
12 :(CGW) outputs the analysis value of active power and relative harmonic content as numerical value
13 :(ALL) outputs the relative harmonic content and analysis value of both voltage and current
"m2" indicates element
m2=1 :Element 1
2 :Element 2 (for model 253503 only)
3 :Element 3 (for WT130 only)

Query OH? <terminator>
Example OH13,1
Description • Parameter error 12 will occur if "m1" or "m2" is set to an illegal value.

OR/OR? **Designates the harmonic order of the harmonic component shown on display B (V,A,W,V %, A%, W%, V deg, A deg)/ inquires about the current settings.**

Syntax OR m <terminator>
"m" indicates the harmonic order
m= any number between 1 to 50 (or 30)

Query OR? <terminator>
Example OR50
Description • Parameter error 12 will occur if "m" is set to an illegal value.
• Depending on the fundamental frequency of the PLL source set as the input, the maximum number of orders varies.
• When an order exceeding the maximum has been set, display B will show [——].

OS **Requests output of setting parameters via communications.**

Syntax OS <terminator>
Example

Line 1 :Model name
MODEL253503 <terminator>
Line 2 :Voltage range
RV9;AV1 <terminator>
Line 3 :Current range
When CM0 is set:
RA9;AA1;SA50.00 <terminator>
When CM1 is set:
RA9;AA1;SA1,50.00;SA2,50.00;
SA3,50.0 <terminator>
Line 4 :Display function
DA1;DB2;DC3 <terminator>
Line 5 :Element
EA1;EB1;EC1 <terminator>
Line 6 :Measurement condition
WR2;FL0;SC0;AG0;HD0;MT0
<terminator>

Line 7 :Measurement mode
MN0 <terminator>
Line 8 :Scaling constant
When CM0 is set:
KV1.000;KA1.000;KW1.000
<terminator>
When CM1 is set:
KV1,1.000;KA1,1.000;KW1,1.000
KV2,1.000;KA2,1.000;KW2,1.000;
KV3,1.000;KA3,1.000;KW3,1.000
<terminator>
Line 9 :Averaging setting
AT1;AC1 <terminator>
Line 10:Integration setting
IC0;TM0,0 <terminator>
Line 11:Storing/recalling setting
SO0;SR0,0,0;RO0;RR0,0,0 <terminator>
Line 12:Command group used
CM0 <terminator>
Line 13:Output end
END <terminator>

Description
- The number of lines varies depending on the options used.
- When the harmonic analysis option is used, the following line must be installed before the used command group.

PS1;HA0;OR1;HE1;DF0 <terminator>
- When the D/A output option is used, the following line must be inserted before the used command group.

RT0,1 <terminator>
- When the comparator option is used, the following line must be inserted before the used command group.

YO0;YM1;DY0;YC1 <terminator>
- When a CM0 is issued, if the shunt current values or scaling values set for each element differ from each other, the value set for element 1 will be output.

OY/OY?

Sets the relay output items in case of normal measurement/inquires about the current setting. Up to four items can be set.

Syntax OY m1,m2,m3,m4,m5 <terminator>

"m1" indicates the output relay channel
1 ≤ m1 ≤ 4

"m2" indicates the output item number
m2=0 : no output
1 :Voltage (V)
2 :Current (A)
3 :Power (W)
4 :Reactive power (var)
5 :Apparent power (VA)
6 :Power factor (PF)
7 :Input voltage frequency (V Hz)
8 :Input current frequency (A Hz)
9 :Watt-hour (Wh)
10 :Ampere-hour (Ah)
11 :Phase angle (deg)
12 : Peak voltage value (Vpk)*
13 : Peak current value (Apk)*
14 : Computation result (MATH)*
24 :Positive watt-hour (Wh+)
25 :Negative watt-hour (Wh–)
26 :Positive ampere-hour (Ah+)
27 :Negative ampere-hour (Ah–)
* Applies to WT110/WT130 with ROM version 2.01 or later

"m3" indicates element.
m=1 :Element 1
2 :Element 2 (for model 253503 only)
3 :Element 3 (for WT130 only)
4 :∑ (for WT130 only)

"m4" indicates setting value.
0.000 ≤ m4 ≤ ±9999

"m5" indicates prefix
m5=0 :m(E-3)
1 :(E+0)
2 :k(E+3)
3 :M(E+6)

Query OY1? <terminator>

Example OY1,1,1,600.0,1

Description
- Parameter error 12 will occur if "m" is set to an illegal value.
- "No output" and "computation result" have no relation to the element, but when using them with the "OY" command, set m3=1.

OYH/OYH?

Sets the relay output items in case of harmonic analysis/inquires about the current setting. Up to four items can be set.

Syntax OYH m1,m2,m3,m4,m5,m6 <terminator>

"m1" indicates the output relay channel
1 ≤ m1 ≤ 4

"m2" indicates the output item number
m2=0 :no output
1 :Voltage (V)
2 :Current (A)
3 :Power (W)
6 :Power factor (PF)
16 :harmonic distortion factor of voltage (V THD)
17 :harmonic distortion factor of current (A THD)
19 :Relative harmonic content of each voltage component (V %)
20 :Relative harmonic content of each current component (A %)
21 :Relative harmonic content of each active power component (W %)
22 :Phase angle between each voltage of the 2nd to 50 (or 30) th order and the fundamental (1st order) voltage (V deg)
23 :Phase angle between each current of the 2nd to 50 (or 30) th order and the fundamental (1st order) current (A deg)

"m3" indicates element.
m=1 :Element 1
2 :Element 2 (for model 253503 only)
3 :Element 3 (for WT130 only)

"m4" indicates order of the harmonic.
m4 = any number between 1 and 50 (or 30)

"m5" indicates setting value.
0.000 ≤ m5 ≤ ±9999

"m6" indicates prefix.
m6=0 : m(E-3)
1 : (E+0)
2 : k(E+3)
3 : M(E+6)

Query OYH3? <terminator>

Example OYH3,3,1,1,1,200,2

Description
- Parameter error 12 will occur if "m" is set to an illegal value.
- "No output" is not related to any element, order or setting value, so in case the OYH command is set, set these all to 1 as a dummy.
- "PF", "VTHD" and "ATHD" are not related to any order, so in case the OYH command is used, set 1 as a dummy.

PS/PS?

Sets the input as the PLL source/inquires about the current setting.

Syntax PS m <terminator>
"m" indicates the input as the PLL source
m=1 :V1
2 :A1
3 :V2 (for model 253503 only)
4 :A2 (for model 253503 only)
5 :V3 (for WT130 only)
6 :A3 (for WT130 only)
Query PS? <terminator>
Example PS1
Description
- Parameter error 12 will occur if any illegal value is set.
- While recalling or storing is in progress, execution error 19 will occur.

RA/RA? Sets current range/inquires about the current setting.

Syntax RA m <terminator>
"m" indicates current range.
m=4 :0.5 A range
5 :1 A range
6 :2 A range
7 :5 A range
8 :10 A range
9 :20 A range
15 :50 mV range (only when equipped with option EX2)
16 :100 mV range (only when equipped with option EX2)
17 :200 mV range (only when equipped with option EX2)
18 :2.5 V range (only when equipped with option EX1)
19 :5 V range (only when equipped with option EX1)
20 :10 V range (only when equipped with option EX1)
Query RA? <terminator>
Example RA9
Description
- Parameter error 12 will occur if "m" is set to an illegal value.
- Changing of the current range is not allowed while integration is in progress; execution error 13 will occur.
- The 50 mV, 100 mV and 200 mV or 2.5V, 5V and 10V ranges are for the external sensor. When using any of these ranges, be sure to set a valid sensor value using the SA command.
- While recalling or storing is in progress, execution error 19 will occur.

RC Initializes setting parameters.

Syntax RC <terminator>

RO/RO? Sets the recall function ON/OFF or inquires about the current setting.

Syntax RO m <terminator>
"m" indicates recall ON or OFF.
m=0 : recall OFF
1 : recall ON
Query RO? <terminator>
Example RO1
Description
- Parameter error 12 will occur if "m" is set to an illegal value.

RR/RR? Sets the recall interval/inquires about the current setting.

Syntax RR m1,m2,m3 <terminator>
"m1" indicates the hour
0 ≤ m1 ≤ 99
"m2" indicates the minutes
0 ≤ m2 ≤ 59
"m3" indicates the seconds
0 ≤ m3 ≤ 59
Query RR? <terminator>
Example RR0,0,0
Description
- Parameter error 12 will occur if an illegal value is set.
- When the recall interval is set to 0hrs, 0min, 0sec, the interval will be 250msec in case of normal measurement and 1s in case of harmonic analysis.
- While recalling or storing is in progress, execution error 19 will occur.

RT/RT? Sets the rated integration time when integrated values are to be output as an analog signal/inquires about the current setting.

Syntax RT m1,m2 <terminator>
"m1" indicates hour, and must be set within the following range.
0 ≤ m1 ≤ 999
"m2" indicates minute, and must be set within the following range.
0 ≤ m2 ≤ 59
Query RT? <terminator>
Example RT1,0
Description
- Parameter error 12 will occur if an illegal value is set.

RV/RV? Sets voltage range/inquires about the current setting.

Syntax RV m <terminator>
"m" indicates voltage range.
m=3 :15V range
4 :30 V range
5 :60 V range
6 :100 V range
7 :150 V range
8 :300 V range
9 :600 V range
Query RV? <terminator>
Example RV9
Description
- Parameter error 12 will occur if an illegal value is set.
- Changing of the voltage range is not allowed while integration is in progress; execution error 13 will occur.
- While recalling or storing is in progress, execution error 19 will occur.

SA/SA? Sets the external sensor scaling value/ inquires about the current setting.

Syntax When CM0 is set:
SA n <terminator>
When CM1 is set:
SA m,n <terminator>
"m" indicates element.
m=0 :All elements (Setting not allowed during inquiry)
1 :Element 1
2 :Element 2 (only for model 253503)
3 :Element 3 (only for the WT130)
"n" indicates external sensor scaling value.
0.001 ≤ n ≤ 1000
Query When CM0 is set:
SA? <terminator>
When CM1 is set:
SAm? <terminator>
Example When CM0 is set:
SA50.00
When CM1 is set:
SA1,50.00
Description
- Parameter error 12 will occur if "m" is set to an illegal value.
- Error 12 will occur when an inquiry is made if the shunt current values set for each element by CM0 differ from each other.

• While recalling or storing is in progress, execution error 19 will occur.

SC/SC? **Determines whether or not to use the scaling function/inquires about the current setting.**

Syntax SC m <terminator>
"m" indicates whether scaling is ON or OFF.
m=0 : OFF
1 : ON
Query SC? <terminator>
Example SC1
Description
• Parameter error 12 will occur if "m" is set to an illegal value.
• While recalling or storing is in progress, execution error 19 will occur.

SL **Recalls set-up parameters from a selected file.**

Syntax SL m <terminator>
"m" indicates file no., and must be set within the following range.
1 ≤ m ≤ 4
Description
• Parameter error 12 will occur if "m" is set to an illegal value.
• It is not possible to recall communications-related information (communication mode, address etc.) using this command.
• While recalling or storing is in progress, execution error 19 will occur.

SO/SO? **Sets the store function ON/OFF or inquires about the current setting.**

Syntax SO m <terminator>
"m" indicates whether storage is ON or OFF.
m=0 : OFF
1 : ON
Query SO? <terminator>
Example SO1
Description
• Parameter error 12 will occur if "m" is set to an illegal value.
• While recalling or storing is in progress, execution error 19 will occur.

SR/SR? **Sets the storage interval/inquires about the current setting.**

Syntax SR m1,m2,m3 <terminator>
"m1" indicates the hour
0 ≤ m1 ≤ 99
"m2" indicates the minutes
0 ≤ m2 ≤ 59
"m3" indicates the seconds
0 ≤ m3 ≤ 59
Query SR? <terminator>
Example SR0,0,0
Description
• Parameter error 12 will occur if an illegal value is set.
• When the storage interval is set to 0hrs, 0min, 0sec, refer to page 9-2.
• While recalling or storing is in progress, execution error 19 will occur.

SS **Stores set-up parameters into a selected file.**

Syntax SS m <terminator>
"m" indicates file no., and must be set within the following range.
1 ≤ m ≤ 4
Description
• Parameter error 12 will occur if "m" is set to an illegal value.
• The following set-up parameters can be stored:
All set-up parameters which can be output by the OS command
Information related to communications (GP-IB, RS-232-C etc.)

• While recalling or storing is in progress, execution error 19 will occur.

TM/TM? **Sets integration preset time/inquires about the current setting.**

Syntax TM m1,m2 <terminator>
"m1" indicates hour, and must be set within the following range.
0 ≤ m1 ≤ 999
"m2" indicates minute, and must be set within the following range.
0 ≤ m2 ≤ 59
Query TM? <terminator>
Example TM0,0
Description
• Parameter error 12 will occur if an illegal value is set.
• While recalling or storing is in progress, execution error 19 will occur.

WR/WR? **Sets the wiring system/inquires about the current setting.**

Syntax WR m <terminator>
m=2 :1Φ3W
3 :3Φ3W
4 :3Φ4W (available only for the 253503)
5 :3V3A (available only for the 253503)
Query WR? <terminator>
Example WR2
Description
• Parameter error 12 will occur if an illegal value is set.

YC/YC? **Sets the display channel while the comparator function is ON/inquires about the current setting.**

Syntax YC m <terminator>
"m" indicates the channel number for display
• in case of single mode
m=1 :Displays limit and measurement value on display 1
2 :Displays limit and measurement value on display 2
3 :Displays limit and measurement value on display 3
4 :Displays limit and measurement value on display 4
• in case of dual mode
m=1,2 :Displays limit and measurement value on display 1 and 2 respectively
m=3,4 :Displays limit and measurement value on display 3 and 4 respectively
Query YC? <terminator>
Example YC1
Description
• Parameter error 12 will occur if "m" is set to an illegal value.

YM/YM? **Sets the mode of the comparator function/ inquires about the current setting.**

Syntax YM m <terminator>
"m" indicates the display mode
m=0 :Single mode
1 :Dual mode
Query YM? <terminator>
Example YM1
Description
• Parameter error 12 will occur if "m" is set to an illegal value.

YO/YO? **Sets the comparator function ON/OFF or inquires about the current setting.**

Syntax YO m <terminator>
"m" indicates whether the comparator function is ON/OFF
m=0 :OFF
1 :ON
Query YO? <terminator>
Example YO1
Description
• Parameter error 12 will occur if "m" is set to an illegal value.

Appendix 1.2 Sample Program

Before Programming

This section describes sample programs for a IBM PC/AT and compatible system with National Instruments GPIB-PCIIA board installed. Sample programs in this manual are written in Quick BASIC version 4.0/4.5

Programming Format

The programming format for this instrument is as follows.

Command + Parameter + Terminator

The used codes are ASCII codes.

Example	**DA**	**2**	**CR LF**
	command	parameter	terminator

Commands

One to three capital characters are used to designate a command.

Parameters

Characters or numericals are in ASCII code.

Terminator

- **In case of GP-IB:**

When this instrument is set to listener mode, either [CR+LF], [LF], or [EOI] can be used as the terminator.
When this instrument is set to talker mode, the terminator set using the DL command becomes valid. Refer to page App1-2.

- **In case of RS-232-C:**

Refer to page 12-7 and App1-2.

Sending Several Commands

You can express several commands on one line. In such a case, enter a ";" (semicolon) between two commands (command + parameter).

Note

It makes no difference whether a space, tab or similar is entered between command and parameter.

Query

A command followed by a "?" (question mark) is called a query command. When such a command is sent, the current data will appear.

Query		Current data
DA?	⇒	**DA1**

Parameter Values

Up to 5 digits after the decimal point will be recognized.

Sample Program

```
'*********************************************************************
'*   WT110/WT130                                                     *
'*   Program to read measurement data 10 times and then display them  *
'*             Microsoft QuickBASIC 4.0/4.5 Version                  *
'*********************************************************************
REM $INCLUDE: 'qbdecl4.bas'
BORD$ = "GPIB0": CALL IBFIND(BORD$, BD%)
IF BD% < 0 THEN GOTO ERRDISP
CALL IBSIC(BD%): GOSUB ERRCHK
DEVICE$ = "WT": CALL IBFIND(DEVICE$, WT%)
IF WT% < 0 THEN GOTO ERRDISP
CALL IBCLR(WT%): GOSUB ERRCHK
'
CMD$ = "HD0"                              ' Hold OFF
CALL IBWRT(WT%, CMD$): GOSUB ERRCHK
CMD$ = "FL0"                              ' Filter OFF
CALL IBWRT(WT%, CMD$): GOSUB ERRCHK
CMD$ = "SC0"                              ' Scaling OFF
CALL IBWRT(WT%, CMD$): GOSUB ERRCHK
CMD$ = "AG0"                              ' Averaging OFF
CALL IBWRT(WT%, CMD$): GOSUB ERRCHK
CMD$ = "DA1;EA1"                          ' Display A = V1
CALL IBWRT(WT%, CMD$): GOSUB ERRCHK
CMD$ = "DB2;EB1"                          ' Display B = A1
CALL IBWRT(WT%, CMD$): GOSUB ERRCHK
CMD$ = "DC3;EC1"                          ' Display C = W1
CALL IBWRT(WT%, CMD$): GOSUB ERRCHK
CMD$ = "RV7;RA7"                           ' Measurement range = 150V/5A
CALL IBWRT(WT%, CMD$): GOSUB ERRCHK
CMD$ = "MN0"                               ' Measurement mode = RMS
CALL IBWRT(WT%, CMD$): GOSUB ERRCHK
' Output items for comm. = default setting for normal measurement
CMD$ = "OFD0"
CALL IBWRT(WT%, CMD$): GOSUB ERRCHK
' Delimiter for Comm. output = CR+LF+EOI
CMD$ = "DL0"
CALL IBWRT(WT%, CMD$): GOSUB ERRCHK
BUF$ = SPACE$(255)
FOR I = 1 TO 10
    FOR J = 0 TO 5000: NEXT J             ' Waiting
    CMD$ = "OD"
     CALL IBWRT(WT%, CMD$): GOSUB ERRCHK
    DO
         CALL IBRD(WT%, BUF$): GOSUB ERRCHK
         PRINT LEFT$(BUF$, IBCNT% - 2)
     LOOP WHILE LEFT$(BUF$, 3) <> "END"
NEXT I
PRGEND:
CALL IBLOC(WT%)
END
'
' When IBFIND call failed
ERRDISP:
PRINT " ===== No such board or device name ===== "
GOTO PRGEND
'
' GP-IB error check
ERRCHK:
IF IBSTA% >= 0 THEN RETURN
PRINT " ===== Error ===== "
GOTO PRGEND
```

```
'************************************************************************
'*   WT110/WT130                                                        *
'*   Program for adjusting range                                        *
'*   Turn ON the power while pressing the SHIFT key.                    *
'*              Microsoft QuickBASIC 4.0/4.5 Version                    *
'************************************************************************
REM $INCLUDE: 'qbdecl4.bas'
BORD$ = "GPIB0": CALL IBFIND(BORD$, BD%)
IF BD% < 0 THEN GOTO ERRDISP
CALL IBSIC(BD%): GOSUB ERRCHK
DEVICE$ = "WT": CALL IBFIND(DEVICE$, WT%)
IF WT% < 0 THEN GOTO ERRDISP
CALL IBCLR(WT%): GOSUB ERRCHK
'
DO
    CLS
     PRINT "Main menu for range adjustment"
    PRINT ""
     PRINT "1:Range adjustment"
     PRINT "2:Adjustment of ext. sensor range"
    PRINT "0:End         "
     PRINT "Command >> "; : LINE INPUT C$
    IF C$ = "1" THEN
        GOSUB RANGE
    ELSEIF C$ = "2" THEN
        GOSUB SHUNT
    ELSEIF C$ = "0" THEN
        EXIT DO
    END IF
LOOP
'
PRGEND:
CALL IBLOC(WT%)
END
'
RANGE:
CMD$ = "CAL1": CALL IBWRT(WT%, CMD$): GOSUB ERRCHK
DO
    CLS
     PRINT "Range adjustment"
    PRINT ""
     PRINT "1: 30.00 V range"
     PRINT "2: 300.0 V range"
     PRINT "3: 1.000 A range"
     PRINT "4: 10.00 A range"
     PRINT "S: Adjustment values will be kept"
     PRINT "C: Adjustment values will not be kept"
     PRINT "Command >> "; : LINE INPUT C$
    IF C$ = "1" THEN
          CMD$ = "CR0": CALL IBWRT(WT%, CMD$): GOSUB ERRCHK: GOSUB ODDISP
    ELSEIF C$ = "2" THEN
          CMD$ = "CR1": CALL IBWRT(WT%, CMD$): GOSUB ERRCHK: GOSUB
ODDISP
    ELSEIF C$ = "3" THEN
          CMD$ = "CR2": CALL IBWRT(WT%, CMD$): GOSUB ERRCHK: GOSUB ODDISP
    ELSEIF C$ = "4" THEN
          CMD$ = "CR3": CALL IBWRT(WT%, CMD$): GOSUB ERRCHK: GOSUB ODDISP
    ELSEIF C$ = "S" THEN
          CMD$ = "END": CALL IBWRT(WT%, CMD$): GOSUB ERRCHK: EXIT DO
    ELSEIF C$ = "C" THEN
          CMD$ = "CAN": CALL IBWRT(WT%, CMD$): GOSUB ERRCHK: EXIT DO
    END IF
LOOP
RETURN
'
ODDISP:
PRINT "1: Adjustment values of this range will be updated"
PRINT "0: Return to previous menu"
DO
     CMD$ = "OD": CALL IBWRT(WT%, CMD$): GOSUB ERRCHK
    LOCATE 15, 1
     BUF$ = SPACE$(255)
    DO
```

```
          CALL IBRD(WT%, BUF$): GOSUB ERRCHK
          PRINT LEFT$(BUF$, IBCNT% - 2)
     LOOP WHILE LEFT$(BUF$, 3) <> "END"
     FOR J = 0 TO 500
          C$ = INKEY$: IF C$ <> "" THEN PRINT C$: EXIT FOR
     NEXT J
     IF C$ = "1" THEN
          CMD$ = "ENT": CALL IBWRT(WT%, CMD$): GOSUB ERRCHK: EXIT DO
     ELSEIF C$ = "0" THEN
          EXIT DO
     END IF
LOOP
RETURN
'
SHUNT:
CMD$ = "CAL2": CALL IBWRT(WT%, CMD$): GOSUB ERRCHK
PRINT "S: Adjustment values of this range will be updated and kept"
PRINT "C: Adjustment values of this range will not be kept"
DO
     CMD$ = "OD": CALL IBWRT(WT%, CMD$): GOSUB ERRCHK
     LOCATE 15, 1
     BUF$ = SPACE$(255)
     DO
          CALL IBRD(WT%, BUF$): GOSUB ERRCHK
          PRINT LEFT$(BUF$, IBCNT% - 2)
     LOOP WHILE LEFT$(BUF$, 3) <> "END"
     FOR J = 0 TO 500
          C$ = INKEY$: IF C$ <> "" THEN PRINT C$: EXIT FOR
     NEXT J
     IF C$ = "S" THEN
          CMD$ = "ENT": CALL IBWRT(WT%, CMD$): GOSUB ERRCHK
          CMD$ = "END": CALL IBWRT(WT%, CMD$): GOSUB ERRCHK
          EXIT DO
     ELSEIF C$ = "C" THEN
          CMD$ = "CAN": CALL IBWRT(WT%, CMD$): GOSUB ERRCHK
          EXIT DO
     END IF
LOOP
RETURN
'
' When IBFIND call failed
ERRDISP:
PRINT " ===== No such board or device name ===== "
GOTO PRGEND
'
' GP-IB error check
ERRCHK:
IF IBSTA% >= 0 THEN RETURN
PRINT " ===== Error ===== "
GOTO PRGEND
```

```
'************************************************************************
'*   WT110/WT130                                                        *
'*   Program for D/A output adjusting                                   *
'*   Turn ON the power while pressing the SHIFT key.                    *
'*            Microsoft QuickBASIC 4.0/4.5 Version                      *
'************************************************************************
REM $INCLUDE: 'qbdecl4.bas'
BORD$ = "GPIB0": CALL IBFIND(BORD$, BD%)
IF BD% < 0 THEN GOTO ERRDISP
CALL IBSIC(BD%): GOSUB ERRCHK
DEVICE$ = "WT": CALL IBFIND(DEVICE$, WT%)
IF WT% < 0 THEN GOTO ERRDISP
CALL IBCLR(WT%): GOSUB ERRCHK
'
CMD$ = "CAL3": CALL IBWRT(WT%, CMD$): GOSUB ERRCHK
DO
    CLS
     PRINT "D/A output adjustment"
    PRINT ""
     PRINT "1-12 : Assigning D/A channel"
     PRINT "S     : Adjustment values will be kept"
     PRINT "C     : Adjustment values will not be kept"
     PRINT "Command >> "; : LINE INPUT CH$
    IF CH$ = "S" THEN
         CMD$ = "END": CALL IBWRT(WT%, CMD$): GOSUB ERRCHK: EXIT DO
    ELSEIF CH$ = "C" THEN
         CMD$ = "CAN": CALL IBWRT(WT%, CMD$): GOSUB ERRCHK: EXIT DO
    ELSE
        CH = VAL(CH$)
        IF CH >= 1 AND CH <= 12 THEN
            GOSUB DACH
        END IF
    END IF
LOOP
'
PRGEND:
CALL IBLOC(WT%)
END
'
DACH:
CH$ = STR$(CH)
CMD$ = "CH" + CH$: CALL IBWRT(WT%, CMD$): GOSUB ERRCHK
CMD$ = "DO0": CALL IBWRT(WT%, CMD$): GOSUB ERRCHK
PRINT ""
PRINT "+5V has been output to"; CH$; "channel"
PRINT "Measure"; CH$; "channel's voltage"
PRINT "Measurement value = "; : LINE INPUT D$
CMD$ = "CD" + CH$ + "," + D$: CALL IBWRT(WT%, CMD$): GOSUB ERRCHK
FOR I = 0 TO 2000: NEXT I
CMD$ = "ENT": CALL IBWRT(WT%, CMD$): GOSUB ERRCHK
CMD$ = "DO1": CALL IBWRT(WT%, CMD$): GOSUB ERRCHK
PRINT ""
PRINT "-5V has been output to"; CH$; "channel"
PRINT "Measure"; CH$; "channel's voltage"

PRINT "Measurement value = "; : LINE INPUT D$
CMD$ = "CD" + CH$ + "," + D$: CALL IBWRT(WT%, CMD$): GOSUB ERRCHK
FOR I = 0 TO 2000: NEXT I
CMD$ = "ENT": CALL IBWRT(WT%, CMD$): GOSUB ERRCHK
RETURN
'
' When IBFIND call failed
ERRDISP:
PRINT " ===== No such board or device name ===== "
GOTO PRGEND
'
' GP-IB error check
ERRCHK:
IF IBSTA% >= 0 THEN RETURN
PRINT " ===== Error ===== "
GOTO PRGEND
```

Appendix 1.3 For Users Using Communication Commands of Digital Power Meter 2533E

The WT110/130 differ from the 2533E in communication commands and data format. The WT110/130 has a function which enables the user to use communication programs created for the 2533E. This function is described below.

Communication Commands

Under usual conditions, the 2533E commands cannot be used. The "CM" command should be set to CM2 to be able to use the 2533E commands (for details about the CM command, refer to Appendix 2).

Description is given below in alphabetical order of those commands which differ from the WT110/130 when the 2533E group is selected.

Note

- For addressable mode setting method, refer to section 11-1, page 11-9.
- WT110/130 code format is used for error code and status byte. For details, refer to page 11-3 and 14-3. The WT110/130 code format differs from 2533E code format.
- To read harmonic analysis data via RS-232-C interface, select a value other than "0" for handshake mode since harmonics analysis data consists of a number of output bytes.

DS

Sets the delimiter EOI output timing. This command is used with the 2533E, but cannot be used with the WT110/130 even if the 2533E group is selected by the "CM" command.

MN/MN?

Sets the measurement mode/inquires about the current setting.

Syntax MNm <terminator>
m stands for measurement mode.
m=0 : RMS
1 : V MEAN
2 : DC

Query MN? <terminator>

Example MN0

Description Parameter error 12 will occur if "m" is set to an illegal value.

OL

Requests output of setting parameters. Output format differs from that of the 2533E

Syntax OL <terminator>

Example

MODEL253503<terminator>
RV9;AV1<terminator>
RV9;AA1;SA50.00<terminator>
DA1;DB2;DC3<terminator>
EA1;EB1;EC1<terminator>
WR3;FL0;SC0;AG0;HD0;MT0<terminator>
MN0<terminator>
KV1.000;KA1.000;KW1.000<terminator>
AT1;AC1<terminator>
IC0;TM0,0<terminator>
SO0;SR0,0,0;RO0;RR0,0,0<terminator>
PS1;HA0;OR1;HE1;DF0<terminator>
RT1,0<terminator>
YO0;YM1;DY0;YC1<terminator>
CM2<terminator>
END<terminator>

Description When the external sensor scaling values and P/C/F scaling values set for each element differ from each other, the value set for element 1 will be output.

OS

Requests output of setting parameters. This command cannot be used if 2533E command group is selected by the "CM" command. However, in this case the "OL" command can be used instead.

WR/WR?

Sets the wiring system/inquires about the current setting.

Syntax WRm <terminator>
m stands for wiring system.
m=0 : 3Φ3W (for 253502, 253503 only)
1 : 3Φ4W (for 253503 only)
3 : 1Φ3W (for 253502, 253503 only)
4 : 3V3A (for 253503 only)

Query WR? <terminator>

Example WR0

Description Parameter error 12 will occur if "m" is set to an illegal value.

Output Items

To read measurement data using the 2533E communication program, the WT110/130 addressable mode B must be set. Output items do no match those displayed on each display as in the WT110/130, but match those set for ch.1 to ch.3 in output function setting for the WT110/130. Select output items according to the 2533E communication programs.

Note

- WT110/130 output items for ch.4 and subsequent ch. nos. are not output.
- For details regarding the setting of output items, refer to page 11-10.

Data Output Format

Data consists of a 12-byte header and 12 bytes of data.
The entire data output format is shown below.

ch.1 header	ch.1 data	,	ch.2 header	ch.2 data	,	ch.3 header	ch.3 data

- **Header Section**

h1	h2	h3	h4	h5	h6	h7	h8	h9	h10	h11	h12

h1 to h2: Output channel
DA: ch1 DB: ch2 DC: ch3
h3 to h4: Data type

1: V (voltage)	8 : HzA (current frequency)	15: HMS (integration elapsed time)
2: A (current)	9 : Wh (watt hour)	24: Wh+ (positive watt hour)
3: W (power)	10: Ah (ampere hour)	25: Wh– (negative watt hour)
4: var (reactive power)	11: DEG (phase angle)	26: Ah+ (positive ampere hour)
5: VA (apparent power)	12: Peak voltage value (Vpk)*	27: Ah– (negative ampere hour)
6 : PF (power factor)	13: Peak current value (Apk)*	
7 : HzV (voltage frequency)	14: Computation result (MATH)*	

* Applies to WT110/WT130 with ROM version 2.01 or later

Note

If "15" is set to h3 and h4 while "DB" is set to h1 and h2, "DB4_" is output to h1 through h4. This is done to conform to 2533E format.

h5 to h6: Output channel
EA: ch1 EB: ch2 EC: ch3
h7: Element
1: element 1 2: element 2 3: element 3 4: Σ _: no element
h8: Data state
N: normal I: overrange/no data O: computation overflow
h9 to h11: Unit
V_ _: V VA_: VA DEG: DEG HM_: integration elapsed time
A_ _: A HZ_: Hz Vpk : Vpk*2
W_ _: W Wh_: Wh Apk : Apk*2
VAR: var Ah_ : Ah Efficiency (EFF) or computation result*1, *2
*1: CV1, CV2, CV3, CA1, CA2, CA3, A+B, A–B, A∗B, A/B, A/2(meaning A/B^2), A2/(meaning A^2/B)
*2: Applies to WT110/WT130 with ROM version 2.01 or later
h12: fixed to ","

- **Output Section**

d1	d2	d3	d4	d5	d6	d7	d8	d9	d10	d11	d12

d1: Polarity : _ (space) or – (minus)
d2 to d9 : Mantissa, floating decimal of max. 7 digits
d10 to d12 : Exponent
E-3 ⇒ m E+0 E+3 ⇒ k E+6 ⇒ M
% – – ⇒ for efficiency(EFF)

Appendix 2.1 Overview of IEEE 488.2-1987

The GP-IB interface provided with this instrument conforms to IEEE 488.2-1987. This standard requires the following 23 points be stated in this document. This appendix describes these points.

(1) Subsets supported by IEEE 488.1 interface functions
Refer to the specifications on page 11-1.

(2) Operation of device when the device is assigned to an address other than one of the addresses 0 to 30
This instrument does not allow assignment to an address other than 0 to 30.

(3) Reaction when the user initializes address settings.
Change of the current address is acknowledged when a new address is set using the INTERFACE key menu. The newly set address is valid until another new address is set.

(4) Device set-up at power ON. Commands which can be used at power ON
Basically, the previous settings (i.e. the settings which were valid when power was turned OFF) are valid.
All commands are available at power ON.

(5) Message transmission options

(a) Input buffer size and operation
The input buffer's capacity is 1024 bytes.

(b) Types of queries which return multiple response messages
Refer to the examples of each command in Appendix 2.3.

(c) Types of queries which generate response data during analysis of the syntax
Every query generates response data when analysis of the syntax is performed.

(d) Types of queries which generate response data during reception
No query generates response data when it is received by the controller.

(e) Types of commands which have pairs of parameters.
No such commands.

(6) List of function elements which configure commands used for the device. All those which are included in elements of composite command program headers
Refer to Appendix 2.2 and 2.3.

(7) Buffer size which affects transmission of block data
Block data are not supported.

(8) List of program data elements which can be used in equations and nesting limit
Cannot be used.

(9) Syntax of response data to queries
Refer to the examples of each command in Appendix 2.3.

(10) Communication between devices which do not follow the rules regarding response data
No other modes than conforming to IEEE 488.2-1987 are supported.

(11) Size of data block of response data
Block data are not supported.

(12) List of supported common commands
Refer to Appendix 2.3.15 Common Command Group.

(13) Condition of device when calibration is successfully completed
*CAL? is not supported.

(14) Maximum length of block data which can be used for definition of trigger macro when *DDT is used
*DDT is not supported.

(15) Maximum length of macro label if macro definition is used; maximum length of block data which can be used for definition of macro; processing when recursion is used in definition of macro
Macro functions are not supported.

(16) Response to *IDN?
Refer to Appendix 2.3.15 Common Command Group.

(17) Size of storage area for protected user data if PUD and *PUD? are used.
*PUD and *PUD? are not supported.

(18) Length of resource name if *RDT and *RDT? are used.
*RDT and *RDT? are not supported.

(19) Change in status if *RST, *LRN?, *RCL and *SAV are used.
*RST
Refer to Appendix 2.3.15 Common Command Group.
*LRN?, *RCL, *SAV
These commands are not supported.

(20) Execution range of self-test using *TST?
Refer to Appendix 2.3.15 Common Command Group.

(21) Structure of extended return status
Refer to Appendix 2.4.

(22) To find out whether each command is performed in parallel or sequentially
Refer to Appendix 2.2.6 Synchronization with the Controller, or Appendix 2.3.

(23) Functions performed until a message indicating completion of the command is displayed
Refer to the function description of each command in Appendix 2.3, and to the corresponding chapters.

Appendix 2.2 Program Format

2.2.1 Symbols Used in Syntax Descriptions

Symbols which are used in the syntax descriptions in Appendix 2.3 are shown below. These symbols are referred to as BNF notation (Backus-Naur Form). For detailed information, refer to pages App2-6 to App2-7.

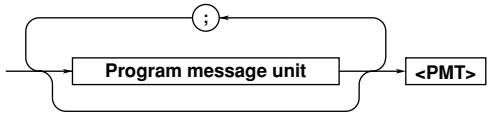
Symbol	Description	Example	Example
< >	Defined value	CHANnel<x> <x>=1, 2	CHANNEL2
{ }	One of the options in { } is selected.	MODE {AND|OR}	MODE AND
|	Exclusive OR	MODE {AND|OR}	MODE AND
[ ]	Abbreviated	:MEASure[:MODE] {<NRf>}	
...	may be repeated		

2.2.2 Messages

Blocks of message data are transferred between the controller and this instrument during communications. Messages sent from the controller to this instrument are called program messages, and messages sent back from this instrument to the controller are called response messages.
If a program message contains a query command, i.e. a command which requests a response, this instrument returns a response message. A single response message is always returned in reply to a program message.

Program Messages

As explained above, the data (message) sent from the controller to this instrument is called a program message. The format of a program message is shown below.



<Program message unit>

A program message consists of zero or more program message units; each unit corresponds to one command. This instrument executes commands one by one according to the order in which they are received.
Program message units are delimited by a “;”.
For a description of the format of the program message unit, refer to the explanation given further below.

Example :CONFIGURE:MODE RMS;FILTER ON<PMT>

Unit Unit

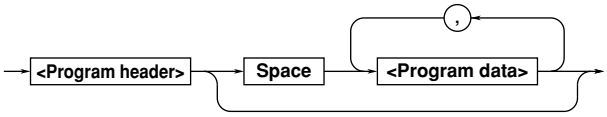
<PMT>

PMT is a terminator used to terminate each program message. The following three types of terminator are available.

NL (New Line) : Same as LF (Line Feed). ASCII code “0AH” is used.
^END : END message defined in IEEE488.1. (EOI signal)
(The data byte sent with an END message will be the final item of the program message unit.)
NL^END : NL with an END message attached
(NL is not included in the program message unit.)

Program message unit format

The format of a program message unit is shown below.



<Program header>

A program header is used to indicate the command type. For details, refer to page App2-4.

<Program data>

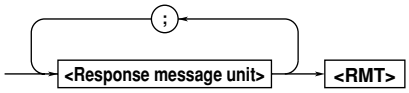
If certain conditions are required for the execution of a command, program data must be added. Program data must be separated from the header by a space (ASCII code "20H"). If multiple items of program data are included, they must be separated by a "," (comma).

Example `:CONFIGURE:AVERAGING:TYPE LINEAR, 8<PMT>`

Header Data

Response Messages

The data returned by this instrument to the controller is called a response message. The format of a response message is shown below.



<Response message units>

A response message consists of one or more response message units: each response message unit corresponds to one response.
Response message units are delimited by a ";".
For the response message format, refer to the next item.

Example
`:CONFIGURE:VOLTAGE:RANGE 15.0E+00;AUTO 0<RMT>`

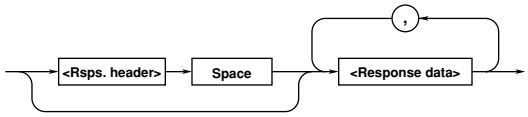
Unit Unit

<RMT>

RMT is the terminator used for every response message. Only one type of response message is available; NL^END.

Response message unit format

The format of a program message unit is shown below.



<Response header>

A response header sometimes precedes the response data. Response data must be separated from the header by a space. For details, refer to page App2-6.

<Response data>

Response data is used to define a response. If multiple items of response data are used, they must be separated by a "," (comma).

Example `:500.0E-03<RMT> :CONFIGURE:MODE RMS<RMT>`

Data Header Data

If a program message contains more than one query, responses are made in the same order as the queries. Normally, each query returns only one response message unit, but there are some queries which return more than one response message unit. The first response message unit always responds to the first query, but it is not always true that the 'n'th unit always responds to the 'n'th query. Therefore, if you want to make sure that a response is made to each query, the program message must be divided up into individual messages.

Points to Note concerning Message Transmission

- It is always possible to send a program message if the previous message which was sent did not contain any queries.
- If the previous message contained a query, it is not possible to send another program message until a response message has been received. An error will occur if a program message is sent before a response message has been received in its entirety. A response message which has not been received will be discarded.
- If an attempt is made by the controller to receive a response message, even if there it no response message, an error will occur. An error will also occur if the controller makes an attempt to receive a response message before transmission of a program message has been completed.
- If a program message of more than one unit is sent and some of the units are incomplete, this instrument receives program message units which the instrument thinks complete and attempts to execute them. However, these attempts may not always be successful and a response may not always be returned, even if the program message contains queries.

Dead Lock

This instrument has a buffer memory in which both program and response messages of 1024 bytes or more can be stored. (The number of bytes available will vary depending on the operating state of the instrument.) If both buffer memories become full at the same time, this instrument becomes inoperative. This state is called dead lock. In this case, operation can be resumed by discarding the response message. No dead lock will occur, if the size of the program message including the PMT is kept below 1024 bytes. Furthermore, no dead lock will occur if the program message does not contain a query.

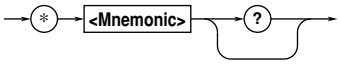
2.2.3 Commands

There are two types of command (program header) which can be sent from the controller to this instrument. They differ in the format of their program headers.

They are
- Common command header
- Compound header

Common Command Header

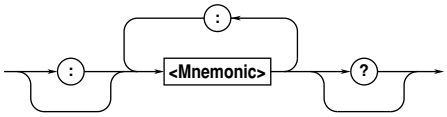
Commands defined in IEEE 488.2-1987 are called common commands. The header format of a common command is shown below. An asterisk (*) must always be attached to the beginning of a command.



An example of a common command
```
*CLS
```

Compound Header

Commands designed to be used only with this instrument are classified and arranged in a hierarchy according to their function. The format of a compound header is illustrated below. A colon (:) must be used when specifying a lower-level header.



An example of a compound header
```
CONFIGURE:MODE RMS
```

Note

A mnemonic is a character string made up of alphanumeric characters.

Consecutive Commands

Command Group

A command group is a group of commands which have the same compound header. A command group may contain sub-groups.

Example

Commands relating to integration

```
INTEGRATE?
INTEGRATE:MODE
INTEGRATE:TIMer
INTEGRATE:STARt
INTEGRATE:STOP
INTEGRATE:RESet
```

When Consecutive Commands are in the Same Group

This instrument stores the hierarchical level of the command which is currently being executed, and performs analysis on the assumption that the next command to be sent will also belong to the same level. Therefore, it is possible to omit the header if the commands belong to the same group.

Example `DISPLAY1:FUNCTION V;ELEMENT 1<PMT>`

When Consecutive Commands are in Different Groups

A colon (:) must be included before the header of a command, if the command does not belong to the same group as the preceding command.

Example `DISPLAY1:FUNCTION V;:SAMPLE:HOLD ON<PMT>`

In Case of Consecutive Common Commands

Common commands defined in IEEE 488.2-1987 are independent of hierarchical level. Thus, it is not necessary to add a colon (:) before a common command.

Example `DISPLAY1:FUNCTION V;*CLS;ELEMENT 1<PMT>`

When Separating Commands by <PMT>

If a terminator is used to separate two commands, each command is a separate message. Therefore, the common header must be typed in for each command even when commands of the same command group are being sent.

Example
```
DISPLAY1:FUNCTION V<PMT>DISPLAY1:ELEMENT 1<PMT>
```

Upper-level Query

An upper-level query is a compound header to which a question mark is appended. Execution of an upper-level query allows all settings of one group to be output at once. Some query groups comprising more than three hierarchical levels can output all their lower level settings.

Example
```
INTEGRATE?<PMT>
:INTEGRATE:MODE NORMAL;TIMER 0,0
```

In reply to a query, a response can be returned as a program message to this instrument.

Header Interpretation Rules

This instrument interprets the header received according to the following rules.

- Mnemonics are not case sensitive.
  Example “FUNCtion” can also be written as “function” or “Function”.
- The lower-case part of a header can be omitted.
  Example “FUNCtion” can also be written as “FUNCT” or “FUNC”.
- If the header ends with a question mark, the command is a query. It is not possible to omit the question mark.
  Example “FUNCtion?” cannot be abbreviated to anything shorter than “FUNC?”.
- If the “x” at the end of a mnemonic is omitted, it is assumed to be “1”.
  Example If “ELEMent<x>” is written as “ELEM”, this represents “ELEMent1”.
- Any part of a command enclosed by [ ] can be omitted.
  Example [CONFigure]:SCALing[:STATe] ON can be written as “SCAL ON”.
- However, a part enclosed by [ ] cannot be omitted if is located at the end of an upper-level query.
  Example “SCALing?” and “SCALing:STATe?” belong to different upper-level query levels.

2.2.4 Responses

On receiving a query from the controller, this instrument returns a response message to the controller. A response message is sent in one of the following two forms.

- Response consisting of a header and data
  If the query can be used as a program message without any change, a command header is attached to the query, which is then returned.

  Example `INTEGRATE:MODE?<PMT>→`
  `:INTEGRATE:MODE NORMAL<RMT>`

- Response consisting of data only
  If the query cannot be used as a program message unless changes are made to it (i.e. it is a query-only command), no header is attached and only the data is returned. Some query-only commands can be returned after a header is attached to them.

  Example `STATUS:ERROR?<PMT>→0,"NO ERROR"<RMT>`

When returning a response without a header

It is possible to remove the header from a response consisting of a header and data. The "`COMMunicate:HEADer`" command is used to do this.

Abbreviated form

Normally, the lower-case part is removed from a response header before the response is returned to the controller. Naturally, the full form of the header can also be used. For this, the "`COMMunicate:VERBose`" command is used. The part enclosed by [ ] is also omitted in the abbreviated form.

2.2.5 Data

A data section comes after the header. A space must be included between the header and the data. The data contains conditions and values. Data is classified as below.

Data	Description
<Decimal>	Value expressed as a decimal number (Example: PT setting →`CONFigure:SCALing PT:ELEMENT1 100`)
<Voltage><Current>	Physical value (Example: Voltage range →`CONFigure:VOLTage:RANge 150V`)
<Register>	Register value expressed as either binary, octal, decimal or hexadecimal (Example: Extended event register value →`STATus:EESE #HFE`)
<Character data>	Specified character string (mnemonic). Can be selected from { } (Example: Selecting measurement mode →`CONFigure:MODE {RMS|VMEan|DC}`)
<Boolean>	Indicates ON/OFF. Set to ON, OFF or value (Example: Averaging ON →`[CONFigure]:AVERaging[:STATe] ON`)
<Character string data>	Arbitrary character string (Example: Timer →`INTEGrate:TIMer "100.00"`)

<Decimal>

<Decimal> indicates a value expressed as a decimal number, as shown in the table below. Decimal values are given in the NR form specified in ANSI X3. 42-1975.

Symbol	Description	Example
<NR1>	Integer	`125 -1 +1000`
<NR2>	Fixed point number	`125.0 -.90 +001.`
<NR3>	Floating point number	`125.0E+0 -9E-1 +.1E4`
<NRf>	Any of the forms <NR1> to <NR3> is allowed.	

Decimal values which are sent from the controller to this instrument can be sent in any of the forms to <NR3>. In this case, <NRf> appears.

For response messages which are returned from this instrument to the controller, the form (<NR1> to <NR3> to be used) is determined by the query. The same form is used, irrespective of whether the value is large or small.

In the case of <NR3>, the "+" after the "E" can be omitted, but the "–" cannot.

If a value outside the setting range is entered, the value will be normalized so that it is just inside the range.

If the value has more than the significant number of digits, the value will be rounded.

<Voltage>, <Current>

<Voltage> and <Current> indicate decimal values which have physical significance. <Multiplier> or <Unit> can be attached to <NRf>. They can be entered in any of the following forms.

Form	Example
`<NRf><Multiplier><Unit>`	`5MV`
`<NRf><Unit>`	`5E-3V`
`<NRf><Multiplier>`	`5M`
`<NRf>`	`5E-3`

<Multiplier>

Multipliers which can be used are shown below.

Symbol	Word	Description
EX	Exa	10^{18}
PE	Peta	10^{15}
T	Tera	10^{12}
G	Giga	10^{9}
MA	Mega	10^{6}
K	Kilo	10^{3}
M	Mili	10^{-3}
U	Micro	10^{-6}
N	Nano	10^{-9}
P	Pico	10^{-12}
F	Femto	10^{-15}

<Unit>

Units which can be used are shown below.

Symbol	Word	Description
V	Volt	Voltage
A	Ampere	Current

<Multiplier> and <Unit> are not case sensitive.
"U" is used to indicate "μ".
"MA" is used for Mega (M) to distinguish it from Mili.
However, when using "MA" for current, Mili-ampere will be valid; therefore use "MAA" to assign Mega-ampere.
If both <Multiplier> and <Unit> are omitted, the default unit will be used.
Response messages are always expressed in <NR3> form.
Neither <Multiplier> nor <Unit> is used, therefore the default unit is used.

<Register>

<Register> indicates an integer, and can be expressed in hexadecimal, octal or binary as well as as a decimal number. <Register> is used when each bit of a value has a particular meaning. <Register> is expressed in one of the following forms.

Form	Example
<NRf>	1
#H<Hexadecimal value made up of the digits 0 to 9, and A to F>	#H0F
#Q<Octal value made up of the digits 0 to 7>	#q777
#B<Binary value made up of the digits 0 and 1>	#B001100

<Register> is not case sensitive.
Response messages are always expressed as <NR1>.

<Character Data>

<Character data> is a specified string of character data (a mnemonic). It is mainly used to indicate options, and is chosen from the character strings given in { }. For interpretation rules, refer to "Header Interpretation Rules" on page App2-5.

Form	Example
{RMS|VMEan|DC}	RMS

As with a header, the "COMMunicate:VERBose" command can be used to return a response message in its full form. Alternatively, the abbreviated form can be used.
The "COMMunicate:HEADer" command does not affect <character data>.

<Boolean>

<Boolean> is data which indicates ON or OFF, and is expressed in one of the following forms.

Form	Example
{ON|OFF|<NRf>}	ON OFF 1 0

When <Boolean> is expressed in <NRf> form, OFF is selected if the rounded integer value is "0" and ON is selected if the rounded integer is "Not 0".
A response message is always "1" if the value is ON and "0" if it is OFF.

<Character String Data>

<Character string data> is not a specified character string like <Character data>. It is an arbitrary character string. A character string must be enclosed in single quotation marks (') or double quotation marks (").

Form	Example
<Character string data>	'ABC' "IEEE488.2-1987"

Response messages are always enclosed in double quotation marks.

If a character string contains a double quotation mark ("), the double quotation mark will be replaced by two concatenated double quotation marks (""). This rule also applies to a single quotation mark within a character string.

<Character string data> is an arbitrary character string, therefore this instrument assumes that the remaining program message units are part of the character string if no single (') or double quotation mark (") is encountered. As a result, no error will be detected if a quotation mark is omitted.

2.2.6 Synchronization with the Controller

There are two kinds of command; overlap commands and sequential commands. Execution of an overlap command may start before execution of the previously sent command is completed.

For example, if the next program message is transmitted after the measurement range has been changed and an query is made about the measurement data, it may occur that regardless whether the measurement data have been updated, MEASure[:NORMal]:VALue? will be executed. The display becomes "——" (no data) and "9.91E+37 (Not a number)" will be output.

```
[CONFigure:]VOLTage:RANGe 60V;:MEASure[:NORMal:
VALue?<PMT>
```

In this case, synchronization with the time at which the update of measurement data is completed must be accomplished, as shown next.

Using STATus:CONDition? query

A "STATus:CONDition?" query is used to make an inquiry about the contents of the condition register (page App2-37). It is possible to judge whether updating measurement data is in progress or not by reading bit 0 of the condition register. Bit 0 is "1" if updating is in progress, and "0" if updating is stopped.

Using the extended event register

Changes in the condition register are reflected in the extended event register (page App2-38).

Example
```
STATus:FILTer1 FALL;:STATus:EESE 1;EESR?;
*SRE8;[:CONFigure]:VOLTage:RANGe 60V<PMT>
(Service request is awaited.)
MEASure[:NORMal]:VALue?<PMT>
```

"STATus:FILTer1 FALL" indicates that the transit filter is set so that bit 0 is set to "1" when bit 0 (FILTer 1) of the condition register is changed from "1" to "0".
"STATus:EESE 1" is a command used only to reflect the status of bit 0 of the extended event register in the status byte.
"STATus:EESR?" is used to clear the extended event register.
The "*SRE" command is used to generate a service request caused solely by the extended event register.
"MEASure[:NORMal]:VALue?" will not be executed until a service request is generated.

Using the COMMunicate:WAIT command

The "COMMunicate:WAIT" command halts communications until a specific event is generated.

Example
```
STATus:FILTer1 FALL;:STATus:EESE 1;EESR?;
[:CONFigure]:VOLTage:RANGe 60V<PMT>
(Response to STATus:EESR?is decoded.)
COMMunicate:WAIT 1;:MEASure[:NORMal]
:VALue?<PMT>
```

For a description of "STATus:FILTer 1 FALL" and "STATus:EESR?", refer to "Using the extended event register" on this page.
"COMMunicate:WAIT 1" means that communications is halted until bit 0 of the extended event register is set to "1".
"MEASure[:NORMal]:VALue?" will not be executed until bit 0 of the extended event register is set to "1".

Appendix 2.3 Commands

2.3.1 Command List

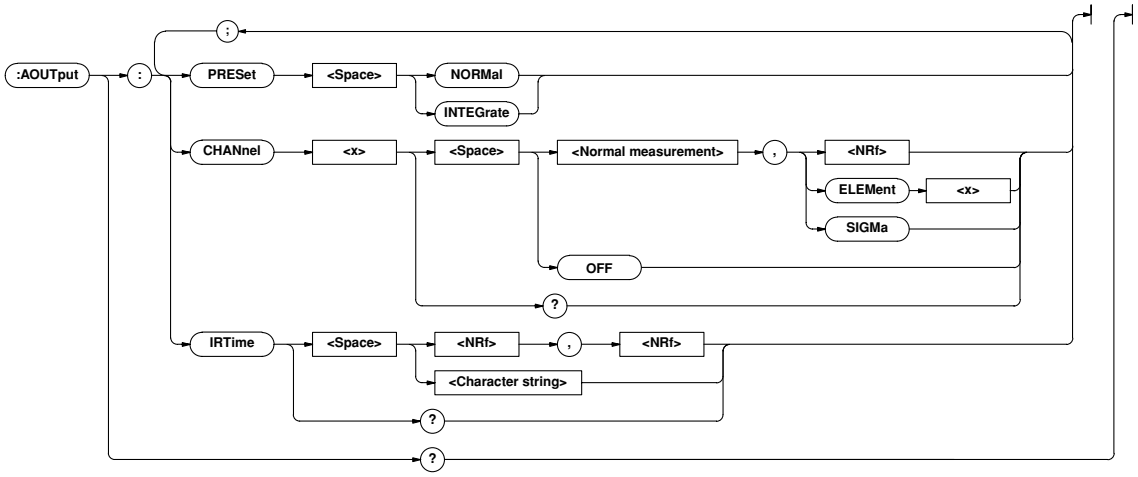
Command	Description	Page
AOUTput Group		
:AOUTput?	Queries all settings related to D/A output.	App. 2-11
:AOUTput:CHANnel<x>	Sets/queries the D/A output item.	App. 2-11
:AOUTput:IRTime	Sets/queries the preset integration time for D/A output of integrated values.	App. 2-11
:AOUTput:PRESet	Sets the default value as D/A output items.	App. 2-11
COMMunicateG roup		
:COMMunicate?	Queries all settings related to communication.	App. 2-12
:COMMunicate:HEADer	Sets/queries whether a header is to be added.	App. 2-12
:COMMunicate:LOCKout	Sets/cancels local lockout.	App. 2-12
:COMMunicate:REMote	Sets remote/local condition.	App. 2-12
:COMMunicate:STATus?	Queries the status of a specified circuit.	App. 2-13
:COMMunicate:VERBose	Sets/queries the response to be in full or abbreviated form.	App. 2-13
:COMMunicate:WAIT	Waits until one of the specified extended event occurs.	App. 2-13
:COMMunicate:WAIT?	Generates a response when on of the specified extended events occurs.	App. 2-13
CONFigure Group		
:CONFigure?	Queries all settings related to the measurement conditions.	App. 2-15
[:CONFigure]:AVERaging?	Queries all settings related to the averaging function.	App. 2-15
[:CONFigure]:AVERaging[:STATe]	Sets/queries averaging ON/OFF.	App. 2-15
[:CONFigure]:AVERaging:TYPE	Sets/queries averaging type and constant.	App. 2-15
[:CONFigure]:CURRent?	Queries all settings related to the current range.	App. 2-15
[:CONFigure]:CURRent:AUTO	Sets/queries the current auto range ON/OFF.	App. 2-15
[:CONFigure]:CURRent:ESCaling?	Queries all settings related to the external sensor.	App. 2-15
[:CONFigure]:CURRent:ESCaling[:ALL]	Sets the scaling values for the external sensor for all elements at once.	App. 2-15
[:CONFigure]:CURRent:ESCaling:ELEMent<x>	Sets/queries the scaling values for the external sensor for each element.	App. 2-15
[:CONFigure]:CURRent:RANGe	Sets/queries the current range.	App. 2-15
[:CONFigure]:FILTer	Sets/queries the filter ON/OFF.	App. 2-15
[:CONFigure]:MODE	Sets/queries the measurement mode.	App. 2-15
[:CONFigure]:SCALing?	Queries all settings related to the scaling function.	App. 2-16
[:CONFigure]:SCALing:{PT|CT|SFACtor}?	Queries all settings related to scaling value for {voltage|current|power}.	App. 2-16
[:CONFigure]:SCALing:{PT|CT|SFACtor}[:ALL]	Sets the scaling values for all elements of {voltage|current|power}.	App. 2-16
[:CONFigure]:SCALing:{PT|CT|SFACtor}:ELEMent<x>	Sets the scaling values for each element of {voltage|current|power}.	App. 2-16
[:CONFigure]:SCALing[:STATe]	Sets/queries the scaling function ON/OFF.	App. 2-16
[:CONFigure]:VOLTage?	Queries all settings related to the voltage range.	App. 2-16
[:CONFigure]:VOLTage:AUTO	Sets/queries the voltage auto range ON/OFF.	App. 2-16
[:CONFigure]:VOLTage:RANGe	Sets/queries the voltage range.	App. 2-16
[:CONFigure]:WIRing	Sets/queries the wiring method.	App. 2-16
DISPlay Group		
:DISPlay<x>?	Queries all the display settings.	App. 2-17
:DISPlay<x>:ELEMent	Sets/queries the element to be displayed.	App. 2-17
:DISPlay<x>:FUNCtion	Sets/queries the function to be displayed.	App. 2-17
:DISPlay<x>:MODE	Sets/queries the contents of the display.	App. 2-17
HARMonics Group		
:HARMonics?	Queries all settings related to harmonic analysis.	App. 2-18
:HARMonics:DISPlay?	Queries all settings related to the display in case of harmonic analysis.	App. 2-18
:HARMonics:DISPlay:ORDer	Sets/queries the order of the harmonic component to be shown on display B.	App. 2-18
:HARMonics:ELEMent	Sets/queries the element for harmonic analysis.	App. 2-18
:HARMonics[:STATe]	Sets/queries the harmonic analysis mode ON/OFF.	App. 2-18
:HARMonics:SYNChronize	Sets/queries the input to be used as PLL source.	App. 2-18
:HARMonics:THD	Sets/queries the computation method for harmonic distortion.	App. 2-18

Command	Description	Page
INTEGrate Group		
:INTEGrate?	Queries all settings related to integration.	App. 2-19
:INTEGrate:MODE	Sets/queries the integration mode.	App. 2-19
:INTEGrate:RESet	Resets the integration values.	App. 2-19
:INTEGrate:STARt	Starts integration.	App. 2-19
:INTEGrate:STOP	Stops integration.	App. 2-19
:INTEGrate:TIMer	Sets/queries the integration timer.	App. 2-19
MATH Group (applies to WT110/WT130 with ROM version 2.01 or later)		
:MATH?	Queries all settings related to the computing function.	App. 2-20
:MATH:ARIThmetic	Sets/queries the computing equation of the four arithmetic operations.	App. 2-20
:MATH:CFACtor	Sets/queries the computing equation of the crest factor.	App. 2-20
:MATH:TYPE	Sets/queries the computing equation.	App. 2-20
MEASure Group		
:MEASure?	Queries all settings related to measurement/computation data.	App. 2-22
:MEASure:HARMonics?	Queries all settings related to harmonic analysis data.	App. 2-22
:MEASure:HARMonics:ITEM?	Queries all settings related to the output items of harmonic analysis data.	App. 2-22
:MEASure:HARMonics:ITEM:PRESet	Sets the ON/OFF pattern for all communication outputs of the harmonic analysis function.	App. 2-22
:MEASure:HARMonics:ITEM:{SYNChronize|<harmonic analysis function>}	Sets/queries the communication output item of harmonic analysis ON/OFF.	App. 2-22
:MEASure:HARMonics:VALue?	Queries harmonic analysis data set by commands other than "MEASure:HARMonics:ITEM".	App. 2-22
:MEASure:NORMal?	Queries all settings related to normal measured/computed data.	App. 2-22
:MEASure[:NORMal]:ITEM?	Queries all settings related to the output items of normal measured/computed data.	App. 2-23
:MEASure[:NORMal]:ITEM:PRESet	Sets the ON/OFF pattern for all communication outputs of the normal measurement function.	App. 2-23
:MEASure[:NORMal]:ITEM:{TIME|MATH}	Sets/queries the ON/OFF state of the communication output of {integration time|MATH}	App. 2-23
:MEASure[:NORMal]:ITEM:<normal measurement function>?	Queries communication output settings of the normal measurement function.	App. 2-23
:MEASure[:NORMal]:ITEM:<normal measurement function>[:ALL]	Sets the communication output items concerning all elements or S ON/OFF at once.	App. 2-23
:MEASure[:NORMal]:ITEM:<normal measurement function>:ELEMent<x>	Sets/queries the communication output items concerning each element ON/OFF.	App. 2-23
:MEASure[:NORMal]:ITEM:<normal measurement function>:SIGMA	Sets/queries the communication output items concerning S ON/OFF.	App. 2-23
:MEASure[:NORMal]:VALue?	Queries normal measured/computed data set by commands other than "MEASure[:NORMal]:ITEM"	App. 2-23
RECall Group		
:RECall?	Queries all settings related to recalling data.	App. 2-27
:RECall:INTerval	Sets/queries the recalling interval.	App. 2-27
:RECall:PANel	Retrieves the set-up parameters file.	App. 2-27
:RECall[:STATe]	Sets/queries recalling ON/OFF.	App. 2-27

Command	Description	Page
RELay Group		
RELay?	Queries all settings related to the comparator function.	App. 2-28
:RELay:DISPLay	Sets/queries the comparator display OFF, or in case of ON, the channel to be displayed.	App. 2-28
:RELay:HCHannel<x>?	Queries all settings related to relay output items in case of harmonic analysis.	App. 2-28
:RELay:HCHannel<x>:FUNCtion	Sets/queries function of the relay output item in case of harmonic analysis.	App. 2-29
:RELay:HCHannel<x>:THReshold	Sets/queries the threshold level for the relay output item.	App. 2-29
:RELay:MODE	Sets/queries the mode of the comparator function.	App. 2-29
:RELay:NCHannel<x>?	Queries all settings related to the relay output items in case of normal measurement.	App. 2-29
:RELay:NCHannel<x>:FUNCtion	Sets/queries the function of the relay output in case of normal measurement.	App. 2-29
:RELay:NCHannel<x>:THReshold	Sets/queries the threshold level for the relay output item.	App. 2-29
:RELay:STATe	Sets/queries the comparator function ON/OFF.	App. 2-29
SAMPle Group		
:SAMPle?	Queries all settings related to sampling.	App. 2-30
:SAMPle:HOLD	Sets/queries to hold the output of data (display, communication).	App. 2-30
STATus Group		
:STATus?	Queries all settings related to the status of communication.	App. 2-31
:STATus:CONDition?	Queries the contents of the condition filter and clears it at the same time.	App. 2-31
:STATus:EESE	Sets/queries the extended event register.	App. 2-31
:STATus:EESR?	Queries the contents of the extended event register and clears it.	App. 2-31
:STATus:ERRor?	Queries the occurred error code and message.	App. 2-31
:STATus:FILTer<x>	Sets/queries the transit filter.	App. 2-31
:STATus:QMESsage	Sets/queries whether or not to apply the corresponding message to the query "STATus:ERRor?".	App. 2-31
:STATus:SPOLl?(Serial Poll)	Executes serial polling.	App. 2-31
STORe Group		
:STORe?	Queries all settings related to storing data.	App. 2-32
:STORe:INTerval	Sets/queries the interval for storing data.	App. 2-32
:STORe:PANel	Saves the set-up parameters to a file.	App. 2-32
:STORe[:STATe]	Sets/queries the store function ON/OFF.	App. 2-32
Common Command Group		
*CLS	Clears the standard event register, extended event register and error queue.	App. 2-33
*ESE	Sets/queries the value of the standard event enable register.	App. 2-33
*ESR?	Sets/queries the value of the standard event register and clears it.	App. 2-33
*IDN?	Queries the instrument model.	App. 2-33
*OPC	This command is not supported by this instrument.	App. 2-33
*OPC?	This command is not supported by this instrument, and is always "1".	App. 2-33
*OPT?	Queries installed options.	App. 2-34
*PSC	Sets/queries whether or not to clear some registers at power ON.	App. 2-34
*RST	Initializes the present settings.	App. 2-34
*SRE	Sets/queries the value of the service request enable register.	App. 2-34
*STB?	Queries the value of the status byte register.	App. 2-34
*TRG	Executes the same operation as the TRIG(SHIFT+HOLD) key.	App. 2-34
*TST?	Executes a self-test and queries the results.	App. 2-34
*WAI	This command is not supported by this instrument.	App. 2-34

2.3.2 AOUTput Group

The commands in the AOUTput group are used to make settings relating to, and inquires about D/A output. This allows you to make the same settings and inquiries as can be set using the lower menus of [OUTPUT]-"dA" or [INTEG SET]-"dAtimE".



AOUTput?

Function Queries all the settings relating to D/A output.
Syntax `AOUTput?`
Example
```
AOUTPUT?Æ:AOUTPUT:CHANNEL1 V,1;CHANNEL2 V,2;
CHANNEL3 V,3;CHANNEL4 V,SIGMA;CHANNEL5 A,1;
CHANNEL6 A,2;CHANNEL7 A,3;CHANNEL8 A,SIGMA;
CHANNEL9 W,1;CHANNEL10 W,2;CHANNEL11 W,3;
CHANNEL12 W,SIGMA;:AOUTPUT:IRTIME 1,0
```

AOUTput:CHANnel<x>

Function Sets the D/A output item, or queries the current setting.
Syntax
```
AOUTput:CHANnel<x> {<normal measurement
function>,(<NRf>|ELEMent<1-3>|SIGMa)|OFF}
<x>=1 to 12(in case of /DA12)
    1 to 4 (in case of /DA4)
<normal measurement function>={V|A|W|VA|VAR|
PF|DEGRee|VHZ|AHZ|WH|WHP|WHM|AH|AHP|AHM|MATH|
VPK|APK}
```
Example
```
AOUTPUT:CHANNEL1 V,1
AOUTPUT:CHANNEL1?→:AOUTPUT:CHANNEL1 V,1
AOUTPUT:CHANNEL2?→:AOUTPUT:CHANNEL2 OFF
```

AOUTput:IRTime

Function Sets the preset integration time for D/A output of integrated values, or queries the current setting.
Syntax
```
AOUTput:IRTime {<NRf>,<NRf>|<String>}
{<NRf>,<NRf>}=0,0 to 999,59
{<String>}=HHH:MM    HHH hour MM minutes
```
Example
```
AOUTPUT:IRTIME 1,0
AOUTPUT:IRTIME "2:00"
AOUTPUT:IRTIME?→:AOUTPUT:IRTIME 2,0
```

AOUTput:PRESet

Function Initializes the output items for D/A output.
Syntax
```
AOUTput:PREset {NORMal|INTEGrate}
NORMal= default for normal measurement
INTEGrate= default for integration
```
Example
```
AOUTPUT:PRESET NORMAL
```
Description Refer to page 10-4 for a description of default D/A output items for normal measurement and integration.

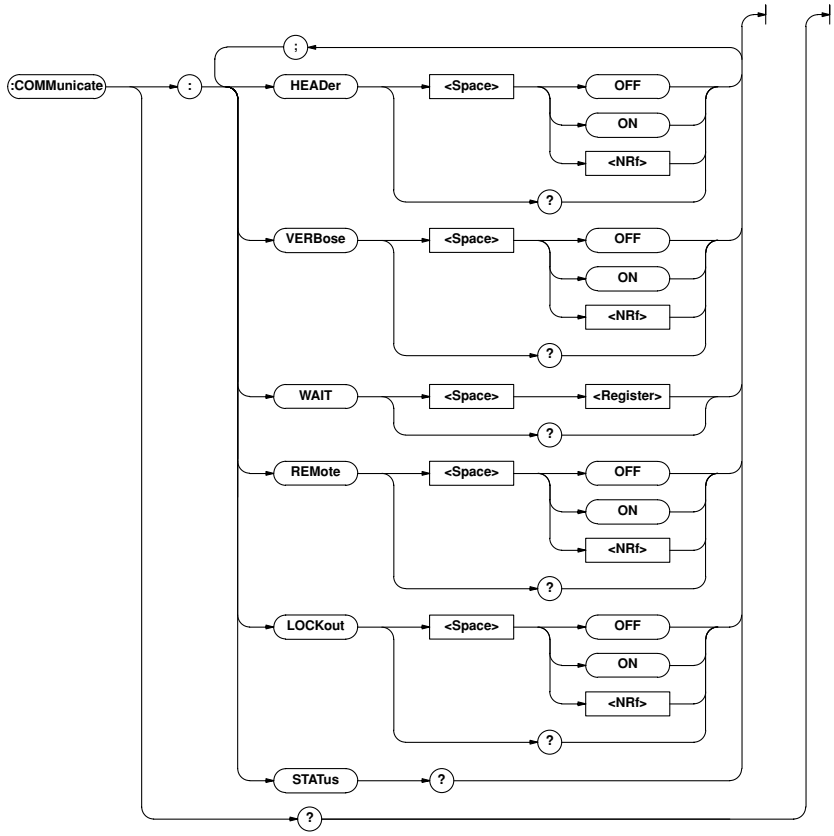
Note

In the following pages, the alphanumeric character strings used in the descriptions of the <normal measurement function> or the <harmonic analysis function> indicates the following data.

- <Normal measurement function>
  V: voltage, A: current, W: effective power, VA: apparent power, VAR: reactive power, PF: power factor, DEGRee: phase angle, VHZ: voltage frequency, AHZ: current frequency, WH: watt hour, WHP: positive watt hour, WHM: negative watt hour, AH: current hour, AHP: positive current hour, AHM: negative current hour, MATH: MATH computation result, VPK: peak voltage, APK: peak current
  However, MATH, VPK, APK applies to WT110/WT130 with ROM version 2.01 or later.
- <Harmonic analysis function>
  See page App2-25.
- Other
  TIME: integration time, ORDer: harmonic order

2.3.3 COMMunicate Group

The commands in the COMMunicate group are used to make settings relating to, and inquires about communications. There is no front panel key for this function.



COMMunicate?

Function Queries all the communication settings.
Syntax `COMMunicate?`
Example `COMMUNICATE?`
`→:COMMUNICATE:HEADER 1;VERBOSE 1`

COMMunicate:HEADer

Function Determines whether a header is to be added (for example:"`CONFIGURE:VOLTAGE:RANGE 150.0E+00`") or not (for example:`150.0E+00`) when sending a response to a query, or queries the current setting.
Syntax `COMMunicate:HEADer {<Boolean>}`
`COMMunicate:HEADer?`
Example `COMMUNICATE:HEADER ON`
`COMMUNICATE:HEADER?→:COMMUNICATE:HEADER 1`

COMMunicate:LOCKout

Function Sets local lockout ON or OFF.
Syntax `COMMunicate:LOCKout {<Boolean>}`
`COMMunicate:LOCKout?`
Example `COMMUNICATE:LOCKOUT ON`
`COMMUNICATE:LOCKOUT?→:COMMUNICATE:LOCKOUT 1`
Description This command is used for the RS-232C interface.

COMMunicate:REMote

Function Sets remote (ON) or local mode (OFF).
Syntax `COMMunicate:REMote {<Boolean>}`
`COMMunicate:REMote?`
Example `COMMUNICATE:REMOTE ON`
`COMMUNICATE:REMOTE?→:COMMUNICATE:REMOTE 1`
Description This command is used for the RS-232C interface.

COMMunicate:STATus?

Function Queries the status of a specified circuit.
Syntax COMMunicate:STATus?
Example COMMUNICATE:STATUS?→:COMMUNICATE:STATUS 0
Description The status condition for each bit is as follows.

bit	GP-IB	RS-232-C
0	permanent comm. error	Parity error
1	always 0	framing error
2	always 0	break character occurrence
3 and up	always 0	always 0

When a status occurs which results in changing of the bits, reading it will clear the error.

COMMunicate:VERBose

Function Determines whether a response to a query is to be returned in full form (for example:CONFIGURE:VOLTAGE:RANGE 150.0E+00), or in abbreviated form (for example: VOLT:RANG 150.0E+00), or queries the current setting.
Syntax COMMunicate:VERBose {<Boolean>}
COMMunicate:VERBose?
Example COMMUNICATE:VERBOSE ON
COMMUNICATE:VERBOSE?→:COMMUNICATE:VERBOSE 1

COMMunicate:WAIT

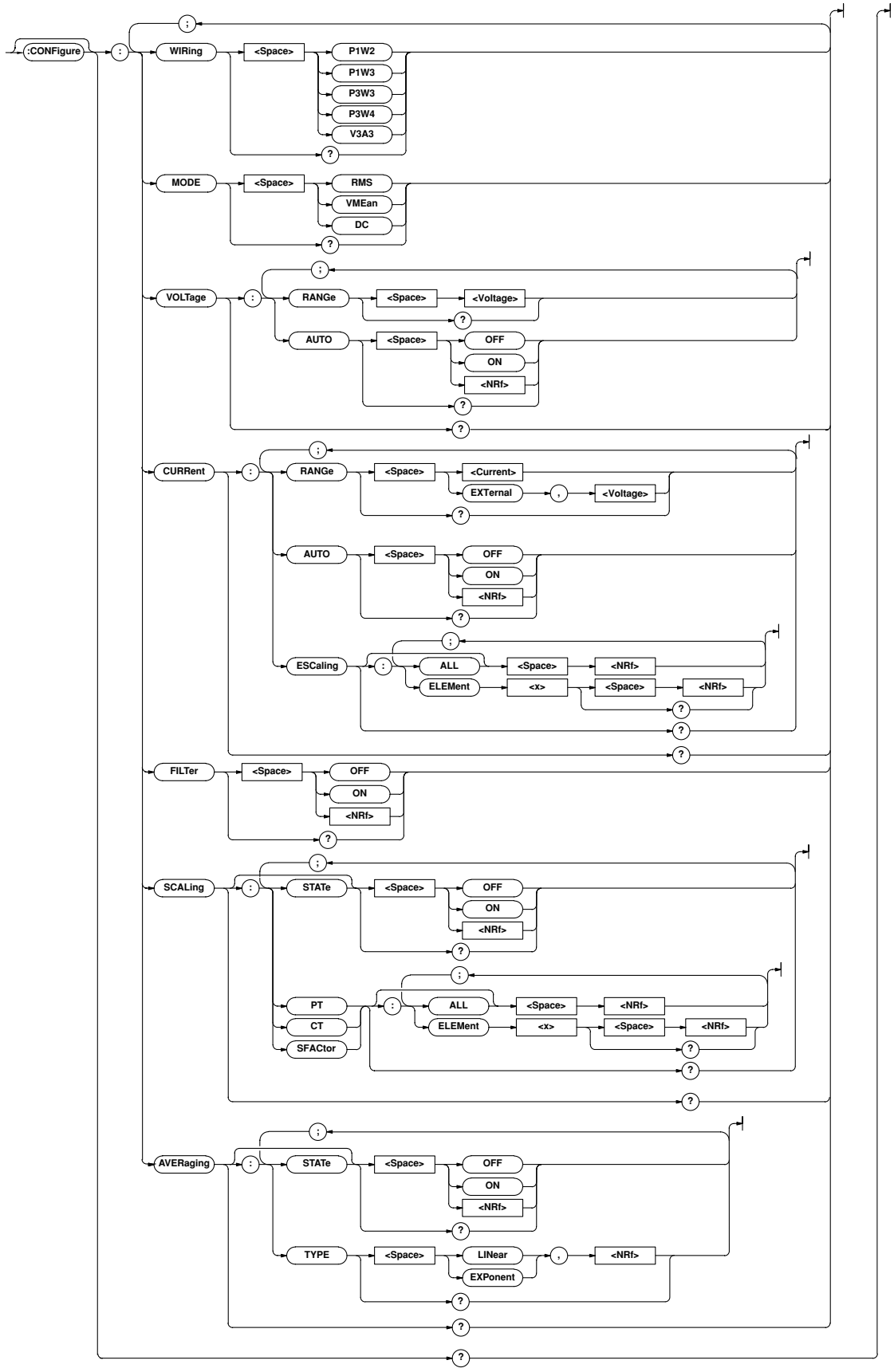
Function Waits until one of the specified extended event occurs.
Syntax COMMunicate:WAIT <Register>
<Register>= 0 to 65535 (For a description of the extended event register, refer to page App2-38.)
Example COMMUNICATE:WAIT 65535
Description For a description of synchronization using "COMMunicate:WAIT", refer to page App2-8.

COMMunicate:WAIT?

Function Generates a response when one of the specified extended events occurs.
Syntax COMMunicate:WAIT? <Register>
<Register>= 0 to 65535 (For a description of the extended event register, refer to page App2-38.)
Example COMMUNICATE:WAIT? 65535→1

2.3.4 CONFigure Group

The CONFigure group relates to the measurement settings. The same function can be performed using the WIRING key, V RANGE key, A RANGE key, MODE (SHIFT + V RANGE) key and SETUP key (except for “PnLrSt”) on the front panel. The external sensor input range and external sensor scaling values are only vald if equipped with the external sensor option (/EX1 or / EX2).



CONFigure?

Function Queries all the settings related to the measurement conditions.

Syntax CONFigure?

Example
```
CONFIGURE?→:CONFIGURE:WIRING P1W3;MODE RMS;
VOLTAGE:RANGE 600.0E+00;AUTO 1;:CONFIGURE:
CURRENT:RANGE 20.0E+00;AUTO 1;ESCALING:
ELEMENT1 50.00E+00;ELEMENT2 50.00E+00;
ELEMENT3 50.00E+00;:CONFIGURE:FILTER 0;
SCALING:STATE 0;PT:ELEMENT1 1.000E+00;
ELEMENT2 1.000E+00;ELEMENT3 1.000E+00;
:CONFIGURE:SCALING:CT:ELEMENT1 1.000E+00;
ELEMENT2 1.000E+00;ELEMENT3 1.000E+00;
:CONFIGURE:SCALING:SFACTOR:ELEMENT1 1.000E+00
;ELEMENT2 1.000E+00;ELEMENT3 1.000E+00;
:CONFIGURE:AVERAGING:STATE 0;TYPE LINEAR,8
```

[CONFigure]:AVERaging?

Function Queries all the setting values related to the averaging function.

Syntax [CONFigure]:AVERaging?

Example
```
[CONFIGURE]:AVERAGING?→:CONFIGURE:AVERAGING:
STATE 0;TYPE LINEAR,8
```

[CONFigure]:AVERaging[:STATe]

Function Sets averaging ON/OFF, or queries the current status.

Syntax
```
[CONFigure]:AVERaging[:STATe] {<Boolean>}
[CONFigure]:AVERaging:STATe?
```

Example
```
[CONFIGURE]:AVERAGING:STATE OFF
[CONFIGURE]:AVERAGING:STATE?→:CONFIGURE:
AVERAGING:STATE 0
```

[CONFigure]:AVERaging:TYPE

Function Sets the averaging type and constant, queries the current setting.

Syntax
```
[CONFigure]:AVERaging:TYPE {LINear|
EXPonent},{<NRf>}
[CONFigure]:AVERaging:TYPE?
{<NRf>}=8, 16, 32, 64 (averaging constant)
```

Example
```
[CONFIGURE]:AVERAGING:TYPE LINEAR,8
[CONFIGURE]:AVERAGING:TYPE?→:CONFIGURE:
AVERAGING:TYPE LINEAR,8
```

[CONFigure]:CURRent?

Function Queries all setting values relating to the current range (external sensor range)

Syntax [CONFigure]:CURRent?

Example
```
[CONFIGURE]:CURRENT?→:CONFIGURE:CURRENT:
RANGE 20.0E+00;AUTO 1;ESCALING:
ELEMENT1 50.00E+00;ELEMENT2 50.00E+00;
ELEMENT3 50.00E+00
```

[CONFigure]:CURRent:AUTO

Function Sets the current auto range ON/OFF, or queries the current setting.

Syntax
```
[CONFigure]:CURRent:AUTO {<Boolean>}
[CONFigure]:CURRent:AUTO?
```

Example
```
[CONFIGURE]:CURRENT:AUTO ON
[CONFIGURE]:CURRENT:AUTO?→:CONFIGURE:
CURRENT:AUTO 1
```

[CONFigure]:CURRent:ESCaling?

Function Queries all scaling values for the external sensor.

Syntax [CONFigure]:CURRent:ESCaling?

Example
```
[CONFIGURE]:CURRENT:ESCALING?→:CONFIGURE:
CURRENT:ESCALING:ELEMENT1 50.00E+00;
ELEMENT2 50.00E+00;ELEMENT3 50.00E+00
```

[CONFigure]:CURRent:ESCaling[:ALL]

Function Sets the scaling values for the external sensor for all elements at once.

Syntax
```
[CONFigure]:CURRent:ESCaling[:ALL] {<NRf>}
{<NRf>}= 0.001 to 1000
```

Example
```
[CONFIGURE]:CURRENT:ESCALING:ALL 50.00
```

Description The setting values differ as follows.
Less than 1.000 : Three digits after the floating-point are valid.
1.000 to 1000 : The first five digits are valid.

[CONFigure]:CURRent:ESCaling:ELEMent<x>

Function Sets the scaling values for the external sensor for each element separately, queries the current setting.

Syntax
```
[CONFigure]:CURRent:ESCaling:
ELEMent<x> {<NRf>}
[CONFigure]:CURRent:ESCaling:ELEMent<x>?
<x>=1     (WT110 single model)
    1, 3  (WT130 three-phase, three-wire
           model)
    1 to 3(WT130 three-phase, four-wire
           model)
{<NRf>}=0.001 to 1000
```

Example
```
[CONFIGURE]:CURRENT:ESCALING:ELEMENT1 50.00
[CONFIGURE]:CURRENT:ESCALING:ELEMENT1?→
:CONFIGURE:CURRENT:ESCALING:
ELEMENT1 50.00E+00
```

Description Setting values differ as described at [CONFigure]: CURRent:ESCaling[:ALL].

[CONFigure]:CURRent:RANGe

Function Sets the current range (external sensor input range), queries the current setting.

Syntax
```
[CONFigure]:CURRent:RANGe
          {<current>|(EXTernal,<voltage>)}
[CONFigure]:CURRent:RANGe?
<current>=500mA to 20A  (0.5, 1, 2, 5, 10,
          20A)
<voltage>=50mV to 200mV (50, 100, 200mV, for
          /EX2 option)
         =2.5V to 10V   (2.5, 5, 10V, for /
          EX1 option)
```

Example Setting of current range/query
```
[CONFIGURE]:CURRENT:RANGE 20A
[CONFIGURE]:CURRENT:RANGE?→:CONFIGURE:
CURRENT:RANGE 20.0E+00
```
Setting of external sensor input range/
query (in case of /EX2 option)
```
[CONFIGURE]:CURRENT:RANGE EXTERNAL,50MV
[CONFIGURE]:CURRENT:RANGE?→:CONFIGURE:
CURRENT:RANGE EXTERNAL,50.0E-03
```

[CONFigure]:FILTer

Function Sets the filter ON/OFF, queries the current setting.

Syntax
```
[CONFigure]:FILTer {<Boolean>}
[CONFigure]:FILTer?
```

Example
```
[CONFIGURE]:FILTER OFF
[CONFIGURE]:FILTER?→:CONFIGURE:FILTER 0
```

[CONFigure]:MODE

Function Sets the measurement mode of current and voltage, queries the current setting.

Syntax
```
[CONFigure]:MODE {RMS|VMEan|DC}
[CONFigure]:MODE?
```

Example
```
[CONFIGURE]:MODE RMS
[CONFIGURE]:MODE?→:CONFIGURE:
MODE RMS
```

[CONFigure]:SCALing?

Function Queries all settings relating to the scaling function.
Syntax `[CONFigure]:SCALing?`
Example
```
[CONFIGURE]:SCALING?→:CONFIGURE:
SCALING:STATE 0;PT:ELEMENT1 1.000E+00;
ELEMENT2 1.000E+00;ELEMENT3 1.000E+00;
:CONFIGURE:SCALING:CT:
ELEMENT1 1.000E+00;ELEMENT2 1.000E+00;
ELEMENT3 1.000E+00;:CONFIGURE:SCALING:
SFACTOR:ELEMENT1 1.000E+00;
ELEMENT2 1.000E+00;ELEMENT3 1.000E+00
```

[CONFigure]:SCALing:{PT|CT|SFACtor}?

Function Queries all scaling values related to {voltage|current|power}.
Syntax `[CONFigure]:SCALing:{PT|CT|SFACtor}?`
Example
```
[CONFIGURE]:SCALING:PT?→:CONFIGURE:SCALING:
PT:ELEMENT1 1.000E+00;ELEMENT2 1.000E+00;
ELEMENT3 1.000E+00
```

[CONFigure]:SCALing:{PT|CT|SFACtor}[:ALL]

Function Sets the scaling values for all elements of {voltage|current|power} at once.
Syntax
```
[CONFigure]:SCALing:{PT|CT|SFACtor}[:ALL]
{<NRf>}
{<NRf>}=0.001 to 1000
```
Example `[CONFIGURE]:SCALING:PT:ALL 1.000`
Description The setting values differ as follows.
Less than 1.000 : Three digits after the decimal point are valid.
1.000 to 1000 : The first five digits are valid.

[CONFigure]:SCALing:{PT|CT|SFACtor}:ELEMent<x>

Function Sets the scaling value for {voltage|current|power} of each element, queries the current setting.
Syntax
```
[CONFigure]:SCALing:{PT|CT|SFACtor}:
ELEMent<x> {<NRf>}
[CONFigure]:SCALing:{PT|CT|SFACtor}:
ELEMent<x>?
<x>=1     (WT110 single-phase model)
    1, 3  (WT130 three-phase, three-wire
           model)
    1 to 3(WT130 three-phase, four-wire
           model)
{<NRf>}=0.001 to 1000
```
Example
```
[CONFIGURE]:SCALING:PT:ELEMENT1 1.000
[CONFIGURE]:SCALING:PT:ELEMENT1?→:
CONFIGURE:SCALING:PT:ELEMENT1 1.000E+00
```
Description Setting values differ as described at `[CONFigure]:CURRent:ESCaling[:ALL]`

[CONFigure]:SCALing[:STATe]

Function Sets scaling ON/OFF, queries the current setting.
Syntax
```
[CONFigure]:SCALing[:STATe] {<Boolean>}
[CONFigure]:SCALing:STATe?
```
Example
```
[CONFIGURE]:SCALING:STATE OFF
[CONFIGURE]:SCALING:STATE?→:CONFIGURE:
SCALING:STATE 0
```

[CONFigure]:VOLTage?

Function Queries all settings relating to voltage range.
Syntax `[CONFigure]:VOLTage?`
Example
```
[CONFIGURE]:VOLTAGE?→:CONFIGURE:VOLTAGE:
RANGE 600.0E+00;AUTO 1
```

[CONFigure]:VOLTage:AUTO

Function Sets the voltage auto range ON/OFF, queries the current setting.
Syntax
```
[CONFigure]:VOLTage:AUTO {<Boolean>}
[CONFigure]:VOLTage:AUTO?
```
Example
```
[CONFigure]:VOLTage:AUTO ON
[CONFIGURE]:VOLTAGE:AUTO?→:CONFIGURE:
VOLTAGE:AUTO 1
```

[CONFigure]:VOLTage:RANGe

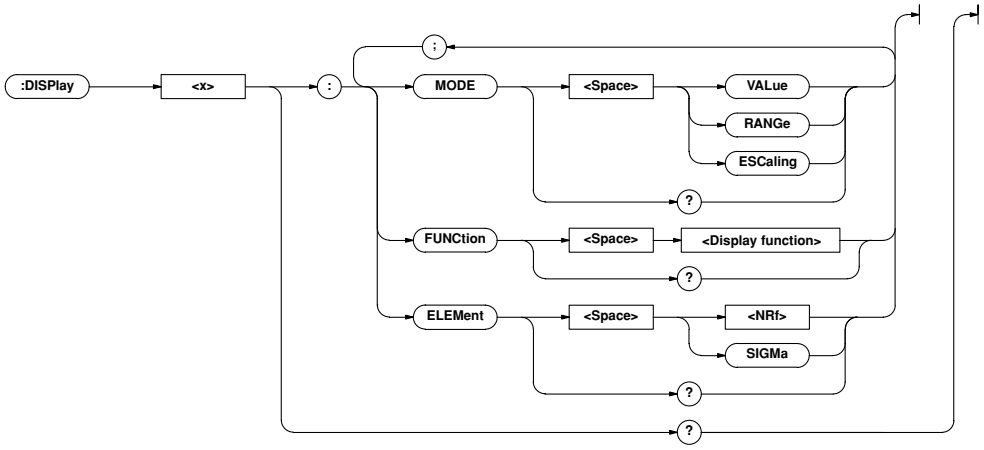
Function Sets the voltage range/queries the current setting.
Syntax
```
[CONFigure]:VOLTage:RANGe {<voltage>}
[CONFigure]:VOLTage:RANGe?
<voltage>=15V to 600V (15, 30, 60, 150, 300,
600V)
```
Example
```
[CONFIGURE]:VOLTAGE:RANGE 600V
[CONFIGURE]:VOLTAGE:RANGE?→:CONFIGURE:
VOLTAGE:RANGE 600.0E+00
```

[CONFigure]:WIRing

Function Sets the wiring method/queries the current setting.
Syntax
```
[CONFigure]:WIRing {P1W2|P1W3|P3W3|P3W4|V3A3}
[CONFigure]:WIRing?
```
Example
```
[CONFIGURE]:WIRING P1W3
[CONFIGURE]:WIRING?→:CONFIGURE:WIRING P1W3
```
Description The selections stand for the following.
P1W2 : Single-phase, two-wires (only for WT110)
P1W3 : Single-phase, three-wires (only for WT130)
P3W3 : Three-phase, three-wires (only for WT130)
P3W4 : Three-phase, four-wires (only for WT130 3-phase, 4-wire model)
V3A3 : Three-voltage, three-current (only for WT130 3-phase, 4-wire model)

2.3.5 DISPlay Group

The commands in the DISPlay group are used to make settings relating to, and inquiries about display. This allows you to make the same settings and queries as when using the FUNCTION key or ELEMENT key on the front panel.



DISPlay<x>?

Function Queries all the display settings.

Syntax
```
DISPlay<x>?
<x>=   1 to 3
       1:Display A
       2:Display B
       3:Display C
```

Example
```
DISPlay1?→:DISPLAY1:MODE VALUE;FUNCTION
V;ELEMENT 1
```

DISPlay<x>:ELEMent

Function Sets the element to be displayed/queries the current setting.

Syntax
```
DISPlay<x>:ELEMent {<NRf>|SIGMa}
DISPlay<x>:ELEMent?
<x>= 1 to 3
     1:Display A
     2:Display B
     3:Display C
{<NRf>}=1     (WT110 single-phase model)
        1, 3  (WT130 three-phase, three-wire
               model)
        1 to 3(WT130 three-phase, four-wire
               model)
```

Example
```
DISPLAY1:ELEMENT 1
DISPLAY1:ELEMENT?→:DISPLAY1:ELEMENT 1
```

DISPlay<x>:FUNCtion

Function Sets the function to be displayed/queries the current setting.

Syntax
```
DISPlay<x>:FUNCtion {<display function>}
DISPlay<x>:FUNCtion?
<x>=   1 to 3
       1:Display A
       2:Display B
       3:Display C
in case of normal measurement
<display function>=
{V|A|W|VA|VAR|PF|DEGRee|
VHZ|AHZ|WH|WHP|WHM|AH|AHP|AHM|MATH|VPK|APK|
TIME}
in case of harmonic analysis
<display function>= {V|A|W|PF|VHZ|AHZ|VTHD|
ATHD|VCON|ACON|WCON|VDEG|ADEG|ORDer}
```

Example
```
DISPLAY1:FUNCTION V
DISPLAY1:FUNCTION?→:DISPLAY1:FUNCTION V
```

Description For the meanings of the symbols of functions, see Note on page App2-11.

DISPlay<x>:MODE

Function Sets the contents of the display/queries the current setting.

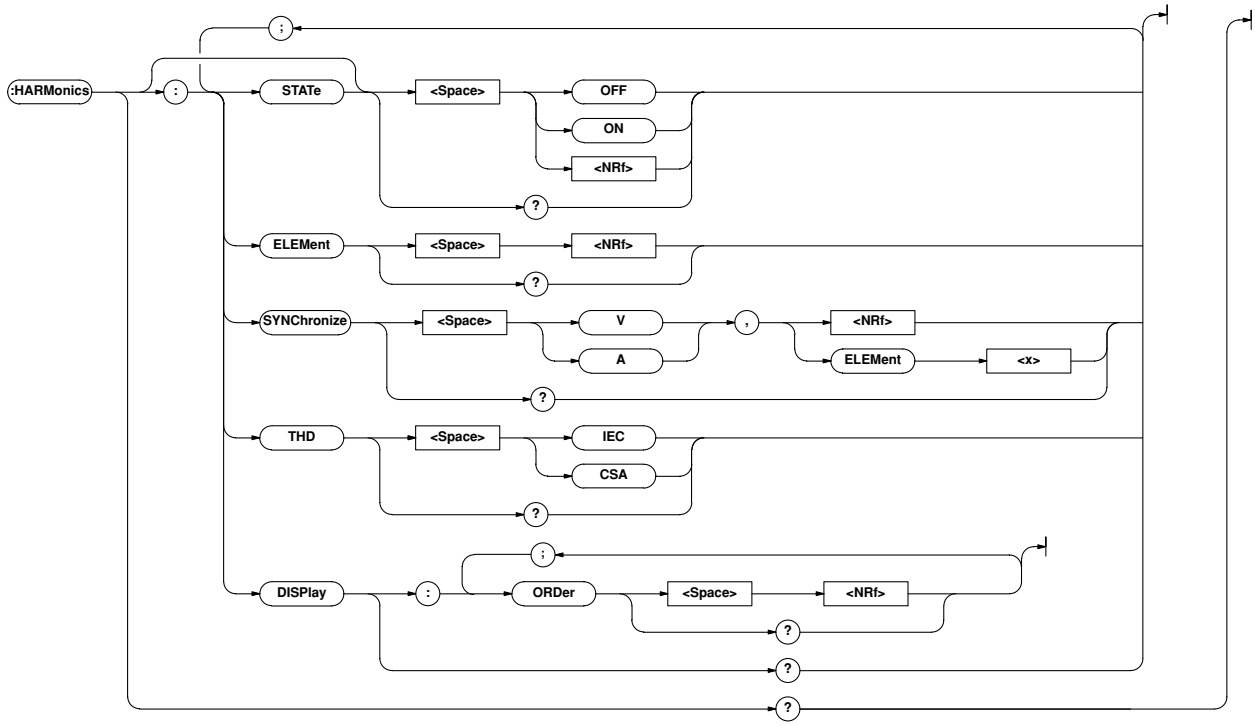
Syntax
```
DISPlay<x>:MODE {VALue|RANGe|ESCaling}
DISPlay<x>:MODE?
<x>= 1 to 3
     1:Display A
     2:Display B
     3:Display C
VALue: displays measurement data
RANGe: displays the present range of voltage
and current, or the scaling values of the
external sensor of element 1.
ESCaling: displays the scaling values of the
current external sensor
```

Example
```
DISPLAY1:MODE VALUE
DISPLAY1:MODE?→:DISPLAY1:MODE VALUE
```

Description <x> will be ignored. The contents of all the displays 1 to 3 will be received.

2.3.6 HARMonics Group

The commands in the HARMonics group relate to the harmonic analysis function. This allow you to make the same settings and inquiries as when using the HARMONICS key on the front panel and the corresponding menus. This group is only useful in case your instrument is equipped with the /HRM option.



HARMonics?

Function Queries all settings relating to harmonic analysis.
Syntax `HARMonics?`
Example `HARMONICS?→:HARMONICS:STATE 0;ELEMENT 1;SYNCHRONIZE V,1;THD IEC;DISPLAY:ORDER 1`

HARMonics:DISPlay?

Function Queries all settings concerning the display in case of harmonic analysis.
Syntax `HARMonics:DISPlay?`
Example `HARMONICS:DISPLAY?`
`HARMONICS:DISPLAY?→:HARMONICS:DISPLAY:ORDER 1`

HARMonics:DISPlay:ORDer

Function Sets the order of the harmonic component to be shown on display B, queries the current setting.
Syntax `HARMonics:DISPlay:ORDer {<NRf>}`
`HARMonics:DISPlay:ORDer?`
`{<NRf>}=1 to 50`
Example `HARMONICS:DISPLAY:ORDER 1`
`HARMONICS:DISPLAY:ORDER?→:HARMONICS:DISPLAY:ORDER 1`

HARMonics:ELEMent

Function Sets the element for harmonic analysis/queries the current setting.
Syntax `HARMonics:ELEMent {<NRf>}`
`HARMonics:ELEMent?`
`{<NRf>}=1 (WT110 single-phase model)`
`1, 3 (WT130 three-phase, three-wire model)`
`1 to 3(WT130 three-phase, four-wire model)`
Example `HARMONICS:ELEMENT 1`
`HARMONICS:ELEMENT?→:HARMONICS:ELEMENT 1`

HARMonics[:STATe]

Function Sets the harmonic analysis mode ON/OFF, queries the current setting.
Syntax `HARMonics[:STATe] {<Boolean>}`
`HARMonics[:STATe]?`
Example `HARMONICS:STATE ON`
`HARMONICS:STATE?→:HARMONICS:STATE 1`

HARMonics:SYNChronize

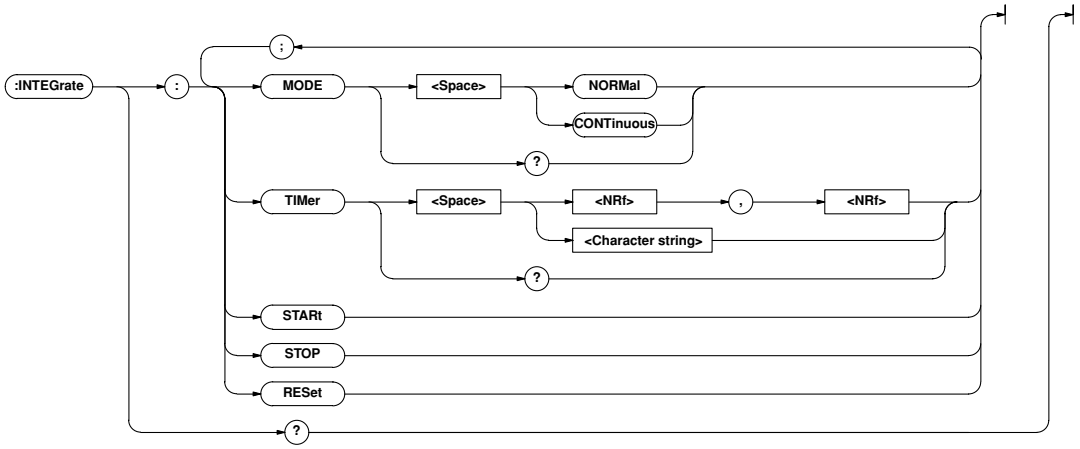
Function Sets the fundamental frequency for PLL synchronization (PLL source)/queries the current setting.
Syntax `HARMonics:SYNChronize {(V|A),(<NRf>|ELEMent<1-3>)}`
`HARMonics:SYNChronize?`
Example `HARMONICS:SYNCHRONIZE V,1`
`HARMONICS:SYNCHRONIZE?→:HARMONICS:SYNCHRONIZE V,1`

HARMonics:THD

Function Sets the computation method for harmonic distortion (THD) for harmonic analysis/queries the current setting.
Syntax `HARMonics:THD {IEC|CSA}`
`HARMonics:THD?`
Example `HARMONICS:THD IEC`
`HARMONICS:THD?→:HARMONICS:THD IEC`

2.3.7 INTEGrate Group

The commands in the INTEGrate group are used to make settings relating to, and inquiries about integration. This allows you to make the same settings and inquiries as when using the START key, STOP key, RESET key, INTEG SET key and their corresponding menus.



INTEGrate?

Function Queries all settings relating to integration.
Syntax `INTEGrate?`
Example `INTEGRATE?→:INTEGRATE:MODE NORMAL;TIMER 0,0`

INTEGrate:MODE

Function Sets the integration mode/queries the current setting.
Syntax `INTEGrate:MODE {NORMal|CONTinuous}`
`INTEGrate:MODE?`
Example `INTEGRATE:MODE NORMAL`
`INTEGRATE:MODE?→:INTEGRATE:MODE NORMAL`

INTEGrate:RESet

Function Resets the integrated values.
Syntax `INTEGrate:RESet`
Example `INTEGRATE:RESET`

INTEGrate:STARt

Function Starts integration.
Syntax `INTEGrate:STARt`
Example `INTEGRATE:START`

INTEGrate:STOP

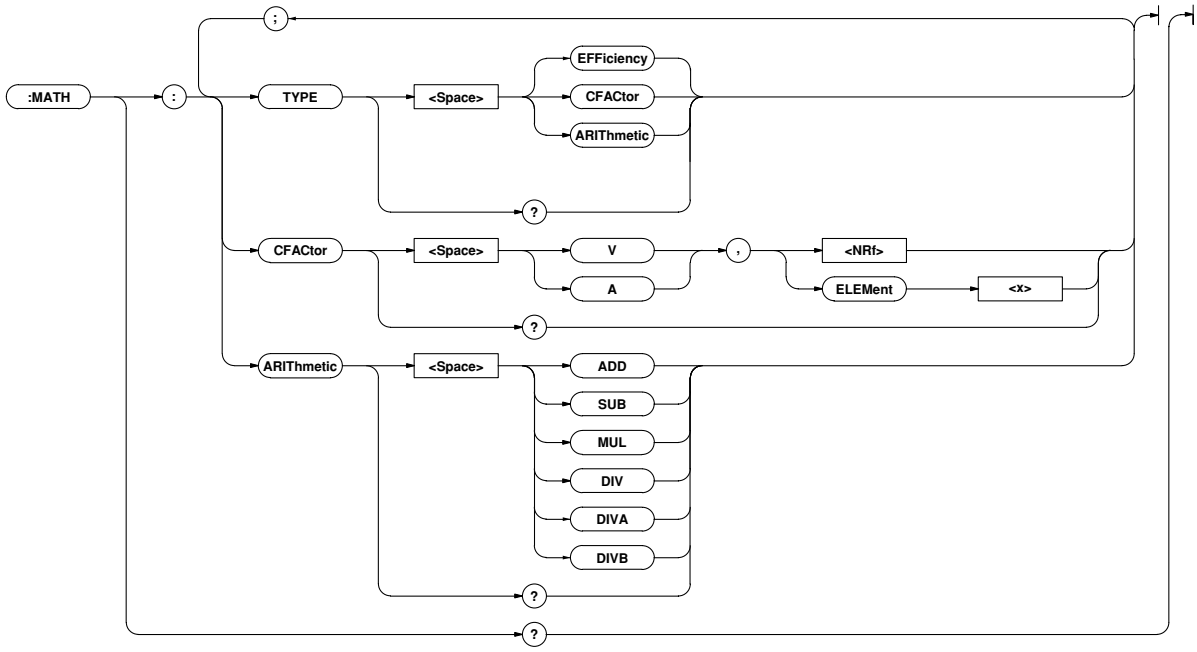
Function Stops integration.
Syntax `INTEGrate:STOP`
Example `INTEGRATE:STOP`

INTEGrate:TIMer

Function Sets the integration timer/queries the current setting.
Syntax `INTEGrate:TIMer {<NRf>,<NRf>|<String>}`
`{<NRf>,<NRf>}=0,0 to 999,59`
`{<String>}=HHH:MM HHH hour MM minute`
Example `INTEGRATE:TIMER 10,0`
`INTEGRATE:TIMER “10:00“`
`INTEGRATE:TIMER?→:INTEGRATE:TIMER 10,0`

2.3.8 MATH Group (applies to WT110/WT130 with ROM version 2.01 or later)

The commands in the MATH group are used to make settings relating to, and to make inquiries about the computing function. The same function can be performed using the "MATH" menu of the [SETUP] key of the front panel.



MATH?

Function Queries all settings related to the computing function
Syntax `MATH?`
Example `MATH?→:MATH:TYPE ARITHMETIC;ARITHMETIC ADD`

MATH:ARIThmetic

Function Sets/queries the computing equation of the four arithmetic operations.
Syntax
```
MATH:ARIThmetic
{ADD|SUB|MUL|DIV|DIVA|DIVB}
MATH:ARIThmetic?
```
Example
```
MATH:ARITHMETIC ADD
MATH:ARITHMETIC?→:MATH:ARITHMETIC ADD
```
Description If [MATH:TYPE] is not set to [ARIThmetic], this command will be meaningless. The computing equation selections are as follows:

ADD : display A + display B
SUB : display A – display B
MUL : display A X display B
DIV : display A / display B
DIVA : display A / (display B)^2
DIVB : (display A)^2 / display B

MATH:CFACtor

Function Sets/queries the computing equation of the crest factor
Syntax
```
MATH:CFACtor
{(V|A),(<NRf>|ELEMent<x>)}
<x>= 1      (WT110 single-phase model)
     1, 3   (WT130 three-phase three-wire
             model)
     1 to 3 (WT130 three phase four-wire
             model)
MATH:CFACtor?
```
Example
```
MATH:CFACTOR V,1
MATH:CFACTOR?→:MATH:CFACTOR V,1
```
Description If [MATH:TYPE] is not set to [CFACtor], this command will be meaningless.

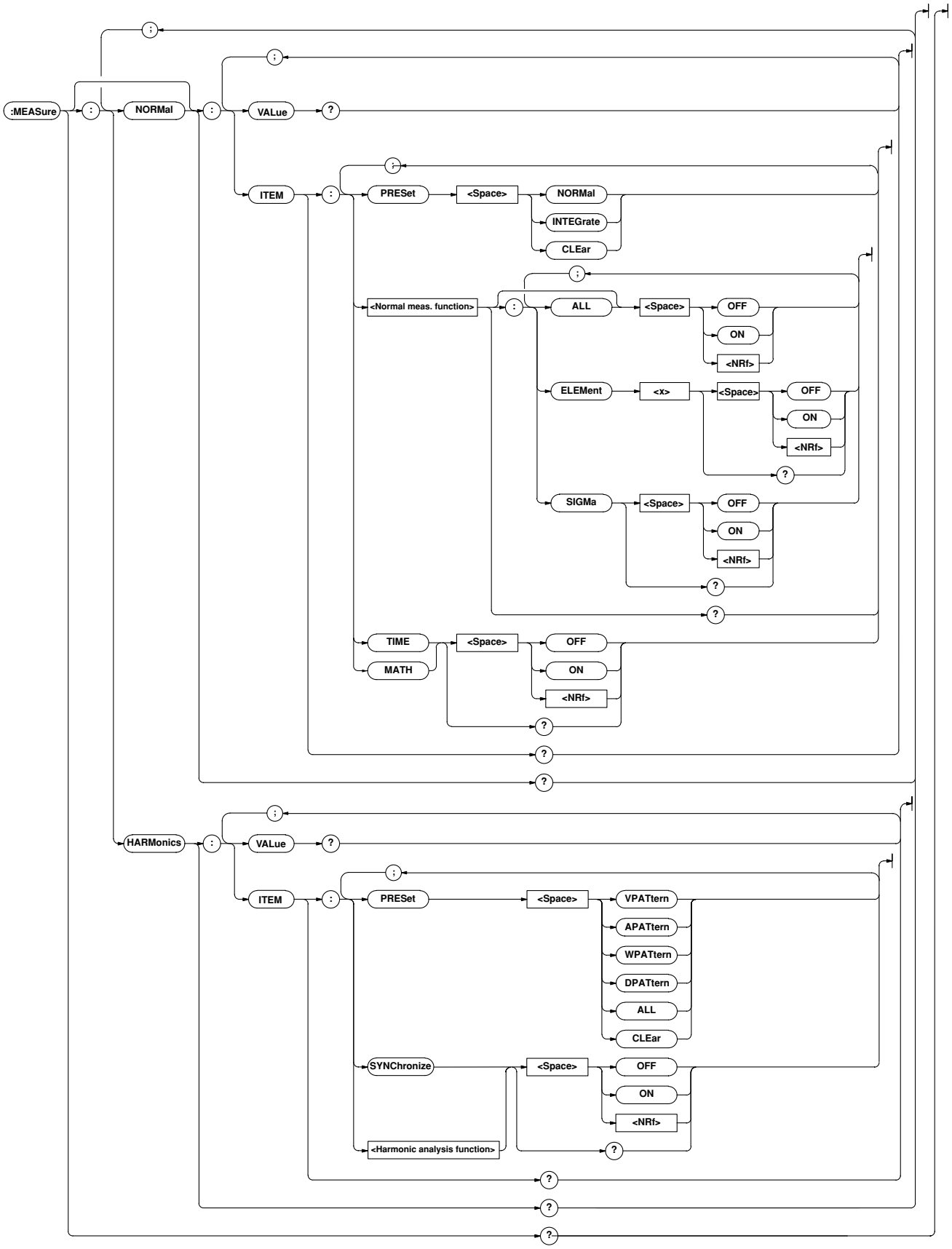
MATH:TYPE

Function Sets/queries the computing equation
Syntax
```
MATH:TYPE
{EFFiciency|CFACtor|ARIThmetic}
MATH:TYPE?
```
Example
```
MATH:TYPE CFACTOR
MATH:TYPE?→:MATH:TYPE CFACTOR
```
Description The equation method selections are as follows:

EFFiciency : Efficiency (valid only for WT130)
CFACtor : Crest factor
ARIThmetic : Four arithmetic operations

2.3.9 MEASure Group

The MEASure group relates to measurement/computation data. There are no front panel keys for these functions. Also, your instrument must be equipped with the /HRM (harmonic analysis function) to be able to use the related commands. Setting the output items for measurement/computation data is only valid in the communication mode.



MEASure?

Function Queries all the settings related to measurement/computation data.

Syntax MEASure?

Example Example of WT130 three-phase four-wire model (ROM version 2.01)

```
MEASURE?→:MEASURE:NORMAL:ITEM:V:ELEMENT1 1;
ELEMENT2 1;ELEMENT3 1;SIGMA 1;:MEASURE:
NORMAL:ITEM:A:ELEMENT1 1;ELEMENT2 1;
ELEMENT3 1;SIGMA 1;:MEASURE:NORMAL:ITEM:W:
ELEMENT1 1;ELEMENT2 1;ELEMENT3 1;SIGMA 1;:
MEASURE:NORMAL:ITEM:VA:ELEMENT1 0;ELEMENT2 0;
ELEMENT3 0;SIGMA 0;:MEASURE:NORMAL:ITEM:VAR:
ELEMENT1 0;ELEMENT2 0;ELEMENT3 0;SIGMA 0;:
MEASURE:NORMAL:ITEM:PF:ELEMENT1 0;
ELEMENT2 0;ELEMENT3 0;SIGMA 0;:MEASURE:
NORMAL:ITEM:DEGREE:ELEMENT1 0;ELEMENT2 0;
ELEMENT3 0;SIGMA 0;:MEASURE:NORMAL:ITEM:VHZ:
ELEMENT1 0;ELEMENT2 0;ELEMENT3 0;SIGMA 0;:
MEASURE:NORMAL:ITEM:AHZ:ELEMENT1 0;
ELEMENT2 0;ELEMENT3 0;SIGMA 0;:MEASURE:
NORMAL:ITEM:WH:ELEMENT1 0;ELEMENT2 0;
ELEMENT3 0;SIGMA 0;:MEASURE:NORMAL:ITEM:WHP:
ELEMENT1 0;ELEMENT2 0;ELEMENT3 0;SIGMA 0;:
MEASURE:NORMAL:ITEM:WHM:ELEMENT1 0;
ELEMENT2 0;ELEMENT3 0;SIGMA 0;:MEASURE:
NORMAL:ITEM:AH:ELEMENT1 0;ELEMENT2 0;
ELEMENT3 0;SIGMA 0;:MEASURE:NORMAL:ITEM:AHP:
ELEMENT1 0;ELEMENT2 0;ELEMENT3 0;SIGMA 0;:
MEASURE:NORMAL:ITEM:AHM:ELEMENT1 0;
ELEMENT2 0;ELEMENT3 0;SIGMA 0;:MEASURE:
NORMAL:ITEM:VPK:ELEMENT1 0;ELEMENT2 0;
ELEMENT3 0;SIGMA 0;:MEASURE:NORMAL:ITEM:APK:
ELEMENT1 0;ELEMENT2 0;ELEMENT3 0;SIGMA 0;:
MEASURE:NORMAL:ITEM:TIME 0;MATH 0;:MEASURE:
HARMONICS:ITEM:SYNCHRONIZE 1;VTHD 1;V 1;
VCON 1;ATHD 0;A 0;ACON 0;PF 0;W 0;WCON 0;
VDEG 0;ADEG 0
```

MEASure:HARMonics?

Function Queries all settings related to harmonic analysis data.

Syntax MEASure:HARMonics?

Example

```
MEASURE:HARMONICS?→:MEASURE:HARMONICS:ITEM:
SYNCHRONIZE 1;VTHD 1;V 1;VCON 1;ATHD 0;A 0;
ACON 0;PF 0;W 0;WCON 0;VDEG 0;ADEG 0
```

MEASure:HARMonics:ITEM?

Function Queries all settings related to the communication output items of harmonic analysis data.

Syntax MEASure:HARMonics:ITEM?

Example MEASURE:HARMONICS:ITEM?→(Same result as for MEASure:HARMonics?)

MEASure:HARMonics:ITEM:PRESet

Function Sets the ON/OFF pattern for all communication outputs of the harmonic analysis function.

Syntax MEASure:HARMonics:ITEM:PRESet {VPATtern|APATtern|WPATtern|DPATtern|ALL|CLEar}

Example MEASURE:HARMONICS:ITEM:PRESET VPATTERN

Description The following six patterns can be selected.

```
VPATtern:SYNChronize/VTHD/V/VCON→ON,
          others→ OFF
APATtern:SYNChronize/ATHD/A/ACON→ON,
          others→ OFF
WPATtern:SYNChronize/PF/W/WCON→ON,
          others→ OFF
DPATtern:SYNChronize/VDEG/ADEG→ON,
          others→ OFF
ALL      :all items→ ON
CLEar    :all items→ OFF
```

MEASure:HARMonics:ITEM:{SYNChronize|<harmonic analysis function>}

Function Sets the communication output item of harmonic analysis ON/OFF, queries the current setting.

Syntax

```
MEASure:HARMonics:ITEM:{SYNChronize|
<harmonic analysis function>} {<Boolean>}
MEASure:HARMonics:ITEM:{SYNChronize|
<harmonic analysis function>}?
<harmonic analysis function>={VTHD|V|VCON|
ATHD|A|ACON|PF|W|WCON|VDEG|ADEG}
SYNChronize=PLL source
```

Example

```
MEASURE:HARMONICS:ITEM:VTHD ON
MEASURE:HARMONICS:ITEM:VTHD?→:MEASURE:
HARMONICS:ITEM:VTHD 1
```

Description The selection SYNChronize is for outputting the frequency of the PLL source.
You can query the PLL source input by the command HARMonics:SYNChronize?

MEASure:HARMonics:VALue?

Function Queries harmonic analysis data set by commands other than"MEASure:HARMonics:ITEM".

Syntax MEASure:HARMonics:VALue?

Example

```
MEASURE:HARMONICS:VALUE?→60.00E+00,
12.01E+00,49.98E+00,49.62E+00,0.03E+00,
5.50E+00,.....
```

Description
- The renewal of harmonic analysis data output here occurs when bit0 (UPD) of the condition register (refer to page App2-38) changes from high to low. For more details, refer to 2.2.6.
- For the output format of harmonic analysis data, refer to page App2-25.

MEASure:NORMal?

Function Queries all settings related to normal measured/computed data.

Syntax MEASure:NORMal?

Example Example of WT130 three-phase four-wire model (ROM version 2.01)

```
MEASURE:NORMAL?→:MEASURE:NORMAL:ITEM:V:
ELEMENT1 1;ELEMENT2 1;ELEMENT3 1;SIGMA 1;
:MEASURE:NORMAL:ITEM:A:ELEMENT1 1;ELEMENT2 1;
ELEMENT3 1;SIGMA 1;:MEASURE:NORMAL:ITEM:W:
ELEMENT1 1;ELEMENT2 1;ELEMENT3 1;SIGMA 1;
:MEASURE:NORMAL:ITEM:VA:ELEMENT1 0;
ELEMENT2 0;ELEMENT3 0;SIGMA 0;:MEASURE:
NORMAL:ITEM:VAR:ELEMENT1 0;ELEMENT2 0;
ELEMENT3 0;SIGMA 0;:MEASURE:NORMAL:ITEM:PF:
ELEMENT1 0;ELEMENT2 0;ELEMENT3 0;SIGMA 0;
:MEASURE:NORMAL:ITEM:DEGREE:ELEMENT1 0;
ELEMENT2 0;ELEMENT3 0;SIGMA 0;:MEASURE:
NORMAL:ITEM:VHZ:ELEMENT1 0;ELEMENT2 0;
ELEMENT3 0;SIGMA 0;:MEASURE:NORMAL:ITEM:AHZ:
ELEMENT1 0;ELEMENT2 0;ELEMENT3 0;SIGMA 0;
:MEASURE:NORMAL:ITEM:WH:ELEMENT1 0;
ELEMENT2 0;ELEMENT3 0;SIGMA 0;:MEASURE:
NORMAL:ITEM:WHP:ELEMENT1 0;ELEMENT2 0;
ELEMENT3 0;SIGMA 0;:MEASURE:NORMAL:ITEM:WHM:
ELEMENT1 0;ELEMENT2 0;ELEMENT3 0;SIGMA 0;
:MEASURE:NORMAL:ITEM:AH:ELEMENT1 0;
ELEMENT2 0;ELEMENT3 0;SIGMA 0;:MEASURE:
NORMAL:ITEM:AHP:ELEMENT1 0;ELEMENT2 0;
ELEMENT3 0;SIGMA 0;:MEASURE:NORMAL:ITEM:AHM:
ELEMENT1 0;ELEMENT2 0;ELEMENT3 0;SIGMA 0;
:MEASURE:NORMAL:ITEM:VPK:ELEMENT1 0;
ELEMENT2 0;ELEMENT3 0;SIGMA 0;:MEASURE:
NORMAL:ITEM:APK:ELEMENT1 0;ELEMENT2 0;
ELEMENT3 0;SIGMA 0;:MEASURE:NORMAL:ITEM:
TIME 0;MATH 0
```

MEASure[:NORMal]:ITEM?

Function Queries all settings related to the communication output items of normal measured/computed data.
Syntax `MEASure[:NORMal]:ITEM?`
Example `MEASURE:NORMAL:ITEM?→(Results are the same as for MEASure:NORMal? )`

MEASure[:NORMal]:ITEM:PRESet

Function Sets the ON/OFF pattern for all communication outputs of the normal measurement function.
Syntax `MEASure[:NORMal]:ITEM:PRESet {NORMal|INTEGrate|CLEar}`
Example `MEASURE:NORMAL:ITEM:PRESET NORMAL`
Description The following three patterns can be selected. The same setting applies to the current all elements or Σ.
`NORMal` : V/A/W→ON, others→OFF
`INTEGrate` : W/WH/AH/TIME→ON, others→OFF
`CLEar` : all items→OFF

MEASure[:NORMal]:ITEM:{TIME|MATH}

Function Sets the communication output of {integration elasped time|MATH} ON/OFF, queries about the current setting.
Syntax `MEASure[:NORMal]:ITEM:{TIME|MATH} {<Boolean>}`
`MEASure[:NORMal]:ITEM:{TIME|MATH}?`
Example `MEASURE:NORMAL:ITEM:TIME OFF`
`MEASURE:NORMAL:ITEM:TIME?→:MEASURE:NORMAL:ITEM:TIME 0`

MEASure[:NORMal]:ITEM:<normal measurement function>?

Function Queries communication output settings of the normal measurement function.
Syntax `MEASure[:NORMal]:ITEM:<normal measurement function>?`
`<normal measurement function>={V|A|W|VA|VAR|PF|DEGRee|VHZ|AHZ|WH|WHP|WHM|AH|AHP|AHM|VPK|APK}`
Example `MEASURE:NORMAL:ITEM:V?→:MEASURE:NORMAL:ITEM:V:ELEMENT1 1;ELEMENT2 1;ELEMENT3 1;SIGMA 1`
Description For the meanings of the symbols of functions, see Note on page App2-11.

MEASure[:NORMal]:ITEM:<normal measurement function>[:ALL]

Function Sets the communication output concerning all elements or Σ ON/OFF at once.
Syntax `MEASure[:NORMal]:ITEM:<normal measurement function>[:ALL] {<Boolean>}`
Example `MEASURE:NORMAL:ITEM:V:ALL ON`

MEASure[:NORMal]:ITEM:<normal measurement function>:ELEMent<x>

Function Sets the communication output concerning each element ON/OFF, queries the current setting.
Syntax `MEASure[:NORMal]:ITEM:<normal measurement function>:ELEMent<x> {<Boolean>}`
`MEASure[:NORMal]:ITEM:<normal measurement function>:ELEMent<x>?`
Example `MEASURE:NORMAL:ITEM:V:ELEMENT1 ON`
`MEASURE:NORMAL:ITEM:V:ELEMENT?→:MEASURE:NORMAL:ITEM:V:ELEMENT1 1`

MEASure[:NORMal]:ITEM:<normal measurement function>:SIGMa

Function Sets the communication output concerning Σ ON/OFF, queries the current setting.
Syntax `MEASure[:NORMal]:ITEM:<normal measurement function>:SIGMa {<Boolean>}`
`MEASure[:NORMal]:ITEM:<normal measurement function>:SIGMa?`
Example `MEASURE:NORMAL:ITEM:V:SIGMA ON`
`MEASURE:NORMAL:ITEM:V:SIGMA?→: MEASURE:NORMAL:ITEM:V:SIGMA 1`

MEASure[:NORMal]:VALue?

Function Queries normal measured/computed data set by commands other than "`MEASure[:NORMal]:ITEM`".
Syntax `MEASure[:NORMal]:VALue?`
Example `MEASURE:NORMAL:VALUE?→`
`10.04E+00,10.02E+00, 10.03E+00,49.41E+00,...`
Description
- The renewal of normal measured/computed data output here occures when bit0 (UPD) of the condition register (refer to page App2-38) changes from high to low. For more details, refer to 2.2.6.
- For the output format of normal measured/computed data, refer to page App2-24.
- When the harmonic analysis function is ON, harmonic analysis data will be returned.

Output Format/Data Format of Normal Measured/Computed Data and Harmonic Analysis Data

The output format/data format of normal measured/computed data and harmonic analysis data which is requested by MEASure[:NORMal]:VALue? or MEASure:HARMonics:VALue?, is as follows.

Data Format of Normal Measured/Computed Data

- All data of the <harmonic analysis function> are output in the <NR3> format.
  (Example) 99.99E+00
  V,A,W,VA,VAR,PF,DEGR,VHZ,AHZ,VPK,APK,MATH →mantissa: max. 4 digits + exponent: 2 digits
  WH,WHP,WHM,AH,AHP,AHM →mantissa: max. 6 digits + exponent: 2 digits
  (max. 5 digits in case of negative value)
- The sign of the mantissa will only be applied in case of negative values. However, phase lead and lag (in case of phase angle (DEG)) will be shown as follows.
  LEAD → +180.0E+00
  LAG → -180.0E+00
  in phase → 0.0E+00(The mantissa will be proceeded by a space)
- In case of overrange or computation over,"9.9E+37"(+∞) will be output.
  (i.e. in case the display shows –oL–, –oF–, PFErr, dEGEr, ErrLo, or ErrHi)
- In case no data is present (i.e. the display shows – – – – –), "9.91E+37" (NAN) will be output.
- The integration elasped time is output as hours, minutes, seconds in the <NR1> format.
  (Example) 999,59,59

Output Format of Normal Measured/Computed Data

The communication output is set ON by any of the commands starting with "MEASure[:NORMal]:ITEM" and the normal measured/computed data or integration elasped time are output according to the following order of priority. Besides, in case of recalling normal measurement or integration data, the data number will be output in <NR1> format as well. Data will be output in the following order corresponding to each element. However, note that for model 253401 only element 1 is valid, and for model 253502 only element 1, 3 and Σ are valid.

(0. Data number in case of recalling)

1. V1	→V2	→V3	→VΣ
2. A1	→A2	→A3	→AΣ
3. W1	→W2	→W3	→WΣ
4. VA1	→VA2	→VA3	→VAΣ
5. VAR1	→VAR2	→VAR3	→VARΣ
6. PF1	→PF2	→PF3	→PFΣ
7. DEGR1	→DEGR2	→DEGR3	→DEGRΣ
8. VHZ1	→VHZ2	→VHZ3	→VHZΣ
9. AHZ1	→AHZ2	→AHZ3	→AHZΣ
10. WH1	→WH2	→WH3	→WHΣ
11. WHP1	→WHP2	→WHP3	→WHPΣ
12. WHM1	→WHM2	→WHM3	→WHMΣ
13. AH1	→AH2	→AH3	→AHΣ
14. AHP1	→AHP2	→AHP3	→AHPΣ
15. AHM1	→AHM2	→AHM3	→AHMΣ

16. TIME (integration elasped time)

Each data is divided by a comma"," and is ended by the terminator <RMT>.

Output Example of Normal Measured/Computed Data

- Output example for model 253502 after having sent the following commands.

(Sent) MEASURE:NORMAL:ITEM:PRESET NORMAL
MEASURE:NORMAL:VALUE?

(Received data) 10.04E+00,10.02E+00,10.03E+00,49.41E+00,49.52E+00,
49.47E+00,429.0E+00,429.2E+00,0.858E+03

(Data contents)

V1:10.04E+00	V3:10.02E+00	VΣ:10.03E+00
A1:49.41E+00	A3:49.52E+00	AΣ:49.47E+00
W1:429.0E+00	W3:429.2E+00	WΣ:0.858E+03

• Output example for model 253503 where measurement data first have been stored during integration, and while recalling these data, the following commands have been sent.

(Sent) `MEASURE:NORMAL:ITEM:PRESET INTEGRATE`
`MEASURE:NORMAL:VALUE?`

(Received data) `10,428.6E+00,428.1E+00,428.8E+00,1.285E+03,71.45E+00,`
`71.37E+00,71.49E+00,214.31E+00,8.2342E+00,8.2354E+00,`
`8.2519E+00,24.721E+00,0,10,0`

(Data contents)

Recalled data number: 10

`W1:10.428E+00 W2:428.1E+00 W3:428.8E+00 W∑:1.285E+03`
`WH1:71.45E+00 WH2:71.37E+00 WH3:71.49E+00 WH∑:214.31E+00`
`AH1:8.2342E+00 AH2:8.2354E+00 AH3:8.2519E+00 AH∑:24.721E+00`

Integration preset time: 0 (hours), 10 (minutes), 0 (seconds)

Data Format of Harmonic Analysis

All data will be output in the <NR3> format. (mantissa: max. 4 digits + exponent: 2 digits)

Output Format of Harmonic Analysis

The communication output is set ON by any of the commands starting with "`MEASure:HARMonics:ITEM`" and the harmonic measurement data or frequency of PLL source (SYNChronize) are output according to the following order of priority. Besides, in case of recalling normal measurement or integration data, the data number will be output in <NR1> format as well.

(`0`.Data number in case of recalling)
`1`.Frequency of PLL source (SYNChronize)

`2.VTHD`	`3.V`	`4.VCON`	`5.ATHD`	`6.A`	`7.ACON`
`8.PF`	`9.W`	`10.WCON`	`11.VDEG`	`12.ADEG`	

Harmonic analysis data will be output for all applicable elements. To find out to which element the data correspond, use the `HARMonics:ELEMent?` command.

• Frequency of PLL Source (SYNChronize) : 1 data
Outputs the fundamental frequency (`VHZ/AHZ`) of the voltage/current for which the PLL source has been set. The input of the PLL source can be found out using `HARMonics:SYNChronize?`.

• `VTHD,ATHD`: 1 data
Outputs the harmonic distortion factor of voltage/current. (for either iEC or CSA). The used computation method can be found out using the `HARMonics:THD?` command.

• `V,A,W`: 51(or 31) data
Rms values of the 1st to 50(or 30)th order→fundamental analysis value (1st order)→harmonic analysis value (2nd order)→ · · · →harmonic analysis value (50(or 30)th order)

• `VCON,ACON,WCON` : 49(or 29) data
Harmonic relative content (2nd order)→ · →harmonic relative content (50(or 30)th order)

• `PF` : 1 data
Outputs the power factor of the fundamental (1st order).

• `VDEG` : 50(or 30) data
Phase angle between the1st order voltage and 1st order current→Phase angle between the 2nd order voltage and 1st order voltage→ · · · →Phase angle between the 50(or 30)th order voltage and the 1st order voltage.

• `ADEG` : 50(or 30) data
Phase angle between the1st order voltage and 1st order current→Phase angle between the 2nd order current and 1st order current→ · · · →Phase angle between the 50(or 30)th order current and the 1st order current.

Each data is divided by a comma "`,`" and ended by the terminator <RMT>.

Output Example of Harmonic Analysis Data

• Output example for model 253503, after having sent the following commands. (Refer also to page 10-19 for output example of external plotter).

(Sent)
```
MEASURE:HARMONICS:ITEM:PRESET VPATTERN
MEASURE:HARMONICS:VALUE?
```

(Received data)
```
60.00E+00,12.01E+00,49.98E+00,49.62E+00,0.03E+00,5.50E+00,
0.01E+00,1.99E+00,0.02E+00,1.01E+00,0.01E+00,0.62E+00,
0.00E+00,0.41E+00,0.00E+00,0.30E+00,0.00E+00,0.22E+00,
0.00E+00,0.17E+00,0.00E+00,0.14E+00,0.00E+00,0.12E+00,
0.00E+00,0.09E+00,0.00E+00,0.08E+00,0.00E+00,0.07E+00,
0.01E+00,0.06E+00,0.00E+00,0.05E+00,0.00E+00,0.04E+00,
0.00E+00,0.05E+00,0.00E+00,0.03E+00,0.00E+00,0.03E+00,
0.01E+00,0.03E+00,0.00E+00,0.03E+00,0.00E+00,0.02E+00,
0.00E+00,0.02E+00,0.00E+00,0.02E+00,0.00E+00,0.06E+00,
11.09E+00,0.02E+00,4.01E+00,0.03E+00,2.03E+00,0.01E+00,
1.24E+00,0.01E+00,0.82E+00,0.01E+00,0.60E+00,0.00E+00,
0.45E+00,0.01E+00,0.35E+00,0.01E+00,0.28E+00,0.00E+00,
0.23E+00,0.01E+00,0.19E+00,0.01E+00,0.16E+00,0.01E+00,
0.14E+00,0.01E+00,0.11E+00,0.01E+00,0.10E+00,0.01E+00,
0.08E+00,0.01E+00,0.09E+00,0.01E+00,0.07E+00,0.00E+00,
0.06E+00,0.01E+00,0.06E+00,0.01E+00,0.05E+00,0.01E+00,
0.05E+00,0.01E+00,0.05E+00,0.01E+00,0.04E+00,0.01E+00
```

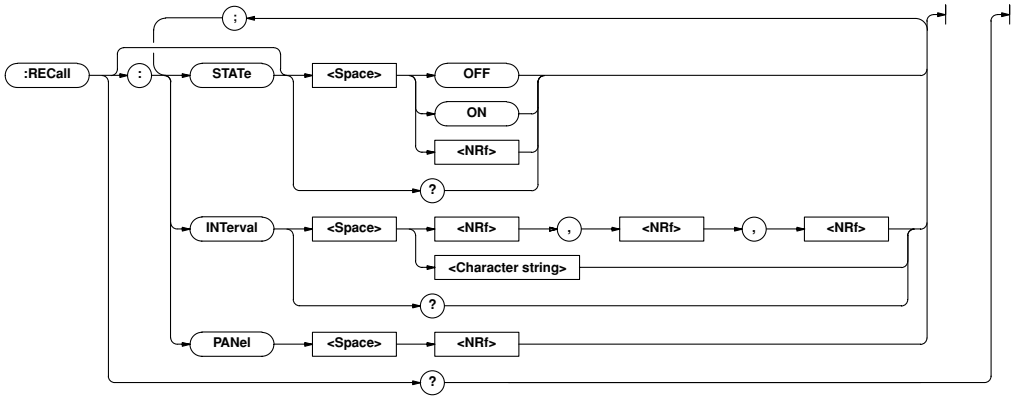
(Data contents)

Frequency of PLL source	:60.00E+00 (Hz)
Harmonic distortion factor of voltage	:12.01E+00 (%)
Rms value of 1st to 50th order	:49.98E+00 (V)
Fundamental analysis value (1st order)	:49.62E+00 (V)
Harmonic analysis value (2nd order)	:0.03E+00 (V)
:	:
Harmonic analysis value (50th order)	:0.00E+00 (V)
Harmonic relative content (2nd order)	:0.06E+00 (%)
:	:
Harmonic relative content (50th order)	:0.01E+00 (%)

The data consist of 102 items in total.

2.3.10 RECall Group

The commands in the RECall group are used to make settings relating to, and inquires about recalling data. This allows you to make the same settings and inquiries as can be set using the lower menus of [MEMORY]-"rECAL" or [MEMORY]-"PnLrC".



RECall?

Function Queries all the settings relating to recalling data.
Syntax `RECall?`
Example `RECALL?→:RECALL:STATE 0;INTERVAL 0,0,0`

RECall:INTerval

Function Sets the recalling interval/queries the current setting.
Syntax `RECall:INTerval {<NRf>,<NRf>,<NRf>|<String>}`
`RECall:INTerval?`
`{<NRf>,<NRf>,<NRf>}=0,0,0 to 99,59,59`
`{<String>}=HH:MM:SS` HH hour MM minutes SS seconds
Example `RECALL:INTERVAL 0,0,0`
`RECALL:INTERVAL "00:00:00"`
`RECALL:INTERVAL?→:RECALL:INTERVAL 0,0,0`
Description Even when the interval has been set to 0,0,0, the interval becomes 250ms in case of normal measurement and 1s in case of harmonic analysis.

RECall:PANel

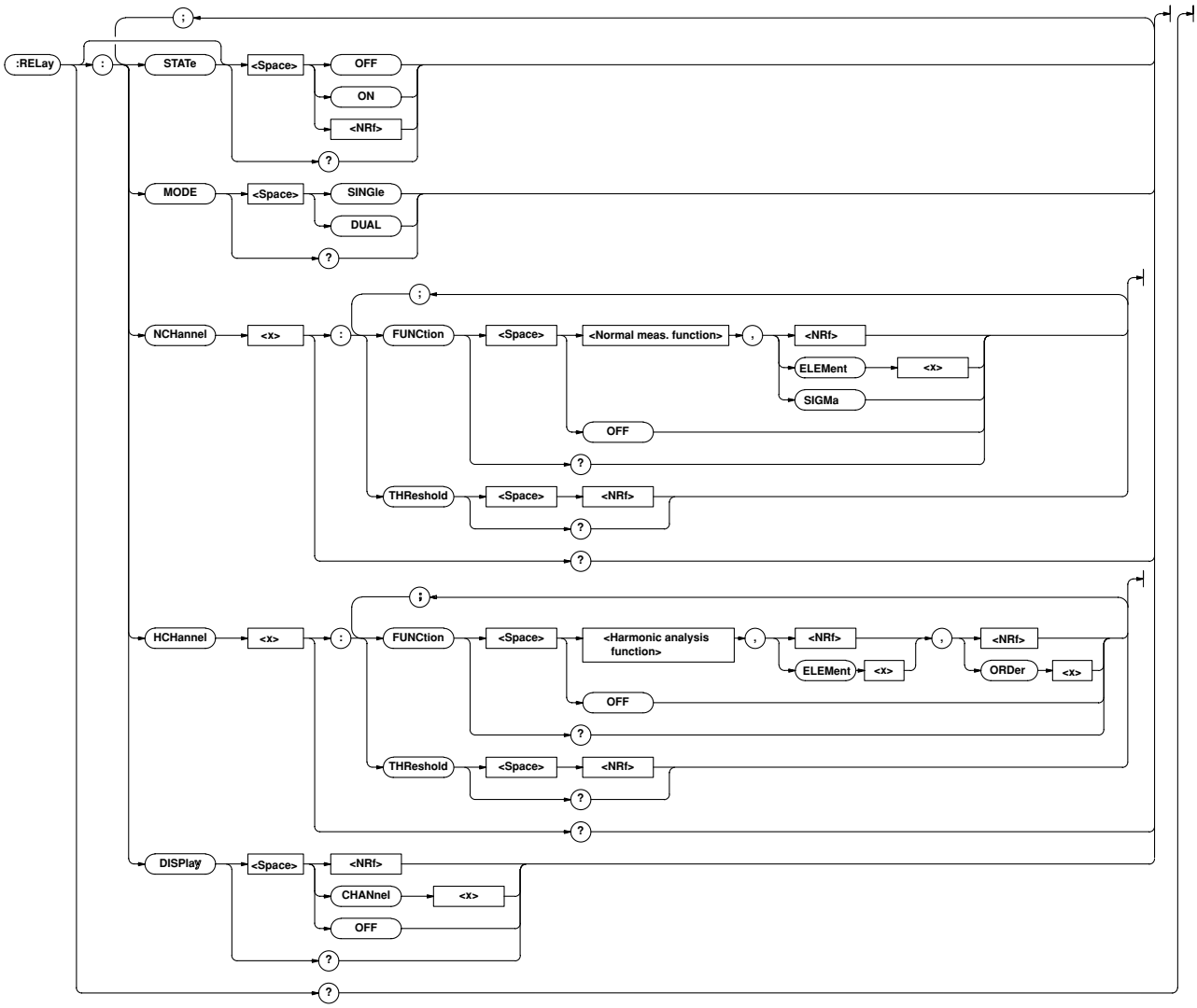
Function Retrieves the set-up parameters file.
Syntax `RECall:PANel {<NRf>}`
`{<NRf>}=1 to 4 : file number`
Example `RECALL:PANEL 1`

RECall[:STATe]

Function Turns recalling ON/OFF, queries the current setting.
Syntax `RECall[:STATe] {<Boolean>}`
`RECall:STATe?`
Example `RECALL:STATE ON`
`RECALL:STATE?→:RECALL:STATE 1`

2.3.11 RELay Group

The commands in the RELay group are used to make settings relating to, and inquiries about the comparator function. This allows you to make the same settings and inquiries as when using the lower menus of [OUTPUT]-"rELAY". This group is only useful in case your instrument is equipped with the /CMP option.



RELay?

Function Queries all settings relating to the comparator function.

Syntax `RELay?`

Example
```
RELAY?→:RELAY:STATE 0;MODE SINGLE;NCHANNEL1:
FUNCTION V,1;THRESHOLD
600.0E+00;:RELAY:NCHANNEL2:
FUNCTION A,1;THRESHOLD
20.00E+00;:RELAY:NCHANNEL3:
FUNCTION W,1;THRESHOLD
1.200E+03;:RELAY:NCHANNEL4:
FUNCTION PF,1;THRESHOLD
1.000E+00;:RELAY:HCHANNEL1:FUNCTION
V,1,1;THRESHOLD
600.0E+00;:RELAY:HCHANNEL2:FUNCTION A,1,1;
THRESHOLD 20.00E+00;:RELAY:HCHANNEL3:
FUNCTION W,1,1;THRESHOLD
1.200E+03;:RELAY:HCHANNEL4:FUNCTION
PF,1;THRESHOLD 1.000E+00;:RELAY:DISPLAY OFF
```

RELay:DISPlay

Function Sets the comparator display OFF, or, in case of ON, the channel to be displayed/queries the current setting.

Syntax
```
RELay:DISPlay {<NRf>|CHANnel<1-4>|OFF}
RELay:DISPlay?
{<NRf>}=1 to 4:channel
```

Example
```
RELAY:DISPLAY 1
RELAY:DISPLAY?→:RELAY:DISPLAY 1
```

RELay:HCHannel<x>?

Function Queries all settings related to relay output items in case of harmonic analysis.

Syntax
```
RELay:HCHannel<x>?
<x>= 1 to 4
```

Example
```
RELAY:HCHANNEL1?→:RELAY:HCHANNEL1:
FUNCTION V,1,1;
THRESHOLD 600.0E+00
```

RELay:HCHannel<x>:FUNCtion

Function Sets the function of the relay output item in case of harmonic analysis/queries the current setting.

Syntax
```
RELay:HCHannel<x>:FUNCtion {<harmonic
analysis function>,(<NRf>|ELEMent<1-3>),
(<NRf>|ORDer<1-50>)|OFF}
<harmonic analysis function>={VTHD|V|VCON|
ATHD|A|ACON|PF|W|WCON|VDEG|ADEG}
```

Example
```
RELAY:HCHANNEL1:FUNCTION V,1,1
RELAY:HCHANNEL1?→:RELAY:HCHANNEL1:
FUNCTION V,1,1
RELAY:HCHANNEL2?→:RELAY:HCHANNEL2:
FUNCTION OFF
RELAY:HCHANNEL4?→:RELAY:HCHANNEL4:
FUNCTION PF,1
```

Description
- The order setting will be ignored in case the harmonic analysis function is set to VTHD, ATHD or PF and might therefore be omitted.
- Even if V,A or W has been selected, the rms value of the 1st to 50th order does not become the corresponding relay output item. Also, even if VDEG or ADEG has been selected, the phase angle between the 1st order voltage and 1st order current does not become the corresponding relay output item.

RELay:HCHannel<x>:THReshold

Function Sets the threshold level for the relay output item in case of harmonic analysis/queries the current setting.

Syntax
```
RELay:HCHannel<x>:THReshold {<NRf>}
<x>= 1 to 4
<NRf>= 0.000E+00 to ±9.999E+09
```

Example
```
RELAY:HCHANNEL1:THRESHOLD 600.0E+00
RELAY:HCHANNEL1:THRESHHOLD?→:RELAY:
HCHANNEL1:THRESHOLD 600.0E+00
```

Description The mantissa of the setting value is rounded a follows.

Less than 1.000 : Rounded to the third digit left of the decimal.

1.000 to 9999 : Rounded to the fourth significant digit.

RELay:MODE

Function Sets the mode of the comparator function/queries the current setting.

Syntax
```
RELay:MODE {SINGle|DUAL}
RELay:MODE?
```

Example
```
RELAY:MODE DUAL
RELAY:MODE?→:RELAY:MODE DUAL
```

RELay:NCHannel<x>?

Function Queries all settings related to the relay output items in case of normal measurement.

Syntax
```
RELay:NCHannel<x>?
<x>=1 to 4
```

Example
```
RELAY:NCHANNEL2?→:RELAY:NCHANNEL2:
FUNCTION A,1;
THRESHOLD 20.00E+00
```

RELay:NCHannel<x>:FUNCtion

Function Sets the function of the relay output item in case of normal measurement/queries the current setting.

Syntax
```
RELay:NCHannel<x>:FUNCtion {<normal
measurement function>,(<NRf>|ELEMent<1-3>|
SIGMa)|OFF}
<x>=1 to 4
<normal measurement function>={V|A|W|VA|VAR|
PF|DEGRee|VHZ|AHZ|WH|WHP|WHM|AH|AHP|AHM|MATH|
VPK|APK}
```

Example
```
RELAY:NCHANNEL3:FUNCTION W,1
RELAY:NCHANNEL3?→:RELAY:NCHANNEL3:
FUNCTION W,1
```

Description
- Except for the case when it is OFF, you will specify <normal measurement function> and <element> for the relay output function. However, if the <normal measurement function> is set to MATH, <element> is ignored. (The response to the query will have the <element> omitted.)
- For the meanings of the symbols of functions, see Note on page App2-11.

RELay:NCHannel<x>:THReshold

Function Sets the threshold level for the relay output item in case of normal measurement/queries the current setting.

Syntax
```
RELay:NCHannel<x>:THReshold {<NRf>}
<x>=1 to 4
<NRf>=0.000E+00 to ±9.999E+09
```

Example
```
RELAY:NCHANNEL3:THRESHOLD 1.200E+03
RELAY:NCHANNEL3:THRESHHOLD?→:RELAY:
NCHANNEL3:THRESHOLD 1.200E+03
```

Description The mantissa of the setting value is rounded a follows.

Less than 1.000 : Rounded to the third digit left of the decimal.

1.000 to 9999 : Rounded to the fourth significant digit.

RELay:STATe

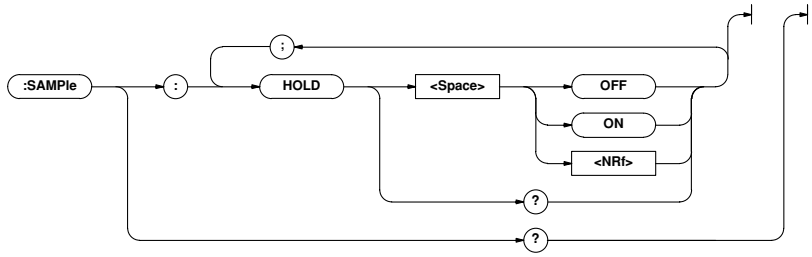
Function Sets the comparator function ON/OFF, queries the current setting.

Syntax
```
RELay[:STATe] {<Boolean>}
RELay:STATe?
```

Example
```
RELAY ON
RELAY:STATE ON
RELAY:STATE?→:RELAY:STATE 1
```

2.3.12 SAMPle Group

The commands in the SAMPle group are used to make settings relating to, and inquiries about sampling. You can make the same settings as when using the [HOLD] key on fhe front panel.



SAMPle?

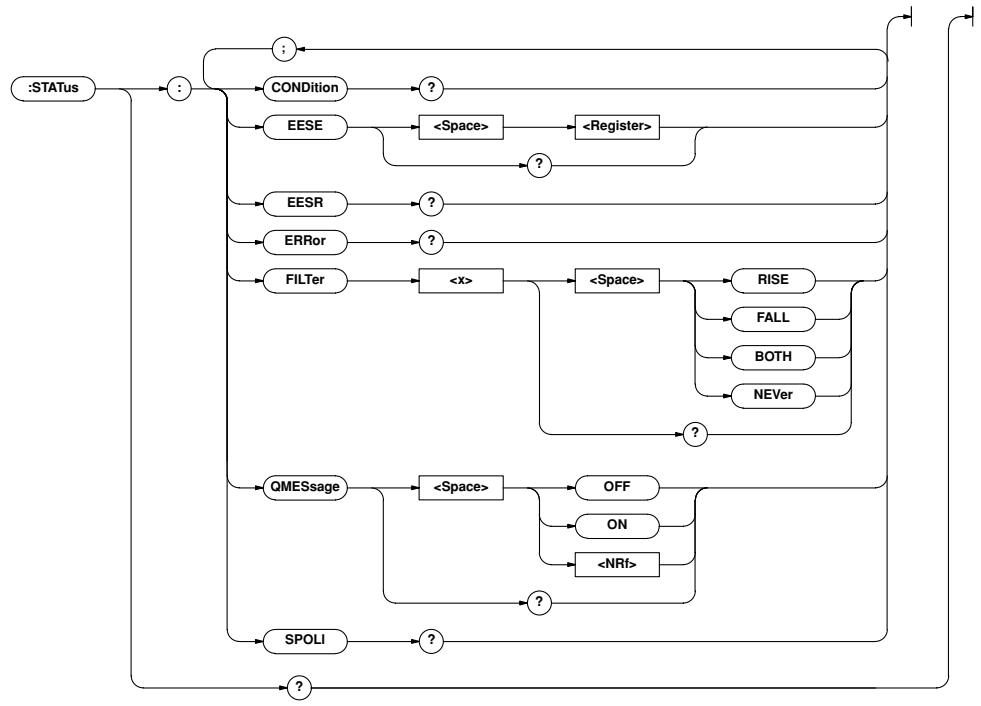
Function Queries all settings related to sampling.
Syntax `SAMPle?`
Example `SAMPLE?→:SAMPLE:HOLD 0`

SAMPle:HOLD

Function Sets to hold the output of data (display, communication)/queries the current setting.
Syntax `SAMPle:HOLD {<Boolean>}`
`SAMPle:HOLD?`
Example `SAMPLE:HOLD ON`
`SAMPLE:HOLD?→:SAMPLE:HOLD 1`

2.3.13 STATus Group

The commands in the STATus group are used to make settings relating to, and inquiries about the communication status. There is no corresponding operation using the front panel. Refer to appendix 2.4 for status reports.



STATus?

Function Queries all settings related to the status of communication.
Syntax `STATus?`
Example
```
STATUS?→:STATUS:EESE 0;FILTER1 NEVER;
FILTER2 NEVER;FILTER3 NEVER;
FILTER4 NEVER;FILTER5 NEVER;
FILTER6 NEVER;FILTER7 NEVER;
FILTER8 NEVER;FILTER9 NEVER;
FILTER10 NEVER;FILTER11 NEVER;
FILTER12 NEVER;FILTER13 NEVER;
FILTER14 NEVER;FILTER15 NEVER;
FILTER16 NEVER;QMESSAGE 1
```

STATus:CONDition?

Function Queries the contents of the condition filter, and clears it at the same time.
Syntax `STATus:CONDition?`
Example
```
STATUS:CONDITION→16
```
Description Refer to App2.4 for details on the condition filter.

STATus:EESE

Function Sets the extended event register/queries the current setting.
Syntax
```
STATus:EESE <Register>
STATus:EESE?
<Register>=0 to 65535
```
Example
```
STATUS:EESE 257
STATUS:EESE?→:STATUS:EESE 257
```
Description Refer to App.2.4 for details on the extended event register.

STATus:EESR?

Function Queries the contents of the extended event register, and clears it.
Syntax `STATus:EESR?`
Example
```
STATUS:EESR?→1
```
Description Refer to App.2.4 for details on the extended event register.

STATus:ERRor?

Function Queries the occurred error code and message.
Syntax `STATus:ERRor?`
Example
```
STATUS:ERROR?→113,"Undefined header"
```

STATus:FILTer<x>

Function Sets the transit filter/queries the current setting.
Syntax
```
STATus:FILTer<x> {RISE|FALL|BOTH|NEVer}
STATus:FILTer<x>?
<x>=1 to 16
```
Example
```
STATUS:FILTER2 RISE
STATUS:FILTER2?→:STATUS:FILTER2 RISE
```
Description Refer to App2.4 for details on the condition filter.

STATus:QMESsage

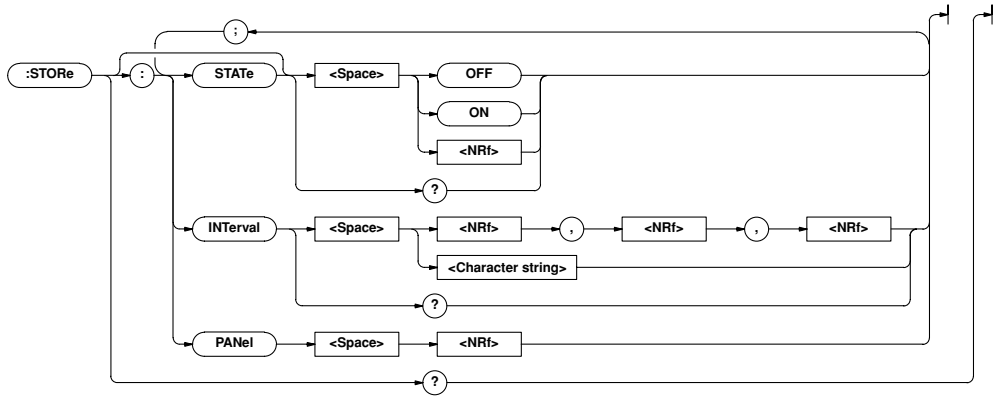
Function Sets whether or not to apply the corresponding message to the query "`STATus:ERRor?`" /queries the current setting.
Syntax
```
STATus:QMESsage {<Boolean>}
STATus:QMESsage?
```
Example
```
STATUS:QMESSAGE OFF
STATUS:QMESSAGE?→:STATUS:QMESSAGE 0
```

STATus:SPOLL?(Serial Poll)

Function Executes serial polling.
Syntax `STATus:SPOLL?`
Example
```
STATUS:SPOLL?→STATUS:SPOLL 0
```
Description Only to be used for RS-232-C interface.

2.3.14 STORe Group

The commands in the STORe group are used to make settings relating to and inquiries about storing data. This allows you to make the same settings as when using the lower menus of [MEMORY]-"StorE" or [MEMORY]-"PnLSt".



STORe?

Function Queries all settings related to storing data.
Syntax STORe?
Example STORE?→:STORE:STATE 0;INTERVAL 0,0,0

STORe:INTerval

Function Sets the interval for storage/queries the current setting.
Syntax STORe:INTerval {<NRf>,<NRf>,<NRf>|<String>}
STORe:INTerval?
{<NRf>,<NRf>,<NRf>}=0,0,0 to 99,59,59
{<String>}=HH:MM:SS HH hour MM min SS sec
Example STORE:INTERVAL 0,0,0
STORE:INTERVAL "00:00:00"
STORE:INTERVAL?→:STORE:INTERVAL 0,0,0
Description
- If the storage interval is set to 0,0,0, the storage interval becomes 250ms in case of normal measurement.
- For the storage interval in case of harmonic analysis, refer to page 9-2.

STORe:PANel

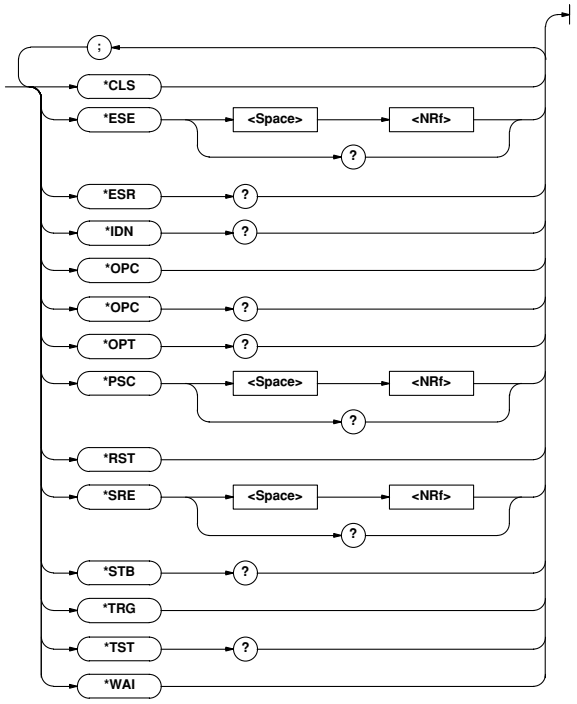
Function Saves the set-up parameters to a file.
Syntax STORe:PANel {<NRf>}
{<NRf>}=1 to 4:file number
Example STORE:PANEL 1

STORe[:STATe]

Function Sets store ON/OFF, queries the current setting.
Syntax STORe[:STATe] {<Boolean>}
STORe:STATe?
Example STORE:STATE ON
STORE:STATE?→:STORE:STATE 1

2.3.15 Common Command Group

The commands in the common command group are independent of the instrument's functions, and are specified in IEEE 488.2-1987. There is no front panel key that corresponds to this group.



*CLS

Function Clears the standard event register, extended event register and error queue.
Syntax `*CLS`
Example `*CLS`
Description
- The output will also be cleared if a `*CLS` command is appended after the program message terminator.
- For details on the registers and queues, refer to appendix 2.4.

*ESE

Function Sets the value for the standard event enable register, or queries the current setting.
Syntax `*ESE {<NRf>}`
`*ESE?`
`{<NRf>}=0 to 255`
Example `*ESE 253`
`*ESE?→253`
Description
- Each bit is expressed as a decimal number.
- For example, if "`*ESE 253`" is set, the standard enable register will be set to "`11111101`". This means that bit 2 of the standard event register is disabled so that bit 5 (ESB) of the status byte register will not be set to "1", even if a query error occurs.
- Default is "`*ESE 255`" , i.e. all bits are enabled.
- The standard event enable register will be cleared when an inquiry is made using `*ESE?`.
- For details referring the standard event enable register, refer to page App2-36.

*ESR?

Function Queries the value of the standard event register and clears it at the same time.
Syntax `*ESR?`
Example `*ESR?→32`
Description
- Each bit is expressed as a decimal number.
- It is possible to ascertain the type of event which has occurred, while SRQ is occuring.
- For example, if "`*ESR 32`" is returned, this means that the standard event register is "00100000" , i.e. the SRQ has occurred due to a command syntax error.
- If a query is made using `*ESR?`, the standard event register will be cleared.
- For details referring the standard event enable register, refer to page App2-37.

*IDN?

Function Queries the instrument model.
Syntax `*IDN?`
Example `*IDN?→YOKOGAWA,253503,0,F1.11`
Description A reply consists of the following information: <Model>,<Type>,<Serial No.> and <Firmware version>

*OPC

Function When `*OPC` is sent, this command sets bit 0 (the OPC bit) of the standard event register to "1". This command is not supported by this instrument.
Syntax `*OPC`

*OPC?

Function When `*OPC?` is sent, "1" in (ASCII code) will be returned. This command is not supported by this instrument.
Syntax `*OPC?`

*OPT?

Function Queries installed options.
Syntax *OPT?
Example *OPT?→EXT1, HARM, DA4, CMP
Description
- "NONE" will be attached to the reply if no options are installed.
- "OPT?" must always be the last query in program message. If there is another query after this, an error will occur.

*PSC

Function Selects whether or not to clear the following registers when turning ON the power, or queries the current setting. The registers are the standard event enable register, the extended event enable register and the transition filter. However, they cannot be cleared if the parameter is "0".
Syntax
```
*PSC {<NRf>}
*PSC?
{<NRf>}=0(no clearance), other than 0(clearance)
```
Example
```
*PSC 1
*PSC?→1
```
Description Refer to App 2.4 for more details on the registers.

*RST

Function Resets (initializes) the present settings.
Syntax *RST
Example *RST
Description
- Refer to 13.2 for initial settings.

*SRE

Function Sets the value of the service request enable register, or queries the current setting.
Syntax
```
*SRE {<NRf>}
*SRE?
{<NRf>}=0 to 255
```
Example
```
*SRE 239
*SRE?→239
```
Description
- Each bit is expressed as a decimal number.
- For example, if "*SRE 239" is set, the service request enable register will be set to "11101111". This means that bit 4 of the service request enable register is disabled, so that bit 5 (ESB0 of the status byte register will not be set to "1", even if the output queue is not empty.
- However, bit 6 (MSS) of the status byte register is the MSS bit, so it will be ignored.
- Default is "*SRE 255", i.e. all bits are enabled.
- The service request enable register will not be cleared, even if a query is made using *SRE?.
- For details of the service request enable register, refer to page App2-36.

*STB?

Function Queries the value of the status byte register.
Syntax *STB?
Example *STB?→4
Description
- Each bit is expressed as a decimal number.
- Bit 6 is RQS and not MSS because the register is read without serial polling.
- For example, if "*STB 4" is returned, the status byte register is set to "00000100", i.e. the error queue is not empty (an error has occurred).
- The status byte register will not be cleared, even if a query is made using *STB?.
- For details of the status byte register, refer to page App2-36.

*TRG

Function Executes the same operation as the TRIG (SHIFT+HOLD) key on the front panel.
Syntax *TRG
Description
- Executes the same operation as when using the multi line message GET (Group Execute Trigger).

*TST?

Function Executes a self-test and queries the result. All internal memory boards are tested.
Syntax *TST?
Example *TST?→0
Description
- "0" will be returned when the result are satisfactory. If an abnormality is detected, "1" will be returned.

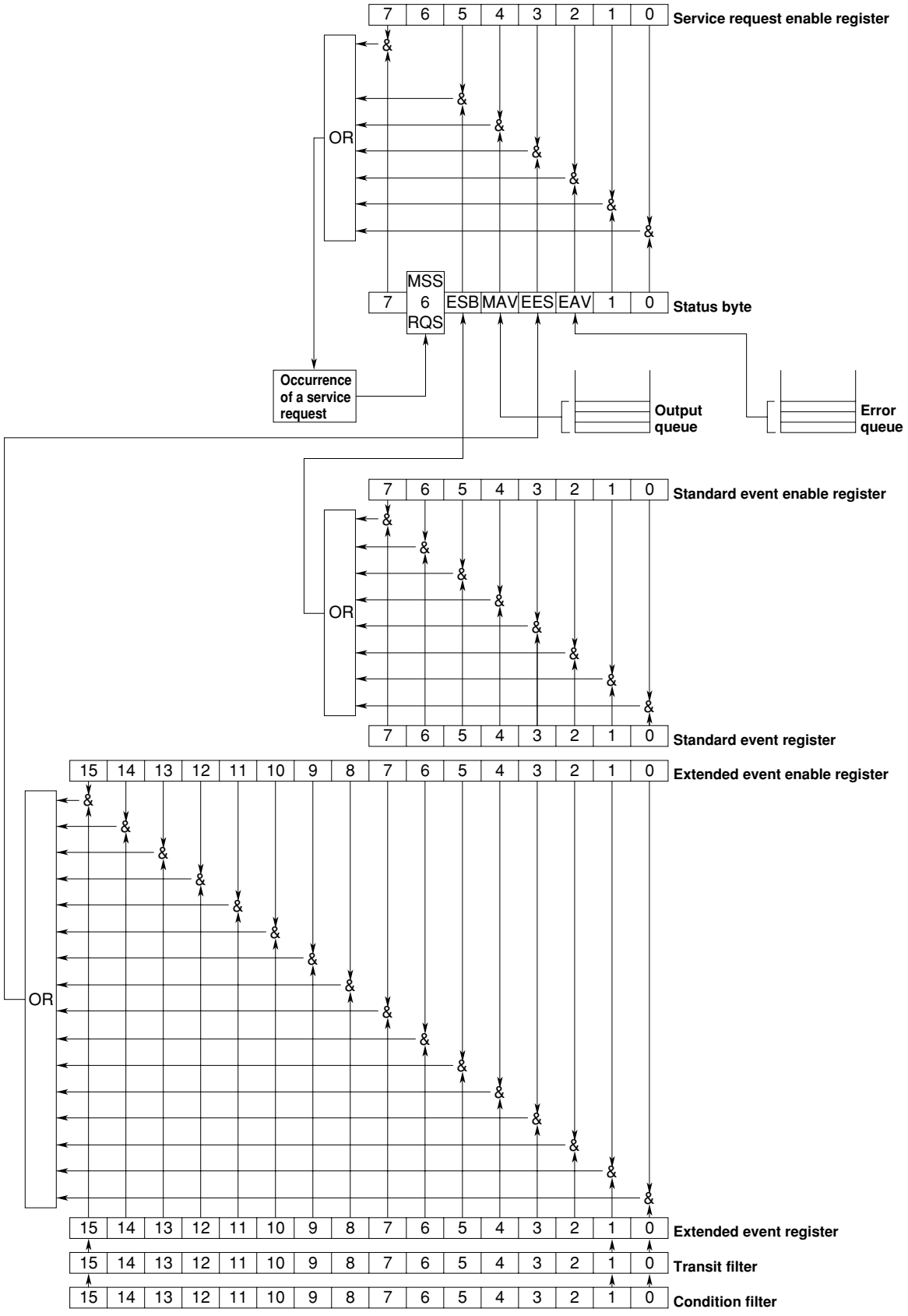
*WAI

Function Waits for the command following *WAI until execution of the designated overlap command has been completed. This command is not supported by this instrument.
Syntax *WAI

Appendix 2.4 Status Report

2.4.1 Overview of the Status Report

The figure below shows the status report which is read by a serial poll. This is an extended version of the one specified in IEEE 488.2-1987.



Overview of Registers and Queues

Name	Function	Writing	Reading
Status byte		—	Serial poll (RQS), *STB?(MSS)
Service request enable register	Masks status byte.	*SRE	*SRE?
Standard event register	Event in the instrument (1)	—	*ESR?
Standard event enable register	Masks standard event register.	*ESE	*ESE?
Extended event register	Event in the instrument (2)	—	STATus:EESR?
Extended event enable register	Masks extended event register.	STATus:EESE	STATus:EESE?
Condition register	Current instrument status	—	STATus:CONDition?
Transition filter	Extended event occurrence conditions	STATus:FILTer <x>	STATus:FILTer <x>
Output queue	Stores response message to a query.	All executable queues	
Error queue	Stores error Nos. and messages.	—	STATus:ERRor?

Registers and Queues which Affect the Status Byte

Registers which affect each bit of the status byte are shown below.

Standard event register : Sets bit 5 (ESB) of status byte to "1" or "0".
Output queue : Sets bit 4 (MAV) of status byte to "1" or "0".
Extended event register : Sets bit 3 (EES) of status byte to "1" or "0".
Error queue : Sets bit 2 (EAV) of status byte to "1" or "0".

Enable Registers

Registers which mask a bit so that the bit does not affect the status byte, even if the bit is set to "1", are shown below.

Status byte : Masks bits using the service request enable register.
Standard event register : Masks bits using the standard event enable register.
Extended event register : Masks bits using the extended event enable register.

Writing/Reading from Registers

The *ESE command is used to set bits in the standard event enable register to "1" or "0", and the *ESR? query is used to check whether bits in that register are set to "1" or "0". For details of these commands, refer to Appendix 2.3.

2.4.2 Status Byte

Overview of Status Byte

Bits 0, 1 and 7

Not used (always "0")

Bit 2 EAV (Error Available)

Set to "1" when the error queue is not empty, i.e. when an error occurs. For details, refer to page App2-39.

Bit 3 EES (Extended Event Summary Bit)

Set to "1" when a logical AND of the extended event register and the corresponding enable register is "1", i.e. when an event takes place in the instrument. Refer to page App2-38.

Bit 4 MAV (Message Available)

Set to "1" when the output queue is not empty, i.e. when there is data which is to be output when an inquiry is made. Refer to page App2-39.

Bit 5 ESB (Event Summary Bit)

Set to "1" when a logical AND of the standard event register and the corresponding enable register is "1", i.e. when an event takes place in the instrument. Refer to page App2-37.

Bit 6 RQS (Request Status)/MSS (Master Summary Status)

MSS is set to "1" when a logical AND of the status byte (except for bit 6) and the service request enable register is not "0", i.e. when the instrument is requesting service from the controller.
RQS is set to "1" when MSS changes from "0" to "1", and is cleared when a serial poll is performed or when MSS changes to "0".

Bit Masking

To mask a bit in the status byte so that it does not cause an SRQ, set the corresponding bit of the service request enable register to "0".
For example, to mask bit 2 (EAV) so that no service will be requested, even if an error occurs, set bit 2 of the service request enable register to "0". This can be done using the *SRE command. To query whether each bit of the service request enable register is "1" or "0", use *SRE?. For details of the *SRE command, refer to App. 2.3.

Operation of the Status Byte

A service request is issued when bit 6 of the status byte becomes "1". Bit 6 becomes "1" when any of the other bits becomes "1" (or when the corresponding bit in the service request enable register becomes "1").
For example, if an event takes place and the logical OR of each bit of the standard event register and the corresponding bit in the enable register is "1", bit 5 (ESB) will be set to "1". In this case, if bit 5 of the service request enable register is "1", bit 6 (MSS) will be set to "1", thus requesting service from the controller.
It is also possible to check what type of event has occurred by reading the contents of the status byte.

Reading from the Status Byte

The following two methods are provided for reading the status byte.

- **Inquiry using the *STB? query**
  Making an inquiry using the *STB? query sets bit 6 to MSS. This causes the MSS to be read. After completion of the read-out, none of the bits in the status byte will be cleared.

- **Serial poll**
  Execution of a serial poll changes bit 6 to RQS. This causes RQS to be read. After completion of the read-out, only RQS is cleared. Using a serial poll, it is not possible to read MSS.

Clearing the Status Byte

No method is provided for forcibly clearing all the bits in the status byte. Bits which are cleared are shown below.

- **When an inquiry is made using the *STB? query**
  No bit is cleared.

- **When a serial poll is performed**
  Only the RQS bit is cleared.

- **When the *CLS command is received**
  When the *CLS command is received, the status byte itself is not cleared, but the contents of the standard event register (which affects the bits in the status byte) are cleared. As a result, the corresponding bits in the status byte are cleared, except bit 4 (MAV), since the output queue cannot be emptied by the *CLS command. However, the output queue will also be cleared if the *CLS command is received just after a program message terminator.

2.4.3 Standard Event Register

Overview of the Standard Event Register

7	6	5	4	3	2	1	0
PON	URQ	CME	EXE	DDE	QYE	RQC	OPC

Bit 7 PON (Power ON)

Bit 7 PON (Power ON) Set to "1" when power is turned ON

Bit 6 URQ (User Request)

Not used (always "0")

Bit 5 CME (Command Error)

Set to "1" when the command syntax is incorrect.
Examples: Incorrectly spelled command name; "9" used in octal data.

Bit 4 EXE (Execution Error)

Set to "1" when the command syntax is correct but the command cannot be executed in the current state.
Examples: Parameters are outside the setting range: an attempt is made to make a hard copy during acquisition.

Bit 3 DDE (Device Dependent Error)

Set to "1" when execution of the command is not possible due to an internal problem in the instrument that is not a command error or an execution error.

Bit 2 QYE (Query Error)

Set to "1" if the output queue is empty or if the data is missing even after a query has been sent.
Examples: No response data; data is lost due to an overflow in the output queue.

Bit 1 RQC (Request Control)

Not used (always "0")

Bit 0 OPC (Operation Complete)

Set to "1" when the operation designated by the *OPC command has been completed.

Bit Masking

To mask a bit in the standard event register so that it does not cause bit 5 (ESB) of the status byte to change, set the corresponding bit in the standard event enable register to "0". For example, to mask bit 2 (QYE) so that ESB will not be set to "1", even if a query error occurs, set bit 2 of the standard event enable register to "0". This can be done using the *ESE command. To inquire whether each bit of the standard event enable register is "1" or "0", use the *ESE?. For details of the *ESE command, refer to App. 2.3.

Operation of the Standard Event Register

The standard event register is provided for eight different kinds of event which can occur inside the instrument. Bit 5 (ESB) of the status byte is set to "1" when any of the bits in this register becomes "1" (or when the corresponding bit of the standard event enable register becomes "1").

Examples

1. A query error occurs.
2. Bit 2 (QYE) is set to "1".
3. Bit 5 (ESB) of the status byte is set to "1" if bit 2 of the standard event enable register is "1".

It is also possible to check what type of event has occurred inside the instrument by reading the contents of the standard event register.

Reading from the Standard Event Register

The contents of the standard event register can be read by the *ESR command. After completion of the read-out, the register will be cleared.

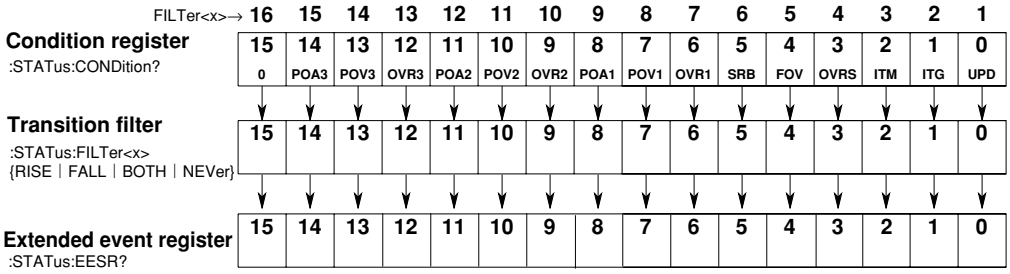
Clearing the Standard Event Register

The standard event register is cleared in the following three cases.

- When the contents of the standard event register are read using *ESR?
- When the *CLS command is received
- When power is turned ON again

2.4.4 Extended Event Register

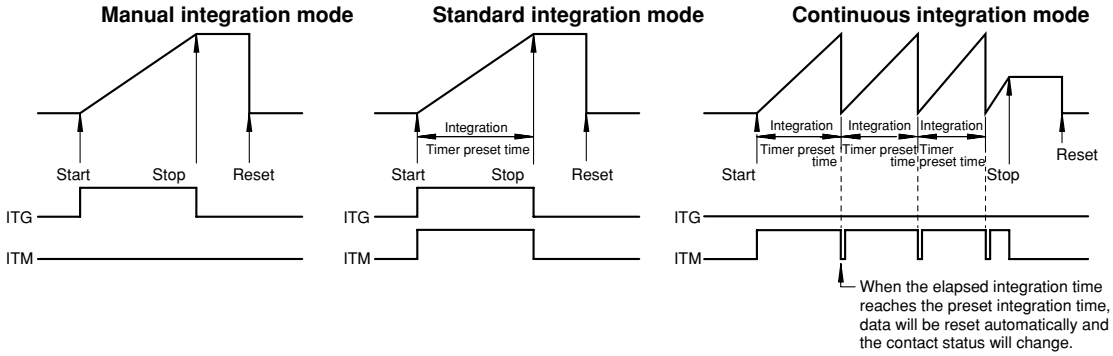
Reading the extended event register tells you whether changes in the condition register (reflecting internal conditions) have occurred. A transition filter can be applied which allows you to decide which events are reported to the extended event register.



The meaning of each bit of the condition register is as follows.

Bit 0 UPD (Updating)	Set to "1" during updating of measurement data.
Bit 1 ITG (Integrate busy)	Set to "1" during integration. (See figure below)
Bit 2 ITM (Integrate timer busy)	Set to "1" during the integration timer is being operated. (See figure below)
Bit 3 OVRS (∑ results overflow)	Set to "1" when the integration results of ∑ overflow. (Display shows "—oF—")
Bit 4 FOV (Frequency over)	Set to "1" when the frequency lies outside the measurement range (Display shows "ErrLo" , "ErrHi" or "FrqEr" .
Bit 5 SRB (Store/Recall busy)	Set to "1" while storing or recalling is in progress.
Bit 6 OVR1 (Element 1; measured data over)	Set to "1" when the measurement/computed data of element 1 overflow, or when an error occurs. (Display shown "—oF—" , "—oL—" , "PFErr" or "dEGEr")
Bit 7 POV1 (Element 1; voltage peak over)	Set to "1" when the voltage value of element 1 exceeds the peak value.
Bit 8 POA1 (Element 1; current peak over)	Set to "1" when the current value of element 1 exceeds the peak value.
Bit 9 OVR2 (Element 2; measured data over)	Set to "1" when the measurement/computed data of element 2 overflow, or when an error occurs. (Display shown "—oF—" , "—oL—" , "PFErr" or "dEGEr")
Bit 10 POV2 (Element 2; voltage peak over)	Set to "1" when the voltage value of element 2 exceeds the peak value.
Bit 11 POA2 (Element 2; current peak over)	Set to "1" when the current value of element 2 exceeds the peak value.
Bit 12 OVR3 (Element 3; measured data over)	Set to "1" when the measurement/computed data of element 3 overflow, or when an error occurs. (Display shown "—oF—" , "—oL—" , "PFErr" or "dEGEr")
Bit 13 POV3 (Element 3; voltage peak over)	Set to "1" when the voltage value of element 3 exceeds the peak value.
Bit 14 POA3 (Element 1; current peak over)	Set to "1" when the current value of element 3 exceeds the peak value.

The transition filter is applied to each bit of the condition register seperately, and can be selected from the following. Note that the numbering of the bits used in the filter setting differs from the actual bit number (1 to 16 vs. 0 to 15).



Rise	The bit of the extended event register becomes “1” when the bit of the condition register changes from “0” to “1”.
Fall	The bit of the extended event register becomes “1” when the bit of the condition register changes from “1” to “0”.
Both	The bit of the extended event register becomes “1” when the bit of the condition register changes from “0” to “1”, or from “1” to “0”.
Never	The bit of the extended event register is disabled and always “0”.

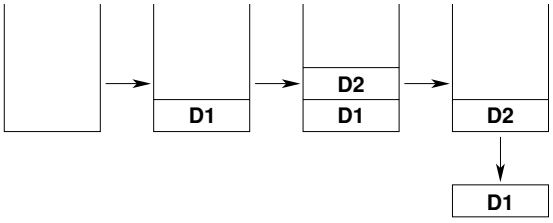
2.4.5 Output Queue and Error Queue

Overview of the Output Queue

The output queue is provided to store response messages to queries. For example, when the WAVeform:SEND? query is sent to request output of the acquired waveform, the response data will be stored in the output queue until it is read out.
The example below shows that data is stored record by record in the output queue, and is read out oldest item first, newest item last. The output queue is emptied in the following cases (in addition to when read-out is performed).

- When a new message is received from the controller
- When dead lock occurs (page App2-4)
- When a device clear command (DCL or SDC) is received
- When power is turned ON again

The output queue cannot be emptied using the *CLS command. To see whether the output queue is empty or not, check bit 4 (MAV) of the status byte.



Overview of the Error Queue

The error queue stores the error No. and message when an error occurs. For example, when the built-in battery has run out, an error occurs and its error No. (901) and message “Backup Failure” will be stored in the error queue.
The contents of the error queue can be read using the STATus:ERRor? query. As with the output queue, messages are read oldest first, newest last (refer to the previous page).
If the error queue becomes full, the final message will be replaced by message 350, “Queue overflow”.

The error queue is emptied in the following cases (in addition to when read-out is performed).

- When the *CLS command is received
- When power is turned ON again

To see whether the error queue is empty or not, check bit 2 (EAV) of the status byte.

Appendix 2.5 Sample Program

This section describes sample programs for a IBM PC/AT and compatible system with National Instruments AT-GPIB/TNTIEEE-488.2 board. Sample programs in this manual are written in Quick BASIC version 4.0/4.5.

```
'*********************************************************************
'*  WT110/WT130                                                      *
'*   After having set the measurement conditions/measurement range,  *
'*   output the following data:voltage(V),current(A),active power(W), *
'*  voltage frequency(VHz) of element 1.                             *
'*                          Microsoft QuickBASIC 4.0/4.5 Version     *
'*********************************************************************
REM $INCLUDE: 'qbdecl4.bas'
N = 4
DIM D$(N)                    ' Array D$(4) is prepared for receiving data
BORD$ = "GPIB0": CALL IBFIND(BORD$, BD%)
IF BD% < 0 THEN GOTO ERRDISP
CALL IBSIC(BD%): GOSUB ERRCHK
DEVICE$ = "WT": CALL IBFIND(DEVICE$, WT%)
IF WT% < 0 THEN GOTO ERRDISP
CALL IBCLR(WT%): GOSUB ERRCHK
V% = 1: CALL IBSRE(BD%, V%)
CLS
' Setting measurement conditions
' Hold OFF, Measurement mode = RMS, Filter OFF, Scaling OFF, Averaging OFF
CMD$ = "SAMPLE:HOLD OFF": CALL IBWRT(WT%, CMD$): GOSUB ERRCHK
CMD$ = "MODE RMS": CALL IBWRT(WT%, CMD$): GOSUB ERRCHK
CMD$ = "FILTER OFF": CALL IBWRT(WT%, CMD$): GOSUB ERRCHK
CMD$ = "SCALING OFF": CALL IBWRT(WT%, CMD$): GOSUB ERRCHK
CMD$ = "AVERAGING OFF": CALL IBWRT(WT%, CMD$): GOSUB ERRCHK
' Setting measurement range(150V/5A)
CMD$ = "VOLTAGE:RANGE 150V;:CURRENT:RANGE 5A"
CALL IBWRT(WT%, CMD$): GOSUB ERRCHK
' Sets display C to VHz1 in order to measure the voltage frequency of element 1
CMD$ = "DISPLAY3:FUNCTION VHZ;ELEMENT 1"
CALL IBWRT(WT%, CMD$): GOSUB ERRCHK
' Sets the communication output items.(V1,A1,W1,VHz1 ON, all others OFF)
CMD$ = "MEASURE:ITEM:PRESET CLEAR": CALL IBWRT(WT%, CMD$): GOSUB ERRCHK
CMD$ = "MEASURE:ITEM:V:ELEMENT1 ON": CALL IBWRT(WT%, CMD$): GOSUB ERRCHK
CMD$ = "MEASURE:ITEM:A:ELEMENT1 ON": CALL IBWRT(WT%, CMD$): GOSUB ERRCHK
CMD$ = "MEASURE:ITEM:W:ELEMENT1 ON": CALL IBWRT(WT%, CMD$): GOSUB ERRCHK
CMD$ = "MEASURE:ITEM:VHZ:ELEMENT1 ON": CALL IBWRT(WT%, CMD$): GOSUB ERRCHK
' Sets the filter to detect the end of data updating
CMD$ = "STATUS:FILTER1 FALL"          ' bit0(UPD)
CALL IBWRT(WT%, CMD$): GOSUB ERRCHK
BUF$ = SPACE$(200)
' Reads the measurement data and displays them (10 times)
FOR I = 1 TO 10
    CMD$ = "STATUS:EESR?"             ' Clears the extended event register
    CALL IBWRT(WT%, CMD$): GOSUB ERRCHK
    CALL IBRD(WT%, BUF$): GOSUB ERRCHK
    ' Waiting until data are finished updating
    CMD$ = "COMMUNICATE:WAIT 1"
    CALL IBWRT(WT%, CMD$): GOSUB ERRCHK
    CMD$ = "MEASURE:VALUE?"           ' Requests output of measurement data
    CALL IBWRT(WT%, CMD$): GOSUB ERRCHK
    CALL IBRD(WT%, BUF$): GOSUB ERRCHK ' Reads measurement data
   K = 1
   FOR J = 1 TO N
        IF J < N THEN S = INSTR(K, BUF$, ",") ELSE S = INSTR(K, BUF$, CHR$(10))
       D$(J) = MID$(BUF$, K, S - K)
      K = S + 1
   NEXT J
    ' Shows the measurement data per function
   PRINT "V1", D$(1)                  'V1
   PRINT "A1", D$(2)                  'A1
   PRINT "W1", D$(3)                  'W1
   PRINT "VHz1", D$(4)                'VHz1
NEXT I
PRGEND:
CALL IBLOC(WT%)
END                                   ' End
'
' When IBFIND call failed
ERRDISP:
PRINT " ===== No such board or device name ===== "
GOTO PRGEND
'
' GP-IB error check
ERRCHK:
IF IBSTA% >= 0 THEN RETURN
PRINT " ===== Error ===== "
GOTO PRGEND
```

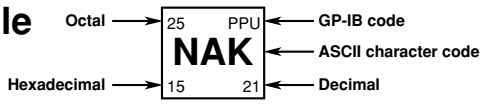
```
'*********************************************************************
'*  WT110/WT130                                                      *
'*  Executes harmonic analysis for element 1 and displays the        *
'*  following:                                                       *
'*   * Frequency of the PLL source(=voltage of element 1)            *
'*   * Harmonic distortion factor of the current(ATHD)                *
'*   * Rms values of the 1st to 50th order current                    *
'*   * Fundamental(1st order) and harmonic analysis values(2nd to     *
'*     50th order)currents                                            *
'*                              Microsoft QuickBASIC 4.0/4.5 Version  *
'*********************************************************************
REM $INCLUDE: 'qbdecl4.bas'
N = 53
DIM D$(N)                       ' Array D$(53) is prepared for receiving data
BORD$ = "GPIB0": CALL IBFIND(BORD$, BD%)
IF BD% < 0 THEN GOTO ERRDISP
CALL IBSIC(BD%): GOSUB ERRCHK
DEVICE$ = "WT": CALL IBFIND(DEVICE$, WT%)
IF WT% < 0 THEN GOTO ERRDISP
CALL IBCLR(WT%): GOSUB ERRCHK
V% = 1: CALL IBSRE(BD%, V%)
CLS
' Settings related to harmonic analysis
' Element=1, PLL source=V1, Computation method of harmonic distortion=IEC
CMD$ = "HARMONICS:STATE ON;ELEMENT 1;SYNCHRONIZE V,1;THD IEC"
CALL IBWRT(WT%, CMD$): GOSUB ERRCHK
' Sets the communication output items.
' Sets all functions OFF. Sets only necessary functions ON.
CMD$ = "MEASURE:HARMONICS:ITEM:PRESET CLEAR"
CALL IBWRT(WT%, CMD$): GOSUB ERRCHK
CMD$ = "MEASURE:HARMONICS:ITEM:SYNCHRONIZE ON;ATHD ON;A ON"
CALL IBWRT(WT%, CMD$): GOSUB ERRCHK
' Sets the filter to detect the end of data updating
CMD$ = "STATUS:FILTER1 FALL"
CALL IBWRT(WT%, CMD$): GOSUB ERRCHK
' Reads the analysis data and displays them (10 times)
FOR I = 1 TO 10
    CMD$ = "STATUS:EESR?"               ' Clears the extended event register
    CALL IBWRT(WT%, CMD$): GOSUB ERRCHK
    BUF$ = SPACE$(255)
    CALL IBRD(WT%, BUF$): GOSUB ERRCHK
    ' Waiting until data are finished updating
    CMD$ = "COMMUNICATE:WAIT 1"
    CALL IBWRT(WT%, CMD$): GOSUB ERRCHK
    CMD$ = "MEASURE:VALUE?"             ' Requests output of analysis data
    CALL IBWRT(WT%, CMD$): GOSUB ERRCHK
    BUF$ = SPACE$(1000)
    CALL IBRD(WT%, BUF$): GOSUB ERRCHK ' Reads analysis data
   K = 1
    FOR J = 1 TO N                      ' Order of output data
        IF J < N THEN S = INSTR(K, BUF$, ",") ELSE S = INSTR(K, BUF$, CHR$(10))
        D$(J) = MID$(BUF$, K, S - K)
        K = S + 1
    NEXT J
    ' Displaying analysis data
    PRINT "V1 FREQ", D$(1)              ' Frequency of PLL source
    PRINT "A1 THD(IEC)", D$(2)          ' Harmonic distortion of current
    PRINT "A1 RMS", D$(3)               ' Rms values of the 1st to 50th order
    FOR J = 1 TO N-3 STEP 2   ' Fundamental/higher harmonics analysis values
        PRINT "A1 Order" + STR$(J), D$(J + 3),        ' odd numbered component
        PRINT "A1 Order" + STR$(J + 1), D$(J + 4)     ' even numbered component
    NEXT J
NEXT I
PRGEND:
CALL IBLOC(WT%)
END                                     ' End
'
' When IBFIND call failed
ERRDISP:
PRINT " ===== No such board or device name ===== "
GOTO PRGEND
'
' GP-IB error check
ERRCHK:
IF IBSTA% >= 0 THEN RETURN
PRINT " ===== Error ===== "
GOTO PRGEND
```

Appendix 2.6 ASCII Character Codes

ASCII chracter codes are given below.

	0	1	2	3	4	5	6	7
0	0 **NUL** 0 0	20 **DEL** 10 16	40 0 **SP** 20 32	60 16 **0** 30 48	100 0 **@** 40 64	120 16 **P** 50 80	140 0 **‘** 60 96	160 16 **p** 70 112
1	1 GTL **SOH** 1 1	21 LLO **DC1** 11 17	41 1 **!** 21 33	61 17 **1** 31 49	101 1 **A** 41 65	121 17 **Q** 51 81	141 1 **a** 61 97	161 17 **q** 71 113
2	2 **STX** 2 2	22 **DC2** 12 18	42 2 **”** 22 34	62 18 **2** 32 50	102 2 **B** 42 66	122 18 **R** 52 82	142 2 **b** 62 98	162 18 **r** 72 114
3	3 **ETX** 3 3	23 **DC3** 13 19	43 3 **#** 23 35	63 19 **3** 33 51	103 3 **C** 43 67	123 19 **S** 53 83	143 3 **c** 63 99	163 19 **s** 73 115
4	4 SDC **EOT** 4 4	24 DCL **DC4** 14 20	44 4 **$** 24 36	64 20 **4** 34 52	104 4 **D** 44 68	124 20 **T** 54 84	144 4 **d** 64 100	164 20 **t** 74 116
5	5 PPC **ENQ** 5 5	25 PPU **NAK** 15 21	45 5 **%** 25 37	65 21 **5** 35 53	105 5 **E** 45 69	125 21 **U** 55 85	145 5 **e** 65 101	165 21 **u** 75 117
6	6 **ACK** 6 6	26 **SYN** 16 22	46 6 **&** 26 38	66 22 **6** 36 54	106 6 **F** 46 70	126 22 **V** 56 86	146 6 **f** 66 102	166 22 **v** 76 118
7	7 **BEL** 7 7	27 **ETB** 17 23	47 7 **’** 27 39	67 23 **7** 37 55	107 7 **G** 47 71	127 23 **W** 57 87	147 7 **g** 67 103	167 23 **w** 77 119
8	10 GET **BS** 8 8	30 SPE **CAN** 18 24	50 8 **(** 28 40	70 24 **8** 38 56	110 8 **H** 48 72	130 24 **X** 58 88	150 8 **h** 68 104	170 24 **x** 78 120
9	11 TCT **HT** 9 9	31 SPD **EM** 19 25	51 9 **)** 29 41	71 25 **9** 39 57	111 9 **I** 49 73	131 25 **Y** 59 89	151 9 **i** 69 105	171 25 **y** 79 121
A	12 **LF** A 10	32 **SUB** 1A 26	52 10 ***** 2A 42	72 26 **:** 3A 58	112 10 **J** 4A 74	132 26 **Z** 5A 90	152 10 **j** 6A 106	172 26 **z** 7A 122
B	13 **VT** B 11	33 **ESC** 1B 27	53 11 **+** 2B 43	73 27 **;** 3B 59	113 11 **K** 4B 75	133 27 **[** 5B 91	153 11 **k** 6B 107	173 27 **{** 7B 123
C	14 **FF** C 12	34 **FS** 1C 28	54 12 **,** 2C 44	74 28 **<** 3C 60	114 12 **L** 4C 76	134 28 **** 5C 92	154 12 **l** 6C 108	174 28 **|** 7C 124
D	15 **CR** D 13	35 **GS** 1D 29	55 13 **-** 2D 45	75 29 **=** 3D 61	115 13 **M** 4D 77	135 29 **]** 5D 93	155 13 **m** 6D 109	175 29 **}** 7D 125
E	16 **SO** E 14	36 **RS** 1E 30	56 14 **.** 2E 46	76 30 **>** 3E 62	116 14 **N** 4E 78	136 30 **^** 5E 94	156 14 **n** 6E 110	176 30 **~** 7E 126
F	17 **SI** F 15	37 **US** 1F 31	57 15 **/** 2F 47	77 UNL **?** 3F 63	117 15 **O** 4F 79	137 UNT **_** 5F 95	157 15 **o** 6F 111	177 **DEL (RUBOUT)** 7F 127
	Address Command	**Universal Command**	**Listener Address**		**Talker Address**		**Secondary Command**	

Example



Appendix 2.7 Communication-related Error Messages

Error messages related to communications are given below.

When servicing is required, contact your nearest YOKOGAWA representative, as given on the back cover of this manual.

Only error messages relating to the communication mode 488.2 are given here. For other error messages, refer to App 1.1 and 14.4.

Errors in communications commands (100 to 199)

Code	Message	Action	Reference Page
102	Syntax error	Incorrect syntax	App. 2.2, App. 2.3
103	Invalid separator	Insert a comma between data items to separate them.	App2-3
104	Data type error	Refer to pages App2-6, 2-7 and enter data using the correct data format.	App2-6, App2-7
105	GET not allowed	GET is not supported as a response to an interface message.	–
108	Parameter not allowed	Check the number of parameters.	App2-6, App. 2.3
109	Missing parameter	Enter the required number of parameters.	App2-6, App. 2.3
111	Header separator error	Insert a space between the header and the data to separate them.	App2-3
112	Program mnemonic too long	Check the mnemonic (character string consisting of letters and numbers).	App. 2.3
113	Undefined header	Check the header.	App. 2.3
114	Header suffix out of range	Check the header.	App. 2.3
120	Numeric data error	Mantissa must be entered before the numeric value in <NRf> format.	App2-6
123	Exponent too large	Use a smaller exponent in <NR3> format.	App2-6, App. 2.3
124	Too many digits	Limit the number of digits to 255 or less.	App2-6, App. 2.3
128	Numeric data not allowed	Enter in a format other than <NRf> format.	App2-6, App. 2.3
131	Invalid suffix	Check the units for <Voltage> and <Current>.	App2-7
134	Suffix too long	Check the units for <Voltage> and <Current>.	App2-7
138	Suffix not allowed	No units are allowed other than <Voltage> and <Current>.	App2-7
141	Invalid character data	Enter one of the character strings in {...|...|...}.	App. 2.3
144	Character data too long	Check the character strings in {...|...|...}.	App. 2.3
148	Character data not allowed	Enter in a format other than one of those in {...|...|...}.	App. 2.3
150	String data error	<Character string> must be enclosed by double quotation marks or single quotation marks.	App2-7
151	Invalid string data	<Character string> is too long or contains characters which cannot be used.	App. 2.3
158	String data not allowed	Enter in a data format other than <Character string>.	App. 2.3
161	Invalid block data	<Block data> is not allowed.	–
168	Block data not allowed	<Block data> is not allowed.	–
171	Invalid expression	Equation is not allowed.	App. 2.3
178	Expression data not allowed	Equation is not allowed.	App. 2.3
181	Invalid outside macro definition	Does not conform to the macro definition specified in IEEE488.2.	—

Errors in communications execution (200 to 299)

Code	Message	Action	Reference Page
221	Setting conflict	Check the relevant setting.	App.2.3
222	Data out of range	Check the setting range.	App.2.3
223	Too much data	Check the data byte length.	App.2.3
224	Illegal parameter value	Check the setting range.	App.2.3
241	Hardware missing	Check availability of options.	—
260	Expression error	Equation is not allowed.	—
270	Macro error	Does not conform to the macro definition specified in IEEE488.2.	—
272	Macro execution error	Does not conform to the macro definition specified in IEEE488.2.	—
273	Illegal macro label	Does not conform to the macro definition specified in IEEE488.2.	—
275	Macro definition too long	Does not conform to the macro definition specified in IEEE488.2.	—
276	Macro recursion error	Does not conform to the macro function specified in IEEE488.2.	—
277	Macro redefinition not allowed	Does not conform to the macro definition specified in IEEE488.2.	—
278	Macro header not found	Does not conform to the macro definition specified in IEEE488.2.	—

Error in communication Query(400 to 499)

Code	Message	Action	Reference Page
410	Query INTERRUPTED	Check transmission/reception order.	App2-3
420	Query UNTERMINATED	Check transmission/reception order.	App2-3
430	Query DEADLOCKED	Limit the length of the program message including <PMT> to 1024 bytes or less.	App2-4
440	Query UNTERMINATED after indefinite response	Do not enter any query after *IDN? and *OPT?.	—

Errors in Execution (800 to 899)

Codes	Message	Action	Reference Page
813 to 819	Invalid operation	Refer to 14.4	14-11
830 to 833	Internal memory access error	Refer to 14.4	14-11
841 to 847	Integrator execute error	Refer to 14.4	14-11

Error in System Operation (912)

Code	Message	Action	Reference Page
912	Fatal error in Communication driver	Service is required.	—

Warnings (350, 390)

Code	Message	Action	Reference Page
350	Queue overflow	Read out the queue.	App2-39
390	Overrun error (only for RS-232C)	Adjust the baud rate.	—

Note

The warning code 350 only appears in case of an overflow of the error queue. The error which occurs in case of clearing the `STATus:ERRor?` will not appear on the screen.

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