Foreword

Thank 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
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.

---

**Model and Suffix codes**

<table>
<thead>
<tr>
<th>Model code</th>
<th>Suffix code</th>
<th>Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>253401</td>
<td></td>
<td>WT110 Single-phase model</td>
</tr>
<tr>
<td>253502</td>
<td></td>
<td>WT130 Three-phase, three-wire model</td>
</tr>
<tr>
<td>253503</td>
<td></td>
<td>WT130 Three-phase, four-wire model</td>
</tr>
<tr>
<td>Interface</td>
<td>-C1</td>
<td>GP-IB interface</td>
</tr>
<tr>
<td></td>
<td>-C2</td>
<td>RS-232-C interface</td>
</tr>
<tr>
<td>Power voltage</td>
<td>-0</td>
<td>100-120V/220-240V</td>
</tr>
<tr>
<td></td>
<td>-R</td>
<td>[Maximum rated voltage: 240V; Maximum rated current: 10A]</td>
</tr>
</tbody>
</table>

**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.

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

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

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.

<table>
<thead>
<tr>
<th>Name</th>
<th>Parts No.</th>
<th>Minimum Q’ty</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Digital printer</td>
<td>740921</td>
<td>1</td>
<td>ESC/P compatible, RS-232-C/Centronics</td>
</tr>
</tbody>
</table>

**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 specified 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 following 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
**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 not 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.

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_Desk...
Contents

Foreword ............................................................................................................................................................................ 1
Checking the Contents of the Package ........................................................................................................................... 2
Safety Precautions .......................................................................................................................................................... 4
How to Use this Manual ................................................................................................................................................ 6
Conventions Used in this Manual .................................................................................................................................. 7

Chapter 1 What this Instrument Can Do
1.1 System Configuration and Block Diagram ................................................................................................. 1-1
1.2 Functions ...................................................................................................................................................... 1-2
1.3 Digital Numbers/Characters, and Initial Menus ............................................................................................. 1-5

Chapter 2 Nomenclature, Keys and Displays
2.1 Front Panel, Rear Panel and Top View ............................................................................................................ 2-1
2.2 Operation Keys and Function/Element Display ............................................................................................. 2-2
2.3 Displays in case of Overrange/Error during Measurement ........................................................................ 2-4

Chapter 3 Before Operation
3.1 Usage Precautions .............................................................................................................................................. 3-1
3.2 Installing the Instrument ..................................................................................................................................... 3-2
3.3 Wiring Precautions ............................................................................................................................................. 3-4
3.4 Wiring the Measurement Circuit ..................................................................................................................... 3-5
3.5 Wiring the Measurement Circuit when Using External PT/CT ..................................................................... 3-7
3.6 Wiring the Measurement Circuit when Using the External Sensor ................................................................. 3-9
3.7 Connecting the Power Supply ........................................................................................................................ 3-12
3.8 Turning the Power ON/OFF ............................................................................................................................ 3-13
3.9 Selecting the Wiring Method (for WT130) ........................................................................................................ 3-15
3.10 Improving the Measurement Accuracy ........................................................................................................ 3-16

Chapter 4 Setting Measurement Conditions
4.1 Selecting the Measurement Mode ....................................................................................................................... 4-1
4.2 Turning the Filter ON/OFF ............................................................................................................................... 4-3
4.3 Selecting the Measurement Range in case of Direct Input ............................................................................ 4-4
4.4 Setting the Scaling Value when External PT/CT is Used .............................................................................. 4-6
4.5 Selecting the Measurement Range and Setting the Scaling Value when External Sensor is Used (option) .... 4-8
4.6 Using the Averaging Function ........................................................................................................................ 4-10
4.7 Using the Four Arithmetical Operation Function (Applies to WT110/WT130 with ROM Version 2.01 or later) .... 4-10
4.8 Computing the Crest Factor (Applies to WT110/WT130 with ROM Version 2.01 or later) ................................. 4-12
4.9 Computing the Efficiency (Applies to WT130 with ROM Version 2.01 or later) ............................................ 4-15

Chapter 5 Measuring/Displaying Voltage, Current, Active Power, Frequency, Four Arithmetic Operation Value, Crest Factor and Peak Value
5.1 Measuring/Displaying Voltage, Current and Active Power ............................................................................. 5-1
5.2 Measuring/Displaying Frequency ..................................................................................................................... 5-3
5.3 Measuring/Displaying Four Arithmetic Operation Value, Crest Factor and Peak Value ............................ 5-4
Contents

Chapter 6  Computing/Displaying Apparent Power, Reactive Power, Power Factor and the Phase Angle
6.1  Computing/Displaying Apparent Power, Reactive Power and Power Factor .............. 6-1
6.2  Computing/Displaying the Phase Angle ....................................................................... 6-2

Chapter 7  Integration
7.1  Integrator Functions ..................................................................................................... 7-1
7.2  Setting Integration Mode and Integration Timer ....................................................... 7-4
7.3  Displaying Integrated Values ...................................................................................... 7-5
7.4  Precautions Regarding Use of Integrator Function ................................................... 7-7

Chapter 8  Using the Harmonic Analysis Function (optional)
8.1  Harmonic Analysis Function ....................................................................................... 8-1
8.2  Setting the Element, PLL Source and Harmonic Distortion Method ....................... 8-3
8.3  Switching the Harmonic Analysis Function ON/OFF .............................................. 8-5
8.4  Setting the Harmonic Order and Displaying the Results of Harmonic Analysis .......... 8-6

Chapter 9  Storing/Recalling
9.1  Storing/Recalling Measured Data ................................................................................ 9-1
9.2  Storing/Recalling Set-up Parameters ........................................................................ 9-4

Chapter 10  Using External In/Output
10.1 Remote Control and D/A Output Connector (optional) ............................................. 10-1
10.2 Remote Control (optional) ......................................................................................... 10-2
10.3 D/A Output (optional) ............................................................................................... 10-3
10.4 Comparator Function (optional) ................................................................................ 10-7
10.5 Setting the Comparator Mode (optional) ................................................................. 10-9
10.6 Setting the Comparator Limit Values (optional) ....................................................... 10-10
10.7 Comparator Display (optional) .................................................................................. 10-14
10.8 Turning the Comparator Function ON/OFF (optional) ............................................ 10-16
10.9 Outputting to an External Plotter/Printer .................................................................. 10-17

Chapter 11  GP-IB Interface
11.1 Using the GP-IB Interface ......................................................................................... 11-1
11.2 Responses to Interface Messages ............................................................................. 11-2
11.3 Status Byte Format (before the IEEE488.2-1987 Standard) .................................... 11-3
11.4 Output Format for Measured/Computed Data, Harmonic Analysis Data, Set-up
    Parameters and Error Codes ....................................................................................... 11-4
11.5 Setting the Address/Addressable Mode .................................................................... 11-9
11.6 Setting the Output Items ......................................................................................... 11-10
11.7 Commands (before the IEEE488.2-1987 Standard) .................................................. 11-12

Chapter 12  RS-232-C Interface
12.1 Using the RS-232-C Interface ................................................................................... 12-1
12.2 Connecting the Interface Cable ................................................................................ 12-2
12.3 Setting the Mode, Handshaking Method, Data Format and Baud Rate ...................... 12-4
12.4 Format and Commands of Output Data (before the IEEE488.2-1987 Standard) ....... 12-7

Chapter 13  Other Useful Functions
13.1 Back-up of Set-up Parameters .................................................................................. 13-1
13.2 Initializing Set-up Parameters ................................................................................... 13-2
Appendix 1 Communication Commands (before the IEEE488.2-1987 Standard)

App.1.1 Commands ................................................................. App1-1
App.1.2 Sample Program ..................................................... App1-10
App.1.3 For Users Using Communication Commands of Digital Power Meter 2533E .......... App1-15

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

App.2.1 Overview of IEEE 488.2-1987 .................................................. App2-1
App.2.2 Program Format .............................................................. App2-2
2.2.1 Symbols Used in Syntax Descriptions ................................. App2-2
2.2.2 Messages ........................................................................ App2-2
2.2.3 Commands ....................................................................... App2-4
2.2.4 Responses ........................................................................ App2-5
2.2.5 Data ................................................................................ App2-5
2.2.6 Synchronization with the Controller ................................. App2-7
App.2.3 Commands ................................................................. App2-8
2.3.1 Command List .............................................................. App2-8
2.3.2 AOUTput Group .......................................................... App2-11
2.3.3 COMMunicate Group .................................................. App2-12
2.3.4 CONFigure Group ....................................................... App2-14
2.3.5 DISPlay Group ............................................................. App2-17
2.3.6 HARMonics Group ...................................................... App2-18
2.3.7 INTEGrate Group ......................................................... App2-19
2.3.8 MATH Group .............................................................. App2-20
2.3.9 MEASure Group .......................................................... App2-21
2.3.10 RECall Group ............................................................ App2-27
2.3.11 RELay Group ............................................................. App2-28

Chapter 14 Adjustment, Calibration and Trouble-Shooting

14.1 Adjustments ........................................................................ 14-1
14.2 Calibration .......................................................................... 14-4
14.3 In Case of Malfunctioning .................................................. 14-10
14.4 Error Codes and Corrective Actions ................................. 14-11
14.5 Replacing the Fuse (for WT130) ......................................... 14-13

Chapter 15 Specifications

15.1 Input .................................................................................. 15-1
15.2 Measurement Functions .................................................. 15-1
15.3 Frequency Measurement .................................................. 15-1
15.4 Communication .............................................................. 15-1
15.5 Computing Functions ...................................................... 15-2
15.6 Display Functions ............................................................ 15-2
15.7 Integrator Functions ........................................................ 15-2
15.8 Internal Memory Function .............................................. 15-2
15.9 D/A Converter (optional) .................................................. 15-2
15.10 External Input (optional) .................................................. 15-3
15.11 Comparator Output (optional) ......................................... 15-3
15.12 External Control and Input Signals
    (in combination with the D/A converter and comparator options) .............................. 15-3
15.13 General Specifications ................................................... 15-3
15.14 Total Harmonic Analysis Function (optional) ................. 15-3
15.15 External Dimensions ..................................................... 15-4

2.2.2 Messages ........................................................................ App2-2
2.2.3 Commands ....................................................................... App2-4
Contents

2.3.12 SAMPLE Group ................................................................. App2-30
2.3.13 STATus Group ................................................................. App2-31
2.3.14 STORE Group ................................................................. App2-32
2.3.15 Common Command Group ................................................. App2-33

App.2.4 Status Report ................................................................. App2-35
2.4.1 Overview of the Status Report ........................................ App2-35
2.4.2 Status Byte ................................................................. App2-36
2.4.3 Standard Event Register ................................................ App2-37
2.4.4 Extended Event Register ................................................ App2-38
2.4.5 Output Queue and Error Queue .......................................... App2-39

App. 2.5 Sample Program ............................................................. App2-40
App. 2.6 ASCII Character Codes .................................................. App2-42
App. 2.7 Communication-related Error Messages ........................ App2-43

Index
1.1 System Configuration and Block Diagram

**System Configuration**

- **Equipment under test**
  - PT: Voltage input
  - CT: Current input
  - Ext. sensor

- **Input either one**
  - Voltage input
  - Current input

- **Digital power meter**
  - WT110 (253401)
  - WT130 (253502, 253503)

- **Contact / relay output**
  - Analog output
  - Recorder
  - GP-IB or RS-232-C
  - Personal Computer
  - Ext. printer or plotter

**Block Diagram**

<table>
<thead>
<tr>
<th>Model</th>
<th>INPUT Section</th>
</tr>
</thead>
<tbody>
<tr>
<td>253401</td>
<td>ELEMENT 1</td>
</tr>
<tr>
<td>253502</td>
<td>ELEMENT 1,3</td>
</tr>
<tr>
<td>253503</td>
<td>ELEMENT 1,2,3</td>
</tr>
</tbody>
</table>

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 electricity 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.

<table>
<thead>
<tr>
<th>model</th>
<th>number of elements</th>
<th>wiring method</th>
</tr>
</thead>
<tbody>
<tr>
<td>253401</td>
<td>1</td>
<td>single-phase, two-wire (1Φ2W)</td>
</tr>
<tr>
<td>253502</td>
<td>2</td>
<td>single-phase, two-wire (1Φ2W); single-phase, three-wire (1Φ3W); three-phase, three-wire (3Φ3W)</td>
</tr>
<tr>
<td>253503</td>
<td>3</td>
<td>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)</td>
</tr>
</tbody>
</table>

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.
1.2 Functions

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 separately.

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 customer’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.

<table>
<thead>
<tr>
<th>Number</th>
<th>Character</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>7</td>
<td>H</td>
</tr>
<tr>
<td>8</td>
<td>I</td>
</tr>
<tr>
<td>9</td>
<td>J</td>
</tr>
<tr>
<td>A</td>
<td>A</td>
</tr>
<tr>
<td>B</td>
<td>B</td>
</tr>
<tr>
<td>C</td>
<td>C</td>
</tr>
<tr>
<td>D</td>
<td>D</td>
</tr>
<tr>
<td>E</td>
<td>E</td>
</tr>
<tr>
<td>F</td>
<td>F</td>
</tr>
<tr>
<td>G</td>
<td>G</td>
</tr>
<tr>
<td>H</td>
<td>H</td>
</tr>
<tr>
<td>I</td>
<td>I</td>
</tr>
<tr>
<td>J</td>
<td>J</td>
</tr>
<tr>
<td>K</td>
<td>K</td>
</tr>
<tr>
<td>L</td>
<td>L</td>
</tr>
<tr>
<td>M</td>
<td>M</td>
</tr>
<tr>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>P</td>
<td>P</td>
</tr>
<tr>
<td>Q</td>
<td>Q</td>
</tr>
<tr>
<td>R</td>
<td>R</td>
</tr>
<tr>
<td>S</td>
<td>S</td>
</tr>
<tr>
<td>T</td>
<td>T</td>
</tr>
<tr>
<td>U</td>
<td>U</td>
</tr>
<tr>
<td>V</td>
<td>V</td>
</tr>
<tr>
<td>W</td>
<td>W</td>
</tr>
<tr>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Z</td>
<td>Z</td>
</tr>
<tr>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>−</td>
<td>−</td>
</tr>
<tr>
<td>×</td>
<td>×</td>
</tr>
<tr>
<td>÷</td>
<td>÷</td>
</tr>
</tbody>
</table>

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

1. (Display C)

<table>
<thead>
<tr>
<th>Range</th>
<th>Setting</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>V Rang e</td>
</tr>
<tr>
<td>10</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

• Current Range Setting

1. (Display C)

When equipped with option /EX1

<table>
<thead>
<tr>
<th>Range</th>
<th>Setting</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

When equipped with option /EX2

<table>
<thead>
<tr>
<th>Range</th>
<th>Setting</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

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

1. (Display C)

<table>
<thead>
<tr>
<th>Setting</th>
<th>Filter Setting</th>
</tr>
</thead>
<tbody>
<tr>
<td>FL</td>
<td>F L</td>
</tr>
<tr>
<td>SCAL E</td>
<td>S CA L E</td>
</tr>
<tr>
<td>R N</td>
<td>R N</td>
</tr>
<tr>
<td>R L</td>
<td>R L</td>
</tr>
<tr>
<td>Computation, crest factor settings</td>
<td></td>
</tr>
</tbody>
</table>

IM 253401-01E 1-5
1.3 Digital Numbers/Characters, and Initial Menus

- **Integration Setting**
  
  1. **SHIFT**<br>  
     **SET**<br>  
     **INTEG**<br>  
     **SET**<br>  
     **RESET**

  2. (Display C)<br>  
     - $\hat{\alpha} \hat{\phi}$$E$ — (Setting integration mod)<br>  
     - $\hat{\alpha} \hat{\phi}$$E$$r$ — (Setting integration timer)<br>  
     - $dR$, $\hat{\alpha}$$E$ — (Setting integration preset time)<br>  

- **Turning the Harmonic Analysis Function ON/OFF**
  
  1. **SHIFT**<br>  
     **HARMONICS**

  2. (Display C)<br>  
     - $E$$L$$E$$n$ — (Setting the element)<br>  
     - $S$$Y$$n$$C$ — (Setting PLL source)<br>  
     - $E$$H$$d$ — (Setting computation method of harmonic distortion)<br>  

- **Storing/Recalling to/from Internal Memory**
  
  1. **SHIFT**<br>  
     **MEMORY**<br>  
     **STOP**

  2. (Display C)<br>  
     - $S$$t$$o$$r$$E$ — (Storing measurement data)<br>  
     - $r$$E$$L$$r$$L$ — (Recalling measurement data)<br>  
     - $P$$n$$L$$S$$t$$r$$r$ — (Storing set-up parameters)<br>  
     - $P$$n$$L$$r$$L$$r$$L$ — (Recalling set-up parameters)<br>  

- **Setting Output**
  
  1. **SHIFT**<br>  
     **OUTPUT**

  2. (Display C)<br>  
     - $C$$o$$N$$n$$n$ — (Setting comm./plotter/printer output)<br>  
     - $P$$r$$o$$u$$t$ — (Execute plotter/printer output)<br>  
     - $dR$ — (Setting D/A output)<br>  
     - $r$$E$$L$$r$$Y$ — (Comparator setting:relay output setting)<br>  

- **Setting Communication Interface (GP-IB)**
  
  1. **SHIFT**<br>  
     **INTERFACE**<br>  
     **LOCAL**

  2. (Display C)<br>  
     - $R$$d$$r$$R$ — (Setting addressable mode A)<br>  
     - $R$$d$$r$$b$ — (Setting addressable mode B)<br>  
     - $t$$o$$n$$l$$Y$ — (Setting talk-only mode)<br>  
     - $P$$r$$, n$ — (Print mode setting:setting plotter/printer output)<br>  
     - $4882$ — (Setting communication commands according to IEEE 488.2-1987)<br>  

- **Setting Communication Interface (RS-232-C)**
  
  1. **SHIFT**<br>  
     **INTERFACE**<br>  
     **LOCAL**

  2. (Display C)<br>  
     - $n$ — (Setting normal mode)<br>  
     - $t$$o$$n$$l$$Y$ — (Setting talk-only mode)<br>  
     - $P$$r$$, n$ — (Print mode setting:setting plotter/printer output)<br>  
     - $4882$ — (Setting communication commands according to IEEE 488.2-1987)
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
- **V RANGE**
  Shows the voltage range setting menu (page 4-4)
- **A RANGE**
  Shows the current range setting menu (page 4-4, 4-8)
- **V RANGE**
- **SHIFT**
  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
- **HOLD**
  Keeps the displayed value, and the HOLD indicator will light up. Pressing once again will result in canceling HOLD
- **SHIFT TRIG**
  When in the HOLD situation this results in updating the displayed value
- **V**
  For decreasing the voltage/current range, and for setting of functions/values
- **A**
  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 INTEG SET**
  Shows the setting menu for integration mode/time, and rated integration time (Ch. 7)

Indicators for operating functions
- **HOLD**
  When a function is set and in operation, this indicator will light up
- **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 operation conditions**
- Shows sampling, voltage/current overrange and measurement mode
- **SHIFT**
  Shows the setting menu for storing/recalling measurement data and set-up information (Ch. 9)
- **LOCAL**
- **SHIFT INTERFACE**
  Shows the setting menu for communication/printing (Ch. 11, 12)
- **SETUP**
- **SHIFT OUTPUT**

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

Indicators for operating functions
- When a function is set and in operation, this indicator will light up
  - AUTO
  - LIGHTS UP WHEN RANGE IS AUTO
  - HOLD
  - Keeps the displayed value, and the HOLD indicator will light up. Pressing once again will result in canceling HOLD
  - V
  - For decreasing the voltage/current range, and for setting of functions/values
  - A
  - For increasing the voltage/current range, and for setting of functions/values
  - ENTER
  - For verifying the set range/function/value
  - START
  - Starts integration
  - STOP
  - Stops integration
  - SHIFT
  - Moves the cursor of a value from left to right
  - SHIFT
  - Moves the decimal point from left to right
  - SHIFT
  - SHIFT
  - HOLD
  - Indicators for operation conditions
  - Shows sampling, voltage/current overrange and measurement mode
  - SHIFT
  - 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
  - LOCAL
  - SHIFT INTERFACE
  - Shows the setting menu for communication/printing (Ch. 11, 12)
  - SHIFT SETUP
  - 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)
  - SHIFT
  - HARMONICS
  - Shows the setting menu for harmonics ON/OFF, PLL source, and element selection (Ch. 8)
  - SHIFT
  - 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
  - LOCAL
  - SHIFT INTERFACE
  - Shows the setting menu for communication/printing (Ch. 11, 12)
  - SHIFT SETUP
  - 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)
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 will appear, which looks as follows.

```
- - O L -
```

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

```
- - O F -
```

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 O V E R
 A O V E R
```

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.

<table>
<thead>
<tr>
<th>Function</th>
<th>Display</th>
</tr>
</thead>
<tbody>
<tr>
<td>V (voltage)</td>
<td>displays zero</td>
</tr>
<tr>
<td>A (current)</td>
<td></td>
</tr>
<tr>
<td>var (reactive power)</td>
<td></td>
</tr>
<tr>
<td>PF (power factor)</td>
<td>( P F E r )</td>
</tr>
<tr>
<td>deg (phase angle)</td>
<td>( d E E r )</td>
</tr>
</tbody>
</table>

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)](image1)

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.

**Fixed positions of the handle**

(We recommend the positions 1, 3, 5, or 8. When using no 4, don’t put any weight on the instrument.)

- **WT130 (253502, 253503)**

  Turn the stands after pulling them approx. 2-3 mm on both sides.
### Rack mount

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

#### Rack mount kit (option)

<table>
<thead>
<tr>
<th>Specifications</th>
<th>Kit</th>
<th>Specifications</th>
<th>Kit</th>
</tr>
</thead>
<tbody>
<tr>
<td>WT110 EIA standard</td>
<td>751533-E2</td>
<td>WT130 EIA standard</td>
<td>751533-E3</td>
</tr>
<tr>
<td>WT110 JIS standard</td>
<td>751533-J2</td>
<td>WT130 JIS standard</td>
<td>751533-J3</td>
</tr>
<tr>
<td>WT110 EIA standard</td>
<td>751534-E2</td>
<td>WT130 EIA standard</td>
<td>751534-E3</td>
</tr>
<tr>
<td>WT110 JIS standard</td>
<td>751534-J2</td>
<td>WT130 JIS standard</td>
<td>751534-J3</td>
</tr>
</tbody>
</table>

#### 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.

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”.

<table>
<thead>
<tr>
<th>Max allowable input</th>
<th>Voltage input</th>
<th>Current input</th>
</tr>
</thead>
<tbody>
<tr>
<td>Instantaneous max</td>
<td>The peak value is 2000V or the RMS value is 1500V, whichever is less</td>
<td>The peak value is 150A or the RMS value is 40A, whichever is less</td>
</tr>
<tr>
<td>Continuous</td>
<td>The peak value is 1500V or the RMS value is 1000V, whichever is less</td>
<td>The peak value is 100A or the RMS value is 30A, whichever is less</td>
</tr>
</tbody>
</table>

- 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.
- 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 4mm².

**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 shown 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.
3.4 Wiring the Measurement Circuit

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.
3.5 Wiring the Measurement Circuit when Using External PT/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 1mm²).
- 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)

![Diagram 1](image1.png)

![Diagram 2](image2.png)
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)
3.6 Wiring the Measurement Circuit when Using the External Sensor

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

- 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
    - 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 starting 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 your 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 specifications 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.
3.8 Turning the Power ON/OFF

Opening Messages

1. Power switch

   ON

   Power switch

2. All LED's light up

   Extinguish

   Display A
   Display B
   Display C

3. (Model)

   A
   B
   C

   (For WT110)

   No display

4. (Version)

   A
   B
   C

   No display

5. (Only for/EX1, EX2)

   A
   B
   C

   (E-1)
   (E-2)

6. (Only for/HRM option)

   A
   B
   C

    HR means

7. (For/DA option)

   A
   B
   C

    dA

8. (For/CMP option)

   A
   B
   C

    rELAY

9. (/GPIB mode)

   A
   B
   C

   *1

   AddrA

10. (/GPIB address)

    A
    B
    C

    AddrA

9. (RS-232-C mode)

   A
   B
   C

   *2

   nor

10. (RS-232-C handshake)

    A
    B
    C

    hAnd0

11. (RS-232-C format)

    A
    B
    C

    For 0

12. (RS-232-C baud rate)

    A
    B
    C

    9600

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

*2 Displays the setting valid before the power was turned OFF.
   Any of non/only/Print can be displayed.

NO

All specs/option have been displayed?

YES

Ready for measurement
3.9 Selecting the Wiring Method (for WT130)

Relevant Keys

<table>
<thead>
<tr>
<th>SCALING</th>
<th>AVG</th>
<th>FILTER</th>
<th>STORE</th>
<th>RECALL</th>
<th>HARMONICS</th>
<th>SAMPLE</th>
<th>V  OVER</th>
<th>A  OVER</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>V</td>
<td>A</td>
<td>MODE</td>
</tr>
<tr>
<td>RMS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>V</td>
<td>A</td>
<td>MODE</td>
</tr>
<tr>
<td>V  MEAN</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>DC</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td>h</td>
<td>h</td>
<td></td>
</tr>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>var</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MW TIME</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VP Fm</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Ak deg</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MW %</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>MW</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TRIG</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>STATE</td>
<td>START</td>
<td>STOP</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>INTEGRATOR</td>
<td>START</td>
<td>STOP</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>REMOTE INTERFACE</td>
<td>OUTPUT</td>
<td>LOCAL SETUP</td>
</tr>
</tbody>
</table>

*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).

103W : Single-phase, three-wire system
303W : Three-phase, three-wire system
304W : 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 or 3, selecting any of the above mentioned wiring 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).

103W : Single-phase, three-wire system
303W : Three-phase, three-wire system
304W : 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 wiring 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 approx. 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 (approx. 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

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”.

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Voltage</th>
<th>Current</th>
</tr>
</thead>
<tbody>
<tr>
<td>RMS</td>
<td>Measures and displays true RMS value</td>
<td>Measures and displays true RMS value</td>
</tr>
<tr>
<td>V MEAN</td>
<td>Displays rectified mean value calibrated to the RMS value</td>
<td>Measures and displays true RMS value</td>
</tr>
<tr>
<td>DC</td>
<td>Displays DC value obtained by averaging the input signal</td>
<td>Displays DC value obtained by averaging the input signal</td>
</tr>
</tbody>
</table>

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.
\[
\frac{\pi}{2\sqrt{2}} \cdot \frac{2}{T} \int_0^T |f(t)| \, dt
\]
\(f(t)\): 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

<table>
<thead>
<tr>
<th>Name</th>
<th>Waveform</th>
<th>Measurement mode</th>
<th>RMS value</th>
<th>Mean value</th>
<th>Mean-value rectification</th>
<th>Linear averaging</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sinewave</td>
<td></td>
<td>Display</td>
<td>RMS</td>
<td>—</td>
<td>V MEAN</td>
<td>DC</td>
</tr>
<tr>
<td></td>
<td><img src="image1" alt="Sinewave Waveform" /></td>
<td></td>
<td>$\frac{E_p}{\sqrt{2}}$</td>
<td>$\frac{2}{\pi} \cdot E_p$</td>
<td>$\frac{E_p}{\sqrt{2}}$</td>
<td>0</td>
</tr>
<tr>
<td>Half-wave rectification</td>
<td><img src="image2" alt="Half-wave rect Waveform" /></td>
<td>Ep</td>
<td>$\frac{E_p}{2}$</td>
<td>$\frac{E_p}{\pi}$</td>
<td>$\frac{E_p}{2 \sqrt{2}}$</td>
<td>$\frac{E_p}{\pi}$</td>
</tr>
<tr>
<td>Full-wave rectification</td>
<td><img src="image3" alt="Full-wave rect Waveform" /></td>
<td>Ep</td>
<td>$\frac{E_p}{\sqrt{2}}$</td>
<td>$\frac{2}{\pi} \cdot E_p$</td>
<td>$\frac{E_p}{\sqrt{2}}$</td>
<td>$\frac{2}{\pi} \cdot E_p$</td>
</tr>
<tr>
<td>Direct current</td>
<td><img src="image4" alt="Direct Current Waveform" /></td>
<td>Ep</td>
<td>Ep</td>
<td>$\frac{\pi}{2 \sqrt{2}} \cdot E_p$</td>
<td>Ep</td>
<td>Ep</td>
</tr>
<tr>
<td>Triangular wave</td>
<td><img src="image5" alt="Triangular Waveform" /></td>
<td>Ep</td>
<td>$\frac{E_p}{\sqrt{3}}$</td>
<td>$\frac{E_p}{2}$</td>
<td>$\frac{\pi}{4 \sqrt{2}} \cdot E_p$</td>
<td>0</td>
</tr>
<tr>
<td>Square wave</td>
<td><img src="image6" alt="Square Waveform" /></td>
<td>Ep</td>
<td>Ep</td>
<td>$\frac{\pi}{2 \sqrt{2}} \cdot E_p$</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Pulse</td>
<td><img src="image7" alt="Pulse Waveform" /></td>
<td>$\sqrt{\frac{\tau}{2\pi}} \cdot E_p$</td>
<td>$\frac{\tau}{2\pi} \cdot E_p$</td>
<td>$\frac{\pi \tau}{4\sqrt{2}} \cdot E_p$</td>
<td>$\frac{\tau}{2\pi} \cdot E_p$</td>
<td></td>
</tr>
</tbody>
</table>

When duty $D (\frac{\tau}{\pi})$ is applied.

$\sqrt{D \cdot E_p}$, $D \cdot E_p$, $\frac{\pi D}{2 \sqrt{2}} \cdot E_p$, $D \cdot E_p$
### 4.2 Turning the Filter 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.

1. **SETUP**
2. 
3. **ENTER**
4. 
5. **ENTER**

**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

![Relevant Keys Diagram]

*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
  1. (Display C)
  2. ENTER
  3. End

• Current Range Setting
  1. (Display C)
  2. ENTER
  3. End

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.
4.3 Selecting the Measurement Range in case of Direct Input

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 measured 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.

<table>
<thead>
<tr>
<th>Wiring method</th>
<th>Power range</th>
</tr>
</thead>
<tbody>
<tr>
<td>single-phase, two-wire (1Φ2W)</td>
<td>voltage range × current range</td>
</tr>
<tr>
<td>single-phase, three-wire (1Φ3W)</td>
<td>voltage range × current range × 2</td>
</tr>
<tr>
<td>three-phase, three-wire (3Φ3W)</td>
<td>voltage range × current range × 2</td>
</tr>
<tr>
<td>three-voltage, three-current (3A3V)</td>
<td>voltage range × current range × 3</td>
</tr>
<tr>
<td>three-phase, four-wire (3Φ4W)</td>
<td>voltage range × current range × 3</td>
</tr>
</tbody>
</table>

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

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

1. (Display C)

2. 

3. (Display C)

4. 

5. ENTER

6. Enter

7. PT ratio selecting

8. up down

9. cursor shift

10. decimal point shift

11. ENTER

12. Same as step 8 to 10

13. ENTER

14. Same as step 8 to 10

15. ENTER

16. ENTER

17. End

• Selecting Scaling ON/OFF

1. (Display C)

2. 

3. (Display C)

4. 

5. Enter

Selecting the input element

(Display C)
Setting Measurement Conditions

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 be displayed or otherwise output.

<table>
<thead>
<tr>
<th>Measured/computed value</th>
<th>Scaled result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voltage V</td>
<td>$P \times V$</td>
</tr>
<tr>
<td>Current A</td>
<td>$C \times A$</td>
</tr>
<tr>
<td>Active power W</td>
<td>$F \times P \times C \times W$</td>
</tr>
<tr>
<td>Reactive power var</td>
<td>$F \times P \times C \times \text{var}$</td>
</tr>
<tr>
<td>Apparent power VA</td>
<td>$F \times P \times C \times \text{VA}$</td>
</tr>
</tbody>
</table>

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 × 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

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
  Select the external sensor function

1. SETUP

2. SCALE

3. ENTER

4. SCALE

5. SCALE

6. ENTER

7. ENTER

8. ENTER

9. ENTER

10. ENTER

11. ENTER

12. ENTER

13. ENTER

• Selecting the Measurement Range (Current, with Scaling function ON)
  In case of EX1 option

1. A RANGE

2. A RANGE

3. ENTER

End

In case of EX2 option

1. A RANGE

2. A RANGE

3. ENTER

End

*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**

**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 be displayed or otherwise output. This function is exactly the same as the one described previously for use with PT/CT.

<table>
<thead>
<tr>
<th>Measured/computed value</th>
<th>Scaled result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current A</td>
<td>E × A</td>
</tr>
<tr>
<td>Active power W</td>
<td>E × W</td>
</tr>
<tr>
<td>Reactive power var</td>
<td>E × var</td>
</tr>
<tr>
<td>Apparent power VA</td>
<td>E × VA</td>
</tr>
</tbody>
</table>

**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 separately.

**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**

```
<table>
<thead>
<tr>
<th>SCALING</th>
<th>AVG</th>
<th>FILTER</th>
<th>STORE</th>
<th>RECALL</th>
<th>HARMONICS</th>
</tr>
</thead>
</table>
```

```
<table>
<thead>
<tr>
<th>SAMPLE</th>
<th>OVER</th>
<th>V</th>
<th>A</th>
<th>OVER</th>
</tr>
</thead>
</table>
```

```
<table>
<thead>
<tr>
<th>MODE</th>
<th>RMS</th>
<th>V MEAN</th>
<th>DC</th>
</tr>
</thead>
</table>
```

```
<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
</table>
```

```
<table>
<thead>
<tr>
<th>VV Am</th>
<th>Ak var</th>
</tr>
</thead>
</table>
```

```
<table>
<thead>
<tr>
<th>MW</th>
<th>TIME</th>
</tr>
</thead>
</table>
```

```
<table>
<thead>
<tr>
<th>VP</th>
<th>Fm</th>
</tr>
</thead>
</table>
```

```
<table>
<thead>
<tr>
<th>MW %</th>
</tr>
</thead>
</table>
```

```
<table>
<thead>
<tr>
<th>FUNCTION</th>
<th>ELEMENT</th>
</tr>
</thead>
</table>
```

```
<table>
<thead>
<tr>
<th>AUTO</th>
<th>AUTO</th>
</tr>
</thead>
</table>
```

```
<table>
<thead>
<tr>
<th>MODE</th>
<th>1</th>
<th>Φ</th>
</tr>
</thead>
</table>
```

```
<table>
<thead>
<tr>
<th>3W</th>
</tr>
</thead>
</table>
```

```
<table>
<thead>
<tr>
<th>Φ</th>
<th>3W</th>
</tr>
</thead>
</table>
```

```
<table>
<thead>
<tr>
<th>Φ</th>
<th>4W</th>
</tr>
</thead>
</table>
```

```
<table>
<thead>
<tr>
<th>Φ</th>
<th>4W</th>
</tr>
</thead>
</table>
```

```
<table>
<thead>
<tr>
<th>3</th>
<th>Φ</th>
</tr>
</thead>
</table>
```

```
<table>
<thead>
<tr>
<th>3</th>
<th>Φ</th>
</tr>
</thead>
</table>
```

```
<table>
<thead>
<tr>
<th>3</th>
<th>Φ</th>
</tr>
</thead>
</table>
```

*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

1. Setting Averaging
   - Selecting the averaging function (Display C)

```
<table>
<thead>
<tr>
<th>SETUP</th>
<th>ENTER</th>
</tr>
</thead>
</table>
```

2. SCALE
   - $E_n$
   - $P_nLrSt$
   - $\bar{n}Rth$

3. FLE
   - RYG

4. A

5. ENTER
   - TYPE
   - $on$

6. ENTER
   - Type
   - $n$

7. ENTER
   - Type
   - $EP$

8. ENTER
   - Selecting the sample number (Display C)
   - $8$
   - $16$
   - $32$
   - $64$

9. ENTER
   - End

### Averaging ON/OFF

1. Averaging ON/OFF
   - Selecting the averaging function (Display C)

```
<table>
<thead>
<tr>
<th>SETUP</th>
<th>ENTER</th>
</tr>
</thead>
</table>
```

2. SCALE
   - $E_n$
   - $P_nLrSt$
   - $\bar{n}Rth$

3. FLE
   - RYG

4. A

5. ENTER
   - TYPE
   - $on$

6. ENTER
   - Type
   - $EP$

7. Enter
   - End
4.6 Using the Averaging Function

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.
  \[ D_n = D_{n-1} + \frac{(M_n - D_{n-1})}{K} \]
  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.
  \[ D_n = \frac{(M_{n-(m-1)} + M_{n-(m-2)} + ... + M_n + M_{n-1} + M_a)}{m} \]
  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;
  - \( M_a \) : the measurement value at \( m \) displays before the \( n \)th display;
  - \( M_{n-1} \) : the measurement value at one display before the \( n \)th display;
  - \( M_a \) : 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 separately. 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

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. “-” is displayed at the front when the computation results are being displayed.

\[
\begin{align*}
R^b & : A + B \\
R^{-b} & : A - B \\
R^{ \circ b} & : A \times B \\
R^{ \circ^{-b}} & : A^{-B} \\
R^{ \circ b}^2 & : A = B^2 \\
R^{ \circ^{-b}}^2 & : A^{-B}^2 \\
\end{align*}
\]

A, B indicates display A, B respectively.

Note

- The meanings of the displayed symbols are as follows:
  - : (Addition)
  - : (Subtraction)
  \times : (Multiplication)
  - : (Division)
  \circ : (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 - - -”.

"Shows the operation panel of the WT130. For the differences between WT110 and WT130, refer to section 2.2, page 2-2, 2-3"
4.7 Using the Four Arithmetical Operation Function (Applies to WT110/WT130 with ROM Version 2.01 or later)

Application Example

- **Power summation**
  \[ a + b \] : Displays the result of display A + display B.

  Computation example:

<table>
<thead>
<tr>
<th>Display A</th>
<th>Display B</th>
<th>Display C</th>
<th>Wiring method</th>
</tr>
</thead>
<tbody>
<tr>
<td>W1</td>
<td>W2 or W3</td>
<td>W1+W2 or W1+W3</td>
<td>Any</td>
</tr>
</tbody>
</table>

- **Power loss**
  \[ a - b \] : Displays the result of display A – display B.

  Computation example 1:

<table>
<thead>
<tr>
<th>Display A</th>
<th>Display B</th>
<th>Display C</th>
<th>Wiring method</th>
</tr>
</thead>
<tbody>
<tr>
<td>W1</td>
<td>W3</td>
<td>W1–W3</td>
<td>Any</td>
</tr>
</tbody>
</table>

  Computation example 2:

<table>
<thead>
<tr>
<th>Display A</th>
<th>Display B</th>
<th>Display C</th>
<th>Wiring method</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \sum W(=W1+W3) )</td>
<td>W2</td>
<td>( \sum W-W2 )</td>
<td>3φ3W</td>
</tr>
</tbody>
</table>

  Computation example 3:

<table>
<thead>
<tr>
<th>Display A</th>
<th>Display B</th>
<th>Display C</th>
<th>Wiring method</th>
</tr>
</thead>
<tbody>
<tr>
<td>W2</td>
<td>( \sum W(=W1+W3) )</td>
<td>W2–W ( \sum W )</td>
<td>3φ3W</td>
</tr>
</tbody>
</table>
4.7 Using the Four Arithmetical Operation Function (Applies to WT110/WT130 with ROM Version 2.01 or later)

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

  \( \frac{A}{B} \) : Displays the result of display A \( \times \) display B.

  
<table>
<thead>
<tr>
<th>Display A</th>
<th>Display B</th>
<th>Display C</th>
<th>Wiring method</th>
</tr>
</thead>
<tbody>
<tr>
<td>V1rms</td>
<td>A1rms</td>
<td>V1rms×A1rms</td>
<td>Any</td>
</tr>
</tbody>
</table>

- **Absolute value of the impedance**

  \( \frac{A}{B} \) : Displays the result of display A \( ÷ \) display B.

  
<table>
<thead>
<tr>
<th>Display A</th>
<th>Display B</th>
<th>Display C</th>
<th>Wiring method</th>
</tr>
</thead>
<tbody>
<tr>
<td>V1rms</td>
<td>A1rms</td>
<td></td>
<td>Z</td>
</tr>
</tbody>
</table>

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

  \( \frac{A}{B} \) : Displays the result of display A \( ÷ \) display B.

  
<table>
<thead>
<tr>
<th>Display A</th>
<th>Display B</th>
<th>Display C</th>
<th>Wiring method</th>
</tr>
</thead>
<tbody>
<tr>
<td>V1rms</td>
<td>A3rms</td>
<td>V1rms</td>
<td>3ΦW</td>
</tr>
<tr>
<td>A1rms</td>
<td>A3rms</td>
<td>A1rms</td>
<td>A3rms</td>
</tr>
</tbody>
</table>

- **Impedance, resistance and reactance**

  \( \frac{A}{B} \sqrt{2} \) : Displays the result of display A \( ÷ \) (display B)\(^2\)

  
<table>
<thead>
<tr>
<th>Display A</th>
<th>Display B</th>
<th>Display C</th>
<th>Wiring method</th>
</tr>
</thead>
<tbody>
<tr>
<td>VA1</td>
<td>A1rms</td>
<td></td>
<td>Z</td>
</tr>
<tr>
<td>W1</td>
<td>A1rms</td>
<td>( R= \frac{W1}{(A1rms)^2} )</td>
<td>Any</td>
</tr>
<tr>
<td>Var1</td>
<td>A1rms</td>
<td>(</td>
<td>X</td>
</tr>
</tbody>
</table>

- **Resistance**

  \( \sqrt{2} \frac{A}{B} \) : Displays the result of \( (display A)^2 \) \( ÷ \) display B

  
<table>
<thead>
<tr>
<th>Display A</th>
<th>Display B</th>
<th>Display C</th>
<th>Wiring method</th>
</tr>
</thead>
<tbody>
<tr>
<td>V1rms</td>
<td>W1</td>
<td>( R= \frac{(V1rms)^2}{W1} )</td>
<td>Any</td>
</tr>
</tbody>
</table>
4.8 Computing the Crest Factor (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.

Selecting the four arithmetical operations function (Display C)

1. Fkt –
2. Rhg –
3. Scale –
4. Pnl stk –
5. Rkh –

Display relevant keys and indicator

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. “—” 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 : PEAK value / 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

*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 four arithmetical operations function

1. (Display C) 2. FLB - 3. SCALE - 4. EFF, ENTER

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

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).

![Diagram of two-wire system](image)

**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.

![Diagram of two-wire to three-wire system](image)

**Computing equation**
Efficiency(μ) = (W1+W3)/W2×100
5.1 Measuring/Displaying Voltage, Current and Active Power

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

Display

Operating Procedure

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

2 Selecting the Input Element
Select the input element by pressing the ELEMENT key.

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
- Σ: Displays according to the wiring method, and is as follows.

<table>
<thead>
<tr>
<th>Wiring method</th>
<th>ΣV</th>
<th>ΣA</th>
<th>ΣW</th>
<th>ΣVA</th>
<th>ΣVAR</th>
</tr>
</thead>
<tbody>
<tr>
<td>1Φ3W</td>
<td>V1+V3/2</td>
<td>A1/A3</td>
<td>W1+W5</td>
<td>V1A1+V3A3</td>
<td>var1+var3</td>
</tr>
<tr>
<td>3Φ3W</td>
<td>V1+V3/2</td>
<td>A1/A3</td>
<td>W1+W5</td>
<td>√3/2(V1A1+V3A3)</td>
<td>var1+var3</td>
</tr>
<tr>
<td>3Φ4W</td>
<td>V1+V2+V3/3</td>
<td>A1+A2/A3</td>
<td>W1+W5+W3</td>
<td>V1A1+V2A2+V3A3</td>
<td>var1+var2+var3</td>
</tr>
<tr>
<td>3V3A</td>
<td>V1+V2+V3/3</td>
<td>A1+A2/A3</td>
<td>W1+W5</td>
<td>√3/3(V1A1+V2A2+V3A3)</td>
<td>var1+var3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Wiring method</th>
<th>ΣPF</th>
<th>Σdeg</th>
</tr>
</thead>
<tbody>
<tr>
<td>1Φ3W</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3Φ3W</td>
<td>ΣW/ΣVA</td>
<td>cos⁻¹ΣPF</td>
</tr>
<tr>
<td>3Φ4W</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3V3A</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
5.2 Measuring/Displaying Frequency

**Relevant Keys**

![Operation Panel of WT130]

*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.

   ![Function Selection Diagram]

   Whz and Ahz will light twice. $\nu$ 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 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
- **∑**: 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

Operating Procedure

1. Selecting the display Function
Select either (four arithmetical operations, crest factor), (voltage peak value) or (current peak value) by pressing the FUNCTION key.

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

Explanation

Measuring/displaying peak value
\( p \) 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 and the crest factor
When display C is set to \( \Phi \), 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

![Function keys diagram]

*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 (apparent power), var (reactive power) or PF (power factor) by pressing the FUNCTION key of display A or B.

Display A

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 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
• 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, PFErr will be displayed.
6.2 Computing/Displaying the Phase Angle

Relevant Keys

Display 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 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
• ∑ : 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.
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 separately.

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 –999999MWh/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 –999999MWh/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 −999999MWh/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**

\[
\sum_{i=0}^{t} \frac{W_i}{4 \times 3600}
\]

- \(W_i\) : Active power between display update interval
- \(t\) : Preset integration time

**Current integration**

\[
\sum_{i=0}^{t} \frac{A_i}{4 \times 3600}
\]

- \(A_i\) : 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.

<table>
<thead>
<tr>
<th>Elapsed time</th>
<th>Integrated value</th>
</tr>
</thead>
<tbody>
<tr>
<td>0s</td>
<td>0.000mWh</td>
</tr>
<tr>
<td>2s</td>
<td>416.67mWh</td>
</tr>
<tr>
<td>4s</td>
<td>833.33mWh</td>
</tr>
<tr>
<td>5s</td>
<td>1.0417Wh</td>
</tr>
<tr>
<td>47</td>
<td>9.7917Wh</td>
</tr>
<tr>
<td>48</td>
<td>10.000Wh</td>
</tr>
<tr>
<td>7m59s</td>
<td>99.792Wh</td>
</tr>
<tr>
<td>8m00s</td>
<td>100.000Wh</td>
</tr>
<tr>
<td>1h00m00s</td>
<td>750.000Wh</td>
</tr>
<tr>
<td>2h00m00s</td>
<td>1.5000kWh</td>
</tr>
<tr>
<td>13h00m00s</td>
<td>9.7500kWh</td>
</tr>
<tr>
<td>14h00m00s</td>
<td>10.500kWh</td>
</tr>
</tbody>
</table>

Display Function of Integrator Values

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

<table>
<thead>
<tr>
<th>Display function</th>
<th>Measurement mode</th>
<th>Display contents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wh</td>
<td>RMS, VMEAN, DC</td>
<td>both positive and negative watt hour values</td>
</tr>
<tr>
<td>Wh±1</td>
<td>RMS, VMEAN, DC</td>
<td>positive watt hour value</td>
</tr>
<tr>
<td>Wh±2</td>
<td>RMS, VMEAN, DC</td>
<td>negative watt hour value</td>
</tr>
<tr>
<td>Ah</td>
<td>RMS, VMEAN</td>
<td>total ampere hour values</td>
</tr>
<tr>
<td></td>
<td>DC</td>
<td>both positive and negative ampere hour values</td>
</tr>
<tr>
<td>Ah±1</td>
<td>RMS, VMEAN</td>
<td>total ampere hour values (same as Ah)</td>
</tr>
<tr>
<td></td>
<td>DC</td>
<td>positive ampere hour value</td>
</tr>
<tr>
<td>Ah±2</td>
<td>RMS, VMEAN</td>
<td>–0</td>
</tr>
<tr>
<td></td>
<td>DC</td>
<td>negative ampere hour value</td>
</tr>
</tbody>
</table>

*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

<table>
<thead>
<tr>
<th>SCALING</th>
<th>AVG</th>
<th>FILTER</th>
<th>STORE</th>
<th>RECALL</th>
<th>HARMONICS</th>
</tr>
</thead>
<tbody>
<tr>
<td>SAMPLE</td>
<td>VOL</td>
<td>OVER</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>INDEX</td>
<td>VOL</td>
<td>A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TIME</td>
<td>VOL</td>
<td>A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MODE</td>
<td>RMS</td>
<td>A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AVG</td>
<td>V</td>
<td>A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MEAN</td>
<td>V</td>
<td>A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DC</td>
<td>V</td>
<td>A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>V V</td>
<td>Am</td>
<td>A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ak var</td>
<td>MW</td>
<td>A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TIME</td>
<td>VP</td>
<td>Fm</td>
<td></td>
<td></td>
<td>MW %</td>
</tr>
<tr>
<td>FUNCTION</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>ELEMENT</td>
</tr>
<tr>
<td>ELEMENT</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ELEMENT</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*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

1. [Display C] 
   - nor
   - Cont

3. ENTER

4. nor

5. ENTER

End

• Setting the Integration Timer

1. [Display C] 
   - nor
   - Cont

3. ENTER

4. nor

5. ENTER

End

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**

<table>
<thead>
<tr>
<th>Key</th>
<th>Display Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>SCALING</td>
<td></td>
</tr>
<tr>
<td>AVG</td>
<td></td>
</tr>
<tr>
<td>FILTER</td>
<td></td>
</tr>
<tr>
<td>STORE</td>
<td></td>
</tr>
<tr>
<td>RECALL</td>
<td></td>
</tr>
<tr>
<td>HARMONICS</td>
<td></td>
</tr>
<tr>
<td>SAMPLE</td>
<td></td>
</tr>
<tr>
<td>V OVER A</td>
<td></td>
</tr>
<tr>
<td>MODE RMS</td>
<td></td>
</tr>
<tr>
<td>V MEAN DC</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td></td>
</tr>
<tr>
<td>HOUR HOUR MIN MIN SEC</td>
<td></td>
</tr>
<tr>
<td>VV Am Ak var</td>
<td></td>
</tr>
<tr>
<td>MW TIME</td>
<td></td>
</tr>
<tr>
<td>VP Fm Ak deg</td>
<td></td>
</tr>
<tr>
<td>MW %</td>
<td></td>
</tr>
<tr>
<td>FUNCTION</td>
<td></td>
</tr>
<tr>
<td>AUTO AUTO</td>
<td></td>
</tr>
<tr>
<td>MODE 1</td>
<td></td>
</tr>
<tr>
<td>φ 3W</td>
<td></td>
</tr>
<tr>
<td>VH zm Ah h</td>
<td></td>
</tr>
<tr>
<td>MW</td>
<td></td>
</tr>
<tr>
<td>TRIG V RANGE A RANGE HOLD</td>
<td></td>
</tr>
<tr>
<td>ENTER INTEGRATOR START HARMONICS MEMORY INTEG  SET</td>
<td></td>
</tr>
<tr>
<td>STOP RESET</td>
<td></td>
</tr>
<tr>
<td>REMOTE INTERFACE OUTPUT LOCAL SETUP</td>
<td></td>
</tr>
<tr>
<td>SHIFT WIRING3 φ 4W 3φ 3W 3V3A</td>
<td></td>
</tr>
</tbody>
</table>

*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).

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.

4 **Holding Integration**
   Press the HOLD key. The HOLD indicator will light, and the displayed values will be held.

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.

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

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.
7.3 Displaying Integrated Values

**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
- Σ: 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 –999999MWh/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.

  ![Diagram of Integration Hold and START/STOP key]

- 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.

  ![Diagram of Integration Hold and START/STOP key]

Relation between Integration Reset and the START/STOP key

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

  ![Diagram of Integration Reset and START/STOP key]
7.4 Precautions Regarding Use of Integrator Function

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.

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

- 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

Display function V, A, W : Displays all rms values (computed values) of 1 up 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 "V" on display B
A% : Displays the current harmonic distortion, proceeded by "A" 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.
8.1 Harmonic Analysis Function

**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

**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

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

1. \[ \text{Setting the element} \]
2. \[ \text{Setting the PLL source} \]
3. \[ \text{Setting the computation method of the Harmonic Distortion} \]
8.2 Setting the Element, PLL Source and Harmonic Distortion Method

**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

\[
\frac{\sum_{k=2}^{n} (C_k)^2}{C_1}
\]

In case of CSA

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

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

1. • Turning the Harmonic Analysis Function ON/OFF
   1. 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.
   2. Pressing the ENTER key after selecting 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**

<table>
<thead>
<tr>
<th>SCALING</th>
<th>AVG</th>
<th>FILTER</th>
<th>STORE</th>
<th>RECALL</th>
<th>HARMONICS</th>
</tr>
</thead>
<tbody>
<tr>
<td>FUNCTION</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*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.

   Display A  →  Light up display function

2. Set the harmonics order.

   ![Display A](image)

**Displaying the Values of Harmonic Analysis**

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

Display B  →  V FUNCTION  A FUNCTION  W FUNCTION  PF FUNCTION  V% FUNCTION  A% FUNCTION

Display C  →  V FUNCTION  A FUNCTION  W FUNCTION  V Hz FUNCTION  A Hz FUNCTION

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

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 440 Hz. However, depending on internal timing, there are cases where measurements in the 20 to 700 Hz 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 \( \sum \).
- 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

1. SHIFT STOP MEMORY
2. ENTER

Selecting the store function (Display C)

3. STORE
4. ENTER
5. Setting interval (Display C)
6. ENTER
7. Shift cursor
8. End

Selecting the store function (Display C)

- STORE
- \( \text{PnLStr} \)
- \( \text{PnLRCL} \)

• Storing of Measurement Data ON/OFF

1. SHIFT STOP MEMORY
2. ENTER

Selecting the store function (Display C)

3. STORE
4. ENTER
5. Setting interval (Display C)
6. ENTER
7. Shift cursor
8. End

Selecting the store function (Display C)

- STORE
- \( \text{PnLStr} \)
- \( \text{PnLRCL} \)

• Setting the Recall Interval for Measurement Data

1. SHIFT STOP MEMORY
2. ENTER

Selecting the recall function (Display C)

3. STORE
4. ENTER
5. Setting interval (Display C)
6. ENTER
7. Shift cursor
8. End

Selecting the recall function (Display C)

- STORE
- \( \text{PnLStr} \)
- \( \text{PnLRCL} \)

• Recalling Measurement Data ON/OFF

1. SHIFT STOP MEMORY
2. ENTER

Selecting the recall function (Display C)

3. STORE
4. ENTER
5. End

Selecting the recall function (Display C)

- STORE
- \( \text{PnLStr} \)
- \( \text{PnLRCL} \)
9.1 Storing/Recalling Measured Data

**Explanation**

**Storing Measured Data (Storing into Internal Memory)**

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

<table>
<thead>
<tr>
<th>Model</th>
<th>In case of normal measurement</th>
<th>In case of harmonic analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>253401</td>
<td>600 Blocks</td>
<td>30 Blocks</td>
</tr>
<tr>
<td>253402</td>
<td>300 Blocks</td>
<td>30 Blocks</td>
</tr>
<tr>
<td>353503</td>
<td>200 Blocks</td>
<td>30 Blocks</td>
</tr>
</tbody>
</table>

**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.
9.1 Storing/Recalling Measured Data

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 will become as those of the data being recalled. After recalling finishes, the original measurement conditions will return.
- 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**

*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**

1. Selecting storage of set-up parameters
   (Display C)

2. STOR Explanation
2. rECAL Explanation
3. PnlStr Explanation
3. PnlrCL Explanation

4. Enter

Select file for storage
(Display B)

4. File, LE1
4. File, LE2
4. File, LE3
4. File, LE4

5. Enter

End

When set-up parameters are stored to a file, display C will show “$\text{SAVE}_d$”

When no data are stored yet, display C will show “$\text{FREE}_d$”

**Recalling Set-up Parameters**

1. Selecting recalling of set-up parameters
   (Display C)

2. STOR Explanation
2. rECAL Explanation
3. PnlStr Explanation
3. PnlrCL Explanation

4. Enter

Select file for recalling
(Display B)

4. File, LE1
4. File, LE2
4. File, LE3
4. File, LE4

5. Enter

End

When set-up parameters are stored to a file, display C will show “$\text{SAVE}_d$”

When no data are stored yet, display C will show “$\text{FREE}_d$”
**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

- 13
- 24

(Rear panel)

WT130 : 253502, 253503

- 13
- 24

(Rear panel)

**Pin Assignment**

### /DA4 specifications (for WT110: 253401 only)

remote control, 4 channel D/A output

<table>
<thead>
<tr>
<th>Pin No.</th>
<th>Signal</th>
<th>Pin No.</th>
<th>Signal</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>DIGITAL COM</td>
<td>13</td>
<td>DIGITAL COM</td>
</tr>
<tr>
<td>2</td>
<td>EXT HOLD</td>
<td>14</td>
<td>EXT TRIG</td>
</tr>
<tr>
<td></td>
<td>(Input)</td>
<td>(Input)</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>EXT START</td>
<td>15</td>
<td>EXT STOP</td>
</tr>
<tr>
<td></td>
<td>(Input)</td>
<td>(Input)</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>EXT RESET</td>
<td>16</td>
<td>INTEG BUSY</td>
</tr>
<tr>
<td></td>
<td>(Input)</td>
<td>(Output)</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>No Connection</td>
<td>17</td>
<td>No Connection</td>
</tr>
<tr>
<td>6</td>
<td>No Connection</td>
<td>18</td>
<td>No Connection</td>
</tr>
<tr>
<td>7</td>
<td>No Connection</td>
<td>19</td>
<td>No Connection</td>
</tr>
<tr>
<td>8</td>
<td>No Connection</td>
<td>20</td>
<td>No Connection</td>
</tr>
<tr>
<td>9</td>
<td>No Connection</td>
<td>21</td>
<td>No Connection</td>
</tr>
<tr>
<td>10</td>
<td>DA 3ch (Output)</td>
<td>22</td>
<td>DA 4ch (Output)</td>
</tr>
<tr>
<td>11</td>
<td>DA 1ch (Output)</td>
<td>23</td>
<td>DA 2ch (Output)</td>
</tr>
<tr>
<td>12</td>
<td>DA COM</td>
<td>24</td>
<td>DA COM</td>
</tr>
</tbody>
</table>

### /DA12 specifications (for WT130: 253502, 253503)

remote control, 12 channel D/A output

<table>
<thead>
<tr>
<th>Pin No.</th>
<th>Signal</th>
<th>Pin No.</th>
<th>Signal</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>DIGITAL COM</td>
<td>13</td>
<td>DIGITAL COM</td>
</tr>
<tr>
<td>2</td>
<td>EXT HOLD</td>
<td>14</td>
<td>EXT TRIG</td>
</tr>
<tr>
<td></td>
<td>(Input)</td>
<td>(Input)</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>EXT START</td>
<td>15</td>
<td>EXT STOP</td>
</tr>
<tr>
<td></td>
<td>(Input)</td>
<td>(Input)</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>EXT RESET</td>
<td>16</td>
<td>INTEG BUSY</td>
</tr>
<tr>
<td></td>
<td>(Input)</td>
<td>(Output)</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>No Connection</td>
<td>17</td>
<td>No Connection</td>
</tr>
<tr>
<td>6</td>
<td>No Connection</td>
<td>18</td>
<td>No Connection</td>
</tr>
<tr>
<td>7</td>
<td>No Connection</td>
<td>19</td>
<td>No Connection</td>
</tr>
<tr>
<td>8</td>
<td>No Connection</td>
<td>20</td>
<td>No Connection</td>
</tr>
<tr>
<td>9</td>
<td>No Connection</td>
<td>21</td>
<td>No Connection</td>
</tr>
<tr>
<td>10</td>
<td>DA 11ch (Output)</td>
<td>22</td>
<td>DA 12ch (Output)</td>
</tr>
<tr>
<td>11</td>
<td>DA 9ch (Output)</td>
<td>23</td>
<td>DA 8ch (Output)</td>
</tr>
<tr>
<td>12</td>
<td>DA 7ch (Output)</td>
<td>24</td>
<td>DA 6ch (Output)</td>
</tr>
<tr>
<td>13</td>
<td>DA COM</td>
<td>25</td>
<td>DA COM</td>
</tr>
</tbody>
</table>

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

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

<table>
<thead>
<tr>
<th>Pin No.</th>
<th>Signal</th>
<th>Pin No.</th>
<th>Signal</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>DIGITAL COM</td>
<td>13</td>
<td>DIGITAL COM</td>
</tr>
<tr>
<td>2</td>
<td>EXT HOLD</td>
<td>14</td>
<td>EXT TRIG</td>
</tr>
<tr>
<td></td>
<td>(Input)</td>
<td>(Input)</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>RELAY 3ch -NC</td>
<td>15</td>
<td>RELAY 4ch -NC</td>
</tr>
<tr>
<td>4</td>
<td>COM</td>
<td>16</td>
<td>COM</td>
</tr>
<tr>
<td>5</td>
<td>NO</td>
<td>17</td>
<td>NO</td>
</tr>
<tr>
<td>6</td>
<td>RELAY 1ch -NC</td>
<td>18</td>
<td>RELAY 2ch -NC</td>
</tr>
<tr>
<td>7</td>
<td>COM</td>
<td>19</td>
<td>COM</td>
</tr>
<tr>
<td>8</td>
<td>NO</td>
<td>20</td>
<td>NO</td>
</tr>
<tr>
<td>9</td>
<td>No Connection</td>
<td>21</td>
<td>No Connection</td>
</tr>
<tr>
<td>10</td>
<td>DA 3ch (Output)</td>
<td>22</td>
<td>DA 4ch (Output)</td>
</tr>
<tr>
<td>11</td>
<td>DA 1ch (Output)</td>
<td>23</td>
<td>DA 2ch (Output)</td>
</tr>
<tr>
<td>12</td>
<td>DA COM</td>
<td>24</td>
<td>DA COM</td>
</tr>
</tbody>
</table>

**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.

![Timing Chart](chart.png)

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.

![Timing Chart](chart.png)

#### 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.

![Timing Chart](chart.png)

- 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.

---

**CAUTION**
10.3 D/A Output (optional)

Relevant Keys

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

Selecting D/A output function (Display C)

Selecting output format (Display C)

Selecting output channel (Display B)*2

Selecting output item (Display C)

*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.

Sets the A column

Moves to the B column

Select from 1 to 4*3
10.3 D/A Output (optional)

- Setting Preset Integration Time

Selecting preset integration time

1. RESET
2. Enter
3. Enter
4. Up/down
5. Cursor shift
6. End

Setting Preset Integration Time

Preset time setting

(Display A)

Selecting preset integration time

(Display C)

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.

<table>
<thead>
<tr>
<th>Option</th>
<th>/DA4</th>
<th>/DA12</th>
<th>/CMP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model</td>
<td>253401</td>
<td>253502</td>
<td>253503</td>
</tr>
<tr>
<td>ch1</td>
<td>V</td>
<td>V1</td>
<td>V1</td>
</tr>
<tr>
<td>ch2</td>
<td>A</td>
<td>-</td>
<td>V2</td>
</tr>
<tr>
<td>ch3</td>
<td>W</td>
<td>V3</td>
<td>V3</td>
</tr>
<tr>
<td>ch4</td>
<td>Hz*1</td>
<td>ΣV</td>
<td>ΣV</td>
</tr>
<tr>
<td>ch5</td>
<td>A1</td>
<td>A1</td>
<td></td>
</tr>
<tr>
<td>ch6</td>
<td>-</td>
<td>A2</td>
<td></td>
</tr>
<tr>
<td>ch7</td>
<td>A3</td>
<td>A3</td>
<td></td>
</tr>
<tr>
<td>ch8</td>
<td>ΣA</td>
<td>ΣA</td>
<td></td>
</tr>
<tr>
<td>ch9</td>
<td>W1</td>
<td>W1</td>
<td></td>
</tr>
<tr>
<td>ch10</td>
<td>W2</td>
<td>W2</td>
<td></td>
</tr>
<tr>
<td>ch11</td>
<td>W3</td>
<td>W3</td>
<td></td>
</tr>
<tr>
<td>ch12</td>
<td>ΣW</td>
<td>ΣW</td>
<td></td>
</tr>
</tbody>
</table>

*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.

<table>
<thead>
<tr>
<th>Option</th>
<th>/DA4</th>
<th>/DA12</th>
<th>/CMP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model</td>
<td>253401</td>
<td>253502</td>
<td>253503</td>
</tr>
<tr>
<td>ch1</td>
<td>W</td>
<td>W1</td>
<td>W1</td>
</tr>
<tr>
<td>ch2</td>
<td>Wh</td>
<td>-</td>
<td>W2</td>
</tr>
<tr>
<td>ch3</td>
<td>Ah</td>
<td>W3</td>
<td>W3</td>
</tr>
<tr>
<td>ch4</td>
<td>Hz*1</td>
<td>ΣW</td>
<td>ΣW</td>
</tr>
<tr>
<td>ch5</td>
<td>Wh1</td>
<td>Wh1</td>
<td></td>
</tr>
<tr>
<td>ch6</td>
<td>WH2</td>
<td>WH2</td>
<td></td>
</tr>
<tr>
<td>ch7</td>
<td>WH3</td>
<td>WH3</td>
<td></td>
</tr>
<tr>
<td>ch8</td>
<td>ΣWh</td>
<td>ΣWh</td>
<td></td>
</tr>
<tr>
<td>ch9</td>
<td>Ah1</td>
<td>Ah1</td>
<td></td>
</tr>
<tr>
<td>ch10</td>
<td>-</td>
<td>Ah2</td>
<td></td>
</tr>
<tr>
<td>ch11</td>
<td>Ah3</td>
<td>Ah3</td>
<td></td>
</tr>
<tr>
<td>ch12</td>
<td>ΣAh</td>
<td>ΣAh</td>
<td></td>
</tr>
</tbody>
</table>

*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), VF (voltage frequency), AF (current frequency), PH (total Watt-hour Wh), AH (total Ampere-hour), dE (phase angle), VP (peak value of voltage), AP (peak value of current), MATH (computational), PH+ (positive watt hour value Wh+), PH- (negative watt hour value Wh-), AH+ (positive ampere hour value), AH- (negative ampere hour value), − − − − (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 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 $\Sigma$.

**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 $\Sigma$, 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.
10.3 D/A Output (optional)

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

- Frequency

![Graph showing D/A output frequency relation with displayed values.]

- Integrated value

![Graph showing D/A output integrated value relation with time.]

- Other items

<table>
<thead>
<tr>
<th>Displayed value</th>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>140%</td>
<td>Approx. 7.5V</td>
</tr>
<tr>
<td>100%</td>
<td>5.0V</td>
</tr>
<tr>
<td>0%</td>
<td>0V</td>
</tr>
<tr>
<td>-100%</td>
<td>-5.0V</td>
</tr>
<tr>
<td>-140%</td>
<td>Approx. -7.0V</td>
</tr>
</tbody>
</table>

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 determined and the circuit becomes closed.
When the current value lies below 1A, or exceeds 3A: 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 erroneous control.

<table>
<thead>
<tr>
<th>Displayed error</th>
<th>Relay status</th>
</tr>
</thead>
<tbody>
<tr>
<td>oL (over range)</td>
<td>The NC contact is closed.</td>
</tr>
<tr>
<td>OF (over flow)</td>
<td>The NC contact is closed.</td>
</tr>
<tr>
<td>deEGer (phase angle error)</td>
<td>The NC contact is closed.</td>
</tr>
<tr>
<td>PFErr (power factor error)</td>
<td>The NC contact is closed.</td>
</tr>
<tr>
<td>ErrLo (frequency error)</td>
<td>The NC contact is closed.</td>
</tr>
<tr>
<td>ErrHi (frequency error)</td>
<td>The NO contact is closed for this case only.</td>
</tr>
<tr>
<td>FrqErr (frequency error in case of harmonic analysis)</td>
<td>The NC contact is closed.</td>
</tr>
<tr>
<td>(error when no data are present)</td>
<td>The NC contact is closed.</td>
</tr>
</tbody>
</table>
10.5 Setting the Comparator Mode (optional)

**Relevant Keys**

```
<table>
<thead>
<tr>
<th>Keys</th>
</tr>
</thead>
<tbody>
<tr>
<td>SCALING</td>
</tr>
<tr>
<td>AVG</td>
</tr>
<tr>
<td>FILTER</td>
</tr>
<tr>
<td>STORE</td>
</tr>
<tr>
<td>RECALL</td>
</tr>
<tr>
<td>HARMONICS</td>
</tr>
<tr>
<td>SAMPLE</td>
</tr>
<tr>
<td>V  OVER</td>
</tr>
<tr>
<td>A  OVER</td>
</tr>
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<td>MODE</td>
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<td>RMS</td>
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<td>B</td>
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<tr>
<td>min sec</td>
</tr>
<tr>
<td>VV Am</td>
</tr>
<tr>
<td>Ak var</td>
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<tr>
<td>MW TIME</td>
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<tr>
<td>VP Fm</td>
</tr>
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<td>Ak deg</td>
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<td>MW %</td>
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</tr>
<tr>
<td>3W</td>
</tr>
<tr>
<td>V3A</td>
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<tr>
<td>Φ</td>
</tr>
<tr>
<td>4W</td>
</tr>
<tr>
<td>3</td>
</tr>
<tr>
<td>Φ</td>
</tr>
<tr>
<td>3W</td>
</tr>
<tr>
<td>3V3A</td>
</tr>
<tr>
<td>ELEMENT</td>
</tr>
<tr>
<td>123</td>
</tr>
<tr>
<td>FUNCTION</td>
</tr>
<tr>
<td>ELEMENT</td>
</tr>
<tr>
<td>123</td>
</tr>
</tbody>
</table>
```

*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.

1. SHIFT SETUP OUTPUT
2. (Display C) 
   - Eaton 
   - P-out 
   - dR-
   - rELAY
3. ENTER
4. (Display C) 
   - off
5. ENTER
6. (Display C) 
   - S, nGL 
   - duAL
7. ENTER

**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.

**CAUTION**

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**

![Diagram of 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

**Selecting the comparator function**

(Display C)

1. **SHIFT**

2. **SETUP**

3. **OUTPUT**

4. **ENTER**

5. **Display C**

**Setting type of limit**

(Display A)

6. **A**

7. **B**

8. **C**

9. **D**

10. **Up/down**

11. **Shift cursor**

12. **Shift decimal point**

13. **Display B**

14. **Display C**

15. **Setting exponent**

16. **Setting limit value**

17. **Setting type of limit**

18. **Setting type of limit**

19. **End**

*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.
**10.6 Setting the Comparator Limit Values (optional)**

- **Setting the Comparator Limit Values in case of Harmonic Analysis**

  1. **Selecting the comparator function**
     - (Display C)
     - \[ E_n \]
     - \[ P \]
     - \[ dR \]
     - \[ r \]

  2. **Setting limit values**
     - (Display C)
     - \[ oFF \]
     - \[ on \]
     - \[ \bar{a} \bar{d}E \]
     - \[ d \]
     - \[ SP \]
     - \[ dR \bar{R} \]
     - \[ dR \bar{R} \]

  3. **ENTER**

  4. **SHIFT**

  5. **OUTPUT**

- **Using External In / Output**

  - **SHIFT**
  - **SETUP**
  - **OUTPUT**
  - **ENTER**

  - **3.**
    - **SELECT**
    - **UP**
    - **DOWN**

  - **4.**
    - **SHIFT**
    - **C**
    - **SHIFT**
    - **B**
    - **SHIFT**
    - **A**

  - **5.**
    - **SELECT**
    - **UP**
    - **DOWN**

  - **6.**
    - **SELECT**
    - **UP**
    - **DOWN**

  - **7.**
    - **SELECT**
    - **UP**
    - **DOWN**

  - **8.**
    - **SELECT**
    - **UP**
    - **DOWN**

  - **9.**
    - **SELECT**
    - **UP**
    - **DOWN**

  - **10.**
    - **SELECT**
    - **UP**
    - **DOWN**

  - **11.**
    - **SELECT**
    - **UP**
    - **DOWN**

  - **12.**
    - **SELECT**
    - **UP**
    - **DOWN**

  - **13.**
    - **SELECT**
    - **UP**
    - **DOWN**

  - **14.**
    - **SELECT**
    - **UP**
    - **DOWN**

  - **15.**
    - **SELECT**
    - **UP**
    - **DOWN**

  - **16.**
    - **SELECT**
    - **UP**
    - **DOWN**

  - **17.**
    - **SELECT**
    - **UP**
    - **DOWN**

  - **18.**
    - **SELECT**
    - **UP**
    - **DOWN**

  - **19.**
    - **SELECT**
    - **UP**
    - **DOWN**

  - **20.**
    - **SELECT**
    - **UP**
    - **DOWN**

  - **21.**
    - **SELECT**
    - **UP**
    - **DOWN**

  - **End**

- **Relay setting** (Display C)

  - **ch 1**
  - **ch 2**
  - **ch 3**
  - **ch 4**

- **Setting type of limit** (Display A)

  - **Y 10 1**
  - **R 10 1**
  - **P 10 1**
  - **Rb 1**
  - **C 10 1**
  - **EP 10 1**
  - **Ed 10 1**
  - **Rd 10 1**

- **Setting limit value** (Display B)

  - **ENTER**

- **Setting exponent** (Display C)

  - **ENTER**

  - **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 in case of a positive value.
### Setting the Comparator Limit Values in case of Normal Measurement

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

- **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 Ah+), Ah– (negative ampere hour value Ah–), – – – – (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 \(\sum\).

- **Setting the limit value**
  No element setting is available on the WT110.

  Setting range: 0.000 to \(\pm 9999\)

  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.

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

### Setting the Comparator Limit Values in case of Harmonic Analysis

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

- **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 (100), E+3 (103), E+6 (106)

**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 separately. 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

![Relevant Keys Diagram]

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.

1. 
2. 
3. 
4. 
5. 
6. 
7. ENTER

End

Selecting the comparator function

(Display C)

Selecting the display function

(Display C)
**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**

  - **Channel (Relay)** (Selectable from ch1 to ch4 by \( \mathbf{\Box} \mathbf{\Delta} \))
  - **Unit** (Corresponding to the relay on display A)

  - **Input element** (Corresponding to the relay on display A)

  - **Measurement/computation/analysis data** (Corresponding to the relay on display A)

  - **Limit value** (Corresponding to the relay on display A)

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

  - **Limit value** (Display the limit value of ch1 or ch3 by \( \mathbf{\Box} \mathbf{\Delta} \))
  - **Unit** (Corresponding to the relay on display A)

  - **Input element** (Corresponding to the relay on display A)

  - **Measurement/computation/analysis data** (Corresponding to the relay on display A and B)

  - **Limit value** (Displays the limit value of ch2 or ch4 by \( \mathbf{\Box} \mathbf{\Delta} \))

  - *1 The limit values on display A and B will show the pairs of ch1&ch2 and ch3&ch4 alternately by pressing the \( \mathbf{\Box} \mathbf{\Delta} \) 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**

![Relevant Keys Diagram]

*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.

```plaintext
1. 
[SHIFT] SETUP OUTPUT
2. 
3. ENTER
4. 
5. ENTER
```

**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”.

- 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 erroneous control.
10.9 Outputting to an External Plotter / Printer

**Relevant Keys**

![Diagram of relevant keys and indicators]

*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

1. **Setting the output Mode**
   
   - (Display C) Enter
   - Communication setting "1" Setting plotter or printer "2"

   *1 Communication settings depend on your communication interface.
   *2 This menu only appears in case of version 1.11 and later.
   *3 PCL is displayed on WT110/WT130 with version 2.21 or later.

### Setting the Output Items

1. **Setting the output items**
   
   - (Display C) Enter
   - (Display C) Enter

### Activating the Output

1. **Activating the output**
   
   - (Display C) Enter
   - Selecting data or setup parameters (Display C) Enter

*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/printer. 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 and the graph of the analyzed voltage values;
  - **G-A**: Prints the numerical values and the graph of the analyzed current values;
  - **G-P**: Prints the numerical values and the graph of the analyzed active power values;
  - **G-Vd**: Prints the numerical values 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 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 and the graph of the relative harmonic content of voltage;
  - **CG-A**: Prints the numerical values and the graph of the relative harmonic content of current;
  - **CG-P**: Prints the numerical values and the graph of the relative harmonic content of active power;
  - **ALL**: Prints the numerical values and the graph of the analysis values and relative harmonic content of voltage and current (V and A are both printed).

*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.
- **PhL**: All set-up parameters will be output.
10.9 Outputting to an External Plotter / Printer

**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.)

#### Harmonic Voltage List

<table>
<thead>
<tr>
<th>Order</th>
<th>Analysis Value</th>
<th>Relative Harmonic Content</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Volt [ V ]</td>
<td>Cont [ % ]</td>
</tr>
<tr>
<td></td>
<td>Volt [ V ]</td>
<td>Cont [ % ]</td>
</tr>
<tr>
<td>1</td>
<td>49.62</td>
<td>2 0.03 0.06</td>
</tr>
<tr>
<td>2</td>
<td>40.01</td>
<td>10 0.00 0.01</td>
</tr>
<tr>
<td>3</td>
<td>60.02</td>
<td>11 0.01 0.02</td>
</tr>
<tr>
<td>4</td>
<td>59.39</td>
<td>12 0.00 0.01</td>
</tr>
<tr>
<td>5</td>
<td>58.78</td>
<td>13 0.00 0.00</td>
</tr>
<tr>
<td>6</td>
<td>58.07</td>
<td>14 0.00 0.01</td>
</tr>
<tr>
<td>7</td>
<td>57.26</td>
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</tr>
<tr>
<td>8</td>
<td>56.45</td>
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</tr>
<tr>
<td>9</td>
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<td>17 0.00 0.01</td>
</tr>
<tr>
<td>10</td>
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</tr>
<tr>
<td>11</td>
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</tr>
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<td>48.54</td>
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<td>31 0.00 0.01</td>
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<tr>
<td>24</td>
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</tr>
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<td>38.01</td>
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</tr>
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<tr>
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<td>36.39</td>
<td>42 0.00 0.01</td>
</tr>
<tr>
<td>35</td>
<td>35.58</td>
<td>43 0.00 0.01</td>
</tr>
<tr>
<td>36</td>
<td>34.77</td>
<td>44 0.00 0.01</td>
</tr>
<tr>
<td>37</td>
<td>33.96</td>
<td>45 0.00 0.01</td>
</tr>
<tr>
<td>38</td>
<td>33.15</td>
<td>46 0.00 0.01</td>
</tr>
<tr>
<td>39</td>
<td>32.34</td>
<td>47 0.00 0.01</td>
</tr>
<tr>
<td>40</td>
<td>31.53</td>
<td>48 0.00 0.01</td>
</tr>
<tr>
<td>41</td>
<td>30.72</td>
<td>49 0.00 0.01</td>
</tr>
<tr>
<td>42</td>
<td>29.91</td>
<td>50 0.00 0.01</td>
</tr>
</tbody>
</table>

#### Harmonic Spectrum (Voltage)

![Harmonic Spectrum](image)
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.

<table>
<thead>
<tr>
<th>Mode</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Addressable mode (mode A and mode B), 488.2 mode</td>
<td>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</td>
</tr>
<tr>
<td></td>
<td>Talker measured/computed/analysis data output setting parameters output error code output status byte output</td>
</tr>
</tbody>
</table>

**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 Std’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 std’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.

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

**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 V rms max.
- Voltage across V terminal and ground 600 V rms 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)
Clears 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 parameters 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)

<table>
<thead>
<tr>
<th>DIO 8</th>
<th>DIO 7</th>
<th>DIO 6</th>
<th>DIO 5</th>
<th>DIO 4</th>
<th>DIO 3</th>
<th>DIO 2</th>
<th>DIO 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Integration BUSY</td>
<td>SRQ</td>
<td>ERROR</td>
<td>STORE/RECALL BUSY</td>
<td>OVER</td>
<td>Syntax ERROR</td>
<td>Integration END</td>
<td>Computation END</td>
</tr>
</tbody>
</table>

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 be 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 by 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 (DIO 1)
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.

<p>| | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>h1</td>
<td>h2</td>
<td>h3</td>
<td>h4</td>
<td>h5</td>
<td>h6</td>
</tr>
</tbody>
</table>

**Header Section**
The header section consists of 6 bytes (h1 to 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: ∑
  - h1-h4: data type (only when the computing equation is A/B or A^2/B on WT110/WT130 with ROM version 2.01 or later)

- **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.

<table>
<thead>
<tr>
<th>d1</th>
<th>d2</th>
<th>d3</th>
<th>d4</th>
<th>d5</th>
<th>d6</th>
<th>d7</th>
<th>d8</th>
<th>d9</th>
<th>d10</th>
<th>d11</th>
</tr>
</thead>
</table>

- **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 | 1 | _ | _ | 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 | . | E | + | 0 |

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

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

**Elapsed time of integration**

<table>
<thead>
<tr>
<th>H</th>
<th>M</th>
<th>S</th>
<th></th>
<th></th>
<th>d1</th>
<th>d2</th>
<th>d3</th>
<th>d4</th>
<th>d5</th>
<th>d6</th>
<th>d7</th>
<th>d8</th>
<th>d9</th>
</tr>
</thead>
</table>

- **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.

<table>
<thead>
<tr>
<th>Line 1</th>
<th>Data number</th>
<th>Terminator</th>
<th>(The data number will only be output in case of recall)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Line 2</td>
<td>ch.1</td>
<td>,</td>
<td>ch.2 , ch.3 , ch.4 Terminator</td>
</tr>
<tr>
<td>Line 3</td>
<td>ch.5</td>
<td>,</td>
<td>ch.6 , ch.7 , ch.8 Terminator</td>
</tr>
<tr>
<td>Line 4</td>
<td>ch.9</td>
<td>,</td>
<td>ch.10 , ch.11 , ch.12 Terminator</td>
</tr>
<tr>
<td>Line 5</td>
<td>ch.13</td>
<td>,</td>
<td>ch.14 Terminator</td>
</tr>
<tr>
<td>Line 6</td>
<td>END</td>
<td>Terminator</td>
<td></td>
</tr>
</tbody>
</table>

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 ch.12 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)

<table>
<thead>
<tr>
<th>Line 1</th>
<th>Data number</th>
<th>Terminator</th>
<th>(The data number will only be output in case of recall)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Line 2</td>
<td>V1 data</td>
<td>Terminator</td>
<td></td>
</tr>
<tr>
<td>Line 3</td>
<td>A1 data</td>
<td>Terminator</td>
<td></td>
</tr>
<tr>
<td>Line 4</td>
<td>W1 data</td>
<td>Terminator</td>
<td></td>
</tr>
<tr>
<td>Line 5</td>
<td>Frequency</td>
<td>,</td>
<td>Display C Terminator</td>
</tr>
<tr>
<td>Line 6</td>
<td>END</td>
<td>Terminator</td>
<td></td>
</tr>
</tbody>
</table>

WT130 (253502)

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

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, “999999.9E+03” will be output.
11.4 Output Format for Normal Measured/Computed Data, Harmonic Analysis Data, Set-up Parameters and Error Codes

**WT130 (253503)**

<table>
<thead>
<tr>
<th>Line</th>
<th>Data number</th>
<th>Terminator</th>
<th>(The data number will only be output in case of recall)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Line 2</td>
<td>V1 data, V2 data, V3 data, SV data</td>
<td>Terminator</td>
<td></td>
</tr>
<tr>
<td>Line 3</td>
<td>A1 data, A2 data, A3 data, SA data</td>
<td>Terminator</td>
<td></td>
</tr>
<tr>
<td>Line 4</td>
<td>W1 data, W2 data, W3 data, SW data</td>
<td>Terminator</td>
<td></td>
</tr>
<tr>
<td>Line 5</td>
<td>Frequency, Display C</td>
<td>Terminator</td>
<td></td>
</tr>
<tr>
<td>Line 6</td>
<td>END</td>
<td>Terminator</td>
<td></td>
</tr>
</tbody>
</table>

**Default Output Format in case Integration Measurement**

**WT110 (253401)**

<table>
<thead>
<tr>
<th>Line</th>
<th>Data number</th>
<th>Terminator</th>
<th>(The data number will only be output in case of recall)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Line 2</td>
<td>W1 data</td>
<td>Terminator</td>
<td></td>
</tr>
<tr>
<td>Line 3</td>
<td>Wh1 data</td>
<td>Terminator</td>
<td></td>
</tr>
<tr>
<td>Line 4</td>
<td>Ah1 data</td>
<td>Terminator</td>
<td></td>
</tr>
<tr>
<td>Line 5</td>
<td>Frequency, Elapsed integration time</td>
<td>Terminator</td>
<td></td>
</tr>
<tr>
<td>Line 6</td>
<td>END</td>
<td>Terminator</td>
<td></td>
</tr>
</tbody>
</table>

**WT130 (253502)**

<table>
<thead>
<tr>
<th>Line</th>
<th>Data number</th>
<th>Terminator</th>
<th>(The data number will only be output in case of recall)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Line 2</td>
<td>W1 data, W3 data, SW data</td>
<td>Terminator</td>
<td></td>
</tr>
<tr>
<td>Line 3</td>
<td>Wh1 data, Wh3 data, SWh data</td>
<td>Terminator</td>
<td></td>
</tr>
<tr>
<td>Line 4</td>
<td>Ah1 data, Ah3 data, SAh data</td>
<td>Terminator</td>
<td></td>
</tr>
<tr>
<td>Line 5</td>
<td>Frequency, Elapsed integration time</td>
<td>Terminator</td>
<td></td>
</tr>
<tr>
<td>Line 6</td>
<td>END</td>
<td>Terminator</td>
<td></td>
</tr>
</tbody>
</table>

**WT130 (253503)**

<table>
<thead>
<tr>
<th>Line</th>
<th>Data number</th>
<th>Terminator</th>
<th>(The data number will only be output in case of recall)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Line 2</td>
<td>W1 data, W2 data, W3 data, SW data</td>
<td>Terminator</td>
<td></td>
</tr>
<tr>
<td>Line 3</td>
<td>Wh1 data, Wh2 data, Wh3 data, SWh data</td>
<td>Terminator</td>
<td></td>
</tr>
<tr>
<td>Line 4</td>
<td>Ah1 data, Ah2 data, Ah3 data, SAh data</td>
<td>Terminator</td>
<td></td>
</tr>
<tr>
<td>Line 5</td>
<td>Frequency, Elapsed integration time</td>
<td>Terminator</td>
<td></td>
</tr>
<tr>
<td>Line 6</td>
<td>END</td>
<td>Terminator</td>
<td></td>
</tr>
</tbody>
</table>
Output Format of Harmonic Analysis Data

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

<table>
<thead>
<tr>
<th>Header</th>
<th>Data</th>
</tr>
</thead>
</table>

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

<table>
<thead>
<tr>
<th>h1</th>
<th>h2</th>
<th>h3</th>
<th>h4</th>
<th>h5</th>
<th>h6</th>
<th>h7</th>
<th>h8</th>
</tr>
</thead>
</table>

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.

<table>
<thead>
<tr>
<th>d1</th>
<th>d2</th>
<th>d3</th>
<th>d4</th>
<th>d5</th>
<th>d6</th>
<th>d7</th>
<th>d8</th>
<th>d9</th>
<th>d10</th>
<th>d11</th>
</tr>
</thead>
</table>

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

<table>
<thead>
<tr>
<th>Line</th>
<th>Output Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>All computed values of the 1st to 50th order, harmonic distortion, Terminator</td>
</tr>
<tr>
<td>2</td>
<td>Analysis value for fundamental (1st order), Frequency, Terminator</td>
</tr>
<tr>
<td>3</td>
<td>Analysis value for 2nd harmonic, Relative harmonic content for 2nd harmonic, Terminator</td>
</tr>
<tr>
<td>51</td>
<td>Analysis value for 50th harmonic, Relative harmonic content for 50th harmonic, Terminator</td>
</tr>
<tr>
<td>52</td>
<td>END, Terminator</td>
</tr>
</tbody>
</table>

In case of active power

<table>
<thead>
<tr>
<th>Line</th>
<th>Output Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>All computed values of the 1st to 50th order, Power factor, Terminator</td>
</tr>
<tr>
<td>2</td>
<td>Analysis value for fundamental (1st order), Frequency, Terminator</td>
</tr>
<tr>
<td>3</td>
<td>Analysis value for 2nd harmonic, Relative harmonic content for 2nd harmonic, Terminator</td>
</tr>
<tr>
<td>51</td>
<td>Analysis value for 50th harmonic, Relative harmonic content for 50th harmonic, Terminator</td>
</tr>
<tr>
<td>52</td>
<td>END, Terminator</td>
</tr>
</tbody>
</table>

In case of phase angle

<table>
<thead>
<tr>
<th>Line</th>
<th>Output Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Phase angle between fundamentals of voltage and current, Frequency, Terminator</td>
</tr>
<tr>
<td>2</td>
<td>Phase angle between fundamental and 2nd harmonic of voltage, Phase angle between fundamental and 2nd harmonic of current, Terminator</td>
</tr>
<tr>
<td>3</td>
<td>Phase angle between fundamental and 3rd harmonic of voltage, Phase angle between fundamental and 3rd harmonic of current, Terminator</td>
</tr>
<tr>
<td>50</td>
<td>Phase angle between fundamental and 50th harmonic of voltage, Phase angle between fundamental and 50th harmonic of current, Terminator</td>
</tr>
<tr>
<td>51</td>
<td>Phase angle between fundamental and 50th harmonic of voltage, Phase angle between fundamental and 50th harmonic of current, Terminator</td>
</tr>
</tbody>
</table>

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

Operating Procedure

1. Perform operations following the thick line in the below menu.
2. Press the ENTER key to confirm the selection or setting.
3. 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”. Initializing 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

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. Setting output channel (Display C)
2. Setting output item (Display C)
3. Setting output channel (Display C)
4. Setting output item (Display C)
5. Selecting output format (Display C)
6. Setting output channel (Display C)
7. Setting output item (Display C)
8. Setting output channel (Display C)
9. Setting output item (Display C)
10. Setting output channel (Display C)
11. Setting output item (Display C)
12. Setting output channel (Display C)
13. Setting output item (Display C)
14. Setting output channel (Display C)
15. Setting output item (Display C)

*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.
11.6 Setting the Output Items

Setting the Output Item in case of Harmonic Analysis

Setting output item (Display C) *1

1. \[\text{Setup} \] SETUP
2. \[\text{Output} \] OUTPUT
3. \[\text{Display} C \] (Display C)  
4. \[\text{Enter} \] ENTER
5. \[\text{Data} \] Enter
6. \[\text{Data} \] Enter
7. \[\text{Data} \] Enter
8. \[\text{Data} \] Enter
9. \[\text{End} \] ENTER

*1 When graph printouts are selected as the output item, only data values will be output by communication.

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)\(^2\), Ah– (negative ampere hour)\(^2\), -- -- -- (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 selected from 1, 2, 3 or 4
  The element number 4 represents \(\Sigma\).

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.

<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>WRm (WiRing)</td>
<td>sets wiring system</td>
</tr>
<tr>
<td>RVm (Range Voltage)</td>
<td>sets voltage range</td>
</tr>
<tr>
<td>AVm (Auto Voltage range)</td>
<td>sets voltage auto range</td>
</tr>
<tr>
<td>RAm (Range current(A))</td>
<td>sets current range</td>
</tr>
<tr>
<td>AAm (Auto current(A) range)</td>
<td>sets current auto range</td>
</tr>
<tr>
<td>SAm (Sensor Ampere)</td>
<td>sets external sensor</td>
</tr>
<tr>
<td>DR (Display Range)</td>
<td>sets external sensor</td>
</tr>
<tr>
<td>MNm (MeaN)</td>
<td>sets external sensor</td>
</tr>
<tr>
<td>FLm (FilTer)</td>
<td>sets filter ON/OFF</td>
</tr>
<tr>
<td>HDM (sampling Hold)</td>
<td>holds display and output data</td>
</tr>
<tr>
<td>E or ST or &lt;GET&gt;</td>
<td>trigger</td>
</tr>
<tr>
<td>DA (Display A)</td>
<td>selects function to be displayed on display A</td>
</tr>
<tr>
<td>DBm (Display B)</td>
<td>selects function to be displayed on display B</td>
</tr>
<tr>
<td>DCm (Display C)</td>
<td>selects function to be displayed on display C</td>
</tr>
<tr>
<td>EAm (Element display A)</td>
<td>selects element to be displayed on display A</td>
</tr>
<tr>
<td>EAm (Element display B)</td>
<td>selects element to be displayed on display B</td>
</tr>
<tr>
<td>EAm (Element display C)</td>
<td>selects element to be displayed on display C</td>
</tr>
<tr>
<td>SCm (Scaling)</td>
<td>sets scaling ON/OFF</td>
</tr>
<tr>
<td>KVm (K*Amplitude)</td>
<td>sets the scaling value</td>
</tr>
<tr>
<td>KAm (K* Wattage)</td>
<td>sets the scaling value</td>
</tr>
<tr>
<td>KWm (K*Voltage)</td>
<td>sets the scaling value</td>
</tr>
<tr>
<td>AGm (Average)</td>
<td>sets averaging ON/OFF</td>
</tr>
<tr>
<td>ATm (Averaging Type)</td>
<td>selects exponential averaging or moving averaging</td>
</tr>
<tr>
<td>ACM (Averaging Coefficient)</td>
<td>sets attenuation constant or averaging number</td>
</tr>
<tr>
<td>MTm (Mathematics)</td>
<td>Sets computing equation</td>
</tr>
<tr>
<td>IS (Integrate Start)</td>
<td>starts integration</td>
</tr>
<tr>
<td>IP (Integrate stop)</td>
<td>stops integration</td>
</tr>
<tr>
<td>IR (Integrate Reset)</td>
<td>resets integration</td>
</tr>
<tr>
<td>Icm (Integrate Continuous)</td>
<td>sets integration mode</td>
</tr>
<tr>
<td>TMm1,m2 (Integrate Timer)</td>
<td>sets integration preset time</td>
</tr>
<tr>
<td>SO (Store On)</td>
<td>starts storage</td>
</tr>
<tr>
<td>SRm (Store Interval)</td>
<td>sets storage interval</td>
</tr>
<tr>
<td>ROM (Recall On)</td>
<td>starts recalling</td>
</tr>
<tr>
<td>RRm1,m2,m3 (Recall Interval)</td>
<td>sets recalling interval</td>
</tr>
<tr>
<td>SLM (Panel Setting Load)</td>
<td>recalling set-up parameters</td>
</tr>
<tr>
<td>SSM (Panel Setting Save)</td>
<td>storing set-up parameters</td>
</tr>
<tr>
<td>RC (Reset Command)</td>
<td>initialize set-up parameters</td>
</tr>
<tr>
<td>CMm (Communication Command)</td>
<td>sets command group to be used</td>
</tr>
<tr>
<td>OFm1,m2,m3 (Output Function)</td>
<td>requests output of measured data</td>
</tr>
<tr>
<td>OFm (Output Function Default)</td>
<td>sets output items</td>
</tr>
<tr>
<td>OSi (Output panel Setting)</td>
<td>sets default output items</td>
</tr>
<tr>
<td>OE (Output Error code)</td>
<td>requests output of setting parameters</td>
</tr>
<tr>
<td>Hm (Header)</td>
<td>sets output data header</td>
</tr>
<tr>
<td>DLM (DeLimiter)</td>
<td>sets output data delimiter</td>
</tr>
<tr>
<td>lmm (Interrupt Mask)</td>
<td>sets status byte interrupt mask</td>
</tr>
<tr>
<td>HAM (option)</td>
<td>sets harmonic analysis ON/OFF</td>
</tr>
<tr>
<td>HEm (Harmonics Element)</td>
<td>sets harmonics element</td>
</tr>
<tr>
<td>OR (harmonics ORDER)</td>
<td>sets harmonics order</td>
</tr>
<tr>
<td>OAm1,m2 (Output Harmonics function)</td>
<td>sets communication or output block</td>
</tr>
<tr>
<td>PSi (PLL Source)</td>
<td>sets PLL source</td>
</tr>
<tr>
<td>DFi (Distortion Formula)</td>
<td>sets distortion formula</td>
</tr>
<tr>
<td>/DA (option)</td>
<td>sets output items yourself</td>
</tr>
<tr>
<td>OA (Output Analog)</td>
<td>sets default output items</td>
</tr>
<tr>
<td>OA (Output Analog Default)</td>
<td>requests output of error code</td>
</tr>
<tr>
<td>RTm1,m2 (Integrate Rated Time)</td>
<td>sets integration time</td>
</tr>
<tr>
<td>dYm (Display relAY)</td>
<td>sets comparator function ON/OFF</td>
</tr>
<tr>
<td>YMm (relAY Mode)</td>
<td>sets comparator mode</td>
</tr>
<tr>
<td>dYm (Display relAY)</td>
<td>sets display relay ON/OFF for comparator</td>
</tr>
<tr>
<td>YCm (relAY Channel)</td>
<td>sets the relay channel</td>
</tr>
<tr>
<td>OYm1,m2,m3,m4,m5</td>
<td>sets the output relay function for normal measurement</td>
</tr>
<tr>
<td>OYm1,m2,m3,m4,m5</td>
<td>sets the output relay function for harmonic analysis</td>
</tr>
</tbody>
</table>

**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.

<table>
<thead>
<tr>
<th>Mode</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal mode</td>
<td>Reception&lt;br&gt;Functions performed by key operations (except for LOCAL key and power ON/OFF)&lt;br&gt;measured/computed/analysis data output request&lt;br&gt;setting parameters output request&lt;br&gt;error code output request</td>
</tr>
<tr>
<td></td>
<td>Transmission&lt;br&gt;measured/computed/analysis data output&lt;br&gt;setting parameters output&lt;br&gt;error code output&lt;br&gt;status byte output</td>
</tr>
<tr>
<td>Talk-only mode</td>
<td>Transmission&lt;br&gt;measured/computed/analysis data output</td>
</tr>
</tbody>
</table>

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 from 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

<table>
<thead>
<tr>
<th>Pin</th>
<th>Signal Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>AA (GND : Protective Ground)</td>
<td>Grounded to the case of this instrument</td>
</tr>
<tr>
<td>2</td>
<td>BA (TXD : Transmitted Data)</td>
<td>Data transmitted to personal computer</td>
</tr>
<tr>
<td>3</td>
<td>BB (RXD : Received Data)</td>
<td>Data received from personal computer</td>
</tr>
<tr>
<td>4</td>
<td>CA (RTS : Request to Send)</td>
<td>Signal used to handshake when receiving data from personal computer</td>
</tr>
<tr>
<td>5</td>
<td>CB (CTS : Clear to Send)</td>
<td>Signal used to handshake when transmitting data to personal computer</td>
</tr>
<tr>
<td>6</td>
<td>CC (DSR : Data Set Ready)</td>
<td>Signal used to handshake when transmitting data to personal computer</td>
</tr>
<tr>
<td>7</td>
<td>AB (GND : Signal Ground)</td>
<td>Ground for signals</td>
</tr>
<tr>
<td>20</td>
<td>CD (DTR : Data Terminal Ready)</td>
<td>Signal used to handshake when receiving data from personal computer</td>
</tr>
</tbody>
</table>

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.
### 12.2 Connecting the Interface Cable

#### Table of RS-232-C Standard Signals and their JIS and CCITT Abbreviations

<table>
<thead>
<tr>
<th>Pin No. (25-pin connector)</th>
<th>Abbreviations</th>
<th>RS-232-C</th>
<th>CCITT</th>
<th>JIS</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>AA(GND)</td>
<td>101</td>
<td>FG</td>
<td></td>
<td>Protective ground</td>
</tr>
<tr>
<td>7</td>
<td>AB(GND)</td>
<td>102</td>
<td>SG</td>
<td></td>
<td>Signal ground</td>
</tr>
<tr>
<td>2</td>
<td>BA(TXD)</td>
<td>103</td>
<td>SD</td>
<td></td>
<td>Transmitted data</td>
</tr>
<tr>
<td>3</td>
<td>BB(RXD)</td>
<td>104</td>
<td>RD</td>
<td></td>
<td>Received data</td>
</tr>
<tr>
<td>4</td>
<td>CA(RTS)</td>
<td>105</td>
<td>RS</td>
<td></td>
<td>Request to send</td>
</tr>
<tr>
<td>5</td>
<td>CB(CTS)</td>
<td>106</td>
<td>CS</td>
<td></td>
<td>Clear to send</td>
</tr>
<tr>
<td>6</td>
<td>CC(DSR)</td>
<td>107</td>
<td>DR</td>
<td></td>
<td>Data set ready</td>
</tr>
<tr>
<td>20</td>
<td>CD(DTR)</td>
<td>108/2</td>
<td>ER</td>
<td></td>
<td>Data terminal ready</td>
</tr>
<tr>
<td>22</td>
<td>CE(RI)</td>
<td>125</td>
<td>CI</td>
<td></td>
<td>Ring indicator</td>
</tr>
<tr>
<td>8</td>
<td>CF(DCD)</td>
<td>109</td>
<td>CD</td>
<td></td>
<td>Data channel received carrier detect</td>
</tr>
<tr>
<td>21</td>
<td>CG(-)</td>
<td>110</td>
<td>SQD</td>
<td></td>
<td>Data signal quality detect</td>
</tr>
<tr>
<td>23</td>
<td>CH/CI(-)</td>
<td>111</td>
<td>SRS</td>
<td></td>
<td>Data signal rate select</td>
</tr>
<tr>
<td>24/15</td>
<td>DA/DB(TXC)</td>
<td>113/114</td>
<td>ST1/ST2</td>
<td></td>
<td>Transmitter signal element timing</td>
</tr>
<tr>
<td>17</td>
<td>DD(RXC)</td>
<td>115</td>
<td>RT</td>
<td></td>
<td>Receiver signal element timing</td>
</tr>
<tr>
<td>14</td>
<td>SBA(-)</td>
<td>118</td>
<td>BSD</td>
<td></td>
<td>Secondary transmitted data</td>
</tr>
<tr>
<td>16</td>
<td>SBB(-)</td>
<td>119</td>
<td>BRD</td>
<td></td>
<td>Secondary received data</td>
</tr>
<tr>
<td>19</td>
<td>SCA(-)</td>
<td>120</td>
<td>BRS</td>
<td></td>
<td>Secondary request to send</td>
</tr>
<tr>
<td>13</td>
<td>SCB(-)</td>
<td>121</td>
<td>BCS</td>
<td></td>
<td>Secondary clear to send</td>
</tr>
<tr>
<td>12</td>
<td>SCF(-)</td>
<td>122</td>
<td>BCD</td>
<td></td>
<td>Secondary received carrier detect</td>
</tr>
</tbody>
</table>

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

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.

1. SHIFT LOCAL INTERFACE
2. A ENTER
3. A ENTER
4. A ENTER
5. For 0
6. For 1
7. For 2
8. For 3
9. Setting baud rate (Display C)
10. Setting interval (Display C)
11. ENTER
12. up down
13. cursor shift

* 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)

<table>
<thead>
<tr>
<th>Mode selection no.</th>
<th>Data sending control (Control method when sending data to computer)</th>
<th>Data receiving control (Control method when receiving data from computer)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Software handshake</td>
<td>Hardware handshake</td>
<td>No handshake</td>
</tr>
<tr>
<td></td>
<td>Sending stops when X-off is received, and sending is resumed when X-on is received.</td>
<td>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.</td>
</tr>
<tr>
<td></td>
<td>Sending stops when CB (CTS) is False, and sending is resumed when CB is True.</td>
<td>Sending stops when CC (DSR) is False, and sending is resumed when CC is True.</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>5</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>6</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>7</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

#### 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 increases 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.
### 12.3 Setting the Mode, Handshaking Method, Data Format and Baud Rate

#### 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.

<table>
<thead>
<tr>
<th>Preset value</th>
<th>Start bit</th>
<th>Data length</th>
<th>Parity</th>
<th>Stop bit</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1</td>
<td>8</td>
<td>No</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>7</td>
<td>Odd</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>7</td>
<td>Even</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>1</td>
<td>7</td>
<td>No</td>
<td>2</td>
</tr>
</tbody>
</table>

#### 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
m = 1 : LF
m = 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

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.

**1. Selecting initializing (Display C)**

**2.**

**3. ENTER**

Settings will be initialized

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.

<table>
<thead>
<tr>
<th>Item</th>
<th>Initial setting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Display A</td>
<td>Display function: V, element: 1</td>
</tr>
<tr>
<td>Display B</td>
<td>Display function: A, element: 1</td>
</tr>
<tr>
<td>Display C</td>
<td>Display function: W, element: 1</td>
</tr>
<tr>
<td>Filter</td>
<td>OFF</td>
</tr>
<tr>
<td>Measurement range</td>
<td>Auto range</td>
</tr>
<tr>
<td>Measurement mode</td>
<td>RMS</td>
</tr>
<tr>
<td>Wiring method (only WT130)</td>
<td>1F3W</td>
</tr>
<tr>
<td>Hold</td>
<td>OFF</td>
</tr>
<tr>
<td>PC/CT scaling value</td>
<td>P: 1.000, C: 1.000, F: 1.000</td>
</tr>
<tr>
<td>Averaging scaling value</td>
<td>50.00A</td>
</tr>
<tr>
<td>Averaging</td>
<td>Averaging type: exponential, attenuation constant: 8</td>
</tr>
<tr>
<td>Averaging ON/OFF</td>
<td>OFF</td>
</tr>
<tr>
<td>MATH computing equation</td>
<td>WT110: Voltage crest factor</td>
</tr>
<tr>
<td></td>
<td>WT130: Efficiency</td>
</tr>
<tr>
<td>Frequency</td>
<td>VHz</td>
</tr>
<tr>
<td>Integration</td>
<td>Reset condition, integration mode: manual</td>
</tr>
<tr>
<td></td>
<td>Integration preset time: 0hr, 0min</td>
</tr>
<tr>
<td>Harmonic analysis (option)</td>
<td>PLL source: V1, harmonic distortion factor computation format: IEC, element: 1</td>
</tr>
<tr>
<td></td>
<td>Harmonic analysis function ON/OFF: OFF</td>
</tr>
<tr>
<td>Storage/recalling</td>
<td>Interval: 0hr 0min 0sec, storage/recalling ON/OFF: OFF</td>
</tr>
<tr>
<td>D/A output (option)</td>
<td>Output items: normal measurement items, integration preset time: 1hr, 0min</td>
</tr>
<tr>
<td>Comparator (option)</td>
<td>Mode: single, determination function: (V1, A1, P1, PF1)</td>
</tr>
<tr>
<td></td>
<td>Limit value: refer to page 10-12, 10-13, display function ON/OFF: OFF</td>
</tr>
<tr>
<td>Data output</td>
<td>Communication, item: normal measurement setting</td>
</tr>
<tr>
<td>GP-IB</td>
<td>Addressable mode: A, address: 1, status byte: 15, delimiter: 0</td>
</tr>
<tr>
<td>RS-232-C</td>
<td>Normal mode, handshaking mode: 0, format: 0, Baud rate: 9600, delimiter: 0, status byte: 15</td>
</tr>
</tbody>
</table>

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.
3. “rAnGE” will appear on display C. Press the \( \wedge \) or \( \vee \) 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 \( \pm \) terminal of this instrument. In case of the WT130, bundle all V terminals together and bundle all \( \pm \) 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.
14.1 Adjustments

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

<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAL1</td>
<td>Enters the range adjustment mode</td>
</tr>
<tr>
<td>CAL2</td>
<td>Enters the external input range adjustment mode</td>
</tr>
<tr>
<td>CAL3</td>
<td>Enters the D/A output adjustment mode</td>
</tr>
<tr>
<td>CAL0</td>
<td>Finishes adjustment (and returns to normal measurement mode)</td>
</tr>
<tr>
<td>CR0</td>
<td>Switches to 30V range in range adjustment mode</td>
</tr>
<tr>
<td>CR1</td>
<td>Switches to 300V range in range adjustment mode</td>
</tr>
<tr>
<td>CR2</td>
<td>Switches to 1A range in range adjustment mode</td>
</tr>
<tr>
<td>CR1</td>
<td>Switches to 10A range in range adjustment mode</td>
</tr>
<tr>
<td>CHm</td>
<td>Switches the channel in D/A output adjustment mode m = 1 to 12</td>
</tr>
<tr>
<td>CDm,n</td>
<td>Enters the actual output value in D/A output adjustment mode m = 1 to 12, n = actual output value</td>
</tr>
<tr>
<td>DO0</td>
<td>Outputs +5V in D/A output adjustment mode</td>
</tr>
<tr>
<td>DO1</td>
<td>Outputs –5V in D/A output adjustment mode</td>
</tr>
<tr>
<td>OD</td>
<td>Requests the output of measurement data, and sets the output format to normal measurement default</td>
</tr>
<tr>
<td>ENT</td>
<td>Corresponds to the ENTER key operation, confirming the adjustment value.</td>
</tr>
<tr>
<td>CAN</td>
<td>Corresponds to the RESET key operation, ignoring the adjustments.</td>
</tr>
<tr>
<td>END</td>
<td>Corresponds to the SHIFT key operation, keeping the adjustments.</td>
</tr>
</tbody>
</table>

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

![Diagram of Direct Input Wiring]

- EUT: Equipment under test
- AC voltage standard
- Digital power meter
- Synchronizer

• External sensor input (equipped with option /EX1)

Change as follows for wiring currents only.

![Diagram of External Sensor Input Wiring]
**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.
14.2 Calibration

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.

<table>
<thead>
<tr>
<th>Symptom</th>
<th>Items to check</th>
<th>Reference page</th>
</tr>
</thead>
</table>
| 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

<table>
<thead>
<tr>
<th>Error Code</th>
<th>Description</th>
<th>Corrective Action</th>
<th>Reference page</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>Received a command not used by this instrument.</td>
<td>Check for error in the command sent.</td>
<td>11-12</td>
</tr>
<tr>
<td>12</td>
<td>Parameter value specified is outside the allowed range.</td>
<td>Correct the value.</td>
<td>App. 2</td>
</tr>
<tr>
<td>13</td>
<td>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.</td>
<td>Check whether integration is in progress or is interrupted.</td>
<td>7-8, 11-12</td>
</tr>
<tr>
<td>14</td>
<td>Attempted to set auto range while external sensor range is selected.</td>
<td>It is not possible to set auto range while external sensor range is selected.</td>
<td>4-5</td>
</tr>
<tr>
<td>15</td>
<td>Attempted to execute a command or key operation that was protected.</td>
<td>Check whether the command or key operation is correct.</td>
<td>7-8, 11-12</td>
</tr>
<tr>
<td>16</td>
<td>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.</td>
<td>Check whether harmonic analysis is in progress or is interrupted.</td>
<td>8-5</td>
</tr>
<tr>
<td>17</td>
<td>Print output time-out.</td>
<td></td>
<td>10-18</td>
</tr>
<tr>
<td>18</td>
<td>No data to be printed or not in the printing mode.</td>
<td></td>
<td>10-17</td>
</tr>
<tr>
<td>19</td>
<td>Attempted to execute a key operation or received a communications command, while storing/recalling of data being performed.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>Invalid file data.</td>
<td></td>
<td>-</td>
</tr>
<tr>
<td>31</td>
<td>File is damaged.</td>
<td></td>
<td>-</td>
</tr>
<tr>
<td>32</td>
<td>No data stored in the internal memory.</td>
<td>Store data in the internal memory or select the proper file to be stored.</td>
<td>Ch. 9</td>
</tr>
<tr>
<td>33</td>
<td>No space to store data in the internal memory.</td>
<td></td>
<td>9-2</td>
</tr>
<tr>
<td>41</td>
<td>Attempted to start integration while there is an overflow condition.</td>
<td>Reset integration.</td>
<td>7-5</td>
</tr>
<tr>
<td>42</td>
<td>Attempted to start integration after integration time has reached its preset value.</td>
<td></td>
<td>7-8</td>
</tr>
<tr>
<td>43</td>
<td>Measurement stopped due to overflow during integration or due to a power failure.</td>
<td></td>
<td>7-8</td>
</tr>
<tr>
<td>44</td>
<td>Attempted to stop integration even though integration was not in progress.</td>
<td></td>
<td>7-8</td>
</tr>
<tr>
<td>45</td>
<td>Attempted to reset integration even though integration was not in progress or integration mode was not selected.</td>
<td></td>
<td>7-6</td>
</tr>
<tr>
<td>46</td>
<td>Attempted to start integration while measurement of peak overflow was in progress or during an overrange condition.</td>
<td></td>
<td>2-4</td>
</tr>
<tr>
<td>47</td>
<td>Attempted to start integration in continuous integration mode when integration preset time was set to &quot;0&quot;.</td>
<td>Set a correct preset time.</td>
<td>7-4</td>
</tr>
<tr>
<td>50</td>
<td>A/D conversion time-out.</td>
<td></td>
<td>-</td>
</tr>
<tr>
<td>51</td>
<td>Measurement data overflow occurred. &quot;oL.&quot; is displayed.</td>
<td></td>
<td>2-4</td>
</tr>
<tr>
<td>52</td>
<td>Voltage peak overflow occurred. V OVER indicator lights up.</td>
<td></td>
<td>2-4</td>
</tr>
<tr>
<td>53</td>
<td>Current peak overflow occurred. A OVER indicator lights up.</td>
<td></td>
<td>2-4</td>
</tr>
</tbody>
</table>
14.4 Error Codes and Corrective Actions

<table>
<thead>
<tr>
<th>Error Code</th>
<th>Description</th>
<th>Corrective Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>54</td>
<td>Power factor exceeded &quot;2&quot; during measurement of power factor.</td>
<td></td>
</tr>
<tr>
<td>55</td>
<td>&quot;PFErr&quot; was displayed at the end of power factor computation during measurement of phase angle.</td>
<td>6-1, 6-2</td>
</tr>
<tr>
<td>56</td>
<td>Input level was too low or below measurement range during measurement of frequency. &quot;Err-Lo&quot; is displayed.</td>
<td>5-3</td>
</tr>
<tr>
<td>57</td>
<td>Measured frequency exceeded the measurement range. &quot;Err-Hi&quot; is displayed.</td>
<td>5-3</td>
</tr>
<tr>
<td>58</td>
<td>Computation overflow occurred. &quot;OF&quot; is displayed.</td>
<td>2-4</td>
</tr>
<tr>
<td>59</td>
<td>Harmonic analysis becomes &quot;FrqEr&quot;</td>
<td>8-2</td>
</tr>
<tr>
<td>60</td>
<td>Data failure of set-up parameters backup. (set-up parameters are set to default)</td>
<td>-</td>
</tr>
<tr>
<td>61</td>
<td>EEPROM (element 1) failure.</td>
<td>Service is required.</td>
</tr>
<tr>
<td>62</td>
<td>EEPROM (element 2) failure.</td>
<td>Service is required.</td>
</tr>
<tr>
<td>63</td>
<td>EEPROM (element 3) failure.</td>
<td>Service is required.</td>
</tr>
<tr>
<td>64</td>
<td>EEPROM (D/A board) failure.</td>
<td>Service is required.</td>
</tr>
<tr>
<td>65</td>
<td>A/D converter (element 1) failure.</td>
<td>Service is required.</td>
</tr>
<tr>
<td>66</td>
<td>A/D converter (element 2) failure.</td>
<td>Service is required.</td>
</tr>
<tr>
<td>67</td>
<td>A/D converter (element 3) failure.</td>
<td>Service is required.</td>
</tr>
<tr>
<td>68</td>
<td>Data file failure.</td>
<td>File will be initialized automatically.</td>
</tr>
<tr>
<td>69</td>
<td>Lithium battery voltage drop.</td>
<td>Service is required.</td>
</tr>
<tr>
<td>71</td>
<td>DSP communications failure.</td>
<td>Service is required.</td>
</tr>
<tr>
<td>75</td>
<td>DSP1 program RAM failure.</td>
<td>Service is required.</td>
</tr>
<tr>
<td>76</td>
<td>DSP2 program RAM failure.</td>
<td>Service is required.</td>
</tr>
<tr>
<td>77</td>
<td>DSP3 program RAM failure.</td>
<td>Service is required.</td>
</tr>
<tr>
<td>79</td>
<td>ROM checksum error.</td>
<td>Service is required.</td>
</tr>
<tr>
<td>80</td>
<td>RAM read/write check error.</td>
<td>Service is required.</td>
</tr>
<tr>
<td>81</td>
<td>DSP1 data RAM error.</td>
<td>Service is required.</td>
</tr>
<tr>
<td>82</td>
<td>DSP2 data RAM error.</td>
<td>Service is required.</td>
</tr>
<tr>
<td>83</td>
<td>DSP3 data RAM error.</td>
<td>Service is required.</td>
</tr>
<tr>
<td>84</td>
<td>DSP1 sample clock failure.</td>
<td>Service is required.</td>
</tr>
<tr>
<td>85</td>
<td>DSP2 sample clock failure.</td>
<td>Service is required.</td>
</tr>
<tr>
<td>86</td>
<td>DSP3 sample clock failure.</td>
<td>Service is required.</td>
</tr>
<tr>
<td>90</td>
<td>Incorrect board combination.</td>
<td>Service is required.</td>
</tr>
<tr>
<td>91</td>
<td>Incorrect board combination.</td>
<td>Service is required.</td>
</tr>
</tbody>
</table>

| 390        | Overrun error. Lower the baud rate.                                         | 12-6              |
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

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.

<table>
<thead>
<tr>
<th>Location</th>
<th>Max. rated voltage</th>
<th>Max. rated current</th>
<th>Type</th>
<th>Approved standard</th>
<th>Part No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main board</td>
<td>250V</td>
<td>1 A</td>
<td>Time lag</td>
<td>UL/VDE</td>
<td>S9564VK</td>
</tr>
</tbody>
</table>
Chapter 15 Specifications

15.1 Input

<table>
<thead>
<tr>
<th>Item</th>
<th>Voltage (V)</th>
<th>Current (A)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input circuit type</td>
<td>Floating input</td>
<td>Shunt input</td>
</tr>
<tr>
<td>Input type</td>
<td>Resistive voltage divider</td>
<td>Shunt input</td>
</tr>
<tr>
<td>Rated inputs (range rms)</td>
<td>15/30/60/150/300/600V</td>
<td>Direct input: 0.5/1/2/5/10/20 A</td>
</tr>
<tr>
<td>Input resistance approx. 2MΩ, Input capacitance approx. 13 pF</td>
<td>Direct input: approx. 0.1 pF</td>
<td></td>
</tr>
<tr>
<td>Instantaneous maximum allowable input for 20 ms, 1 cycle</td>
<td>The peak is 2.8 kV or the RMS value is 2.0 kV, whichever is less.</td>
<td></td>
</tr>
<tr>
<td>Instantaneous maximum allowable input for 1 s</td>
<td>The peak is 2.0 kV or the RMS value is 1.5 kV, whichever is less.</td>
<td></td>
</tr>
<tr>
<td>Continuous maximum allowable input</td>
<td>The peak is 1.5 kV or the RMS value is 1.0 kV, whichever is less.</td>
<td></td>
</tr>
<tr>
<td>Continuous common mode voltage (at 50/60 Hz)</td>
<td>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</td>
<td></td>
</tr>
<tr>
<td>Common mode rejection ratio at 600 Vrms between input terminals and case</td>
<td>50/60 Hz, better than 40 dB</td>
<td></td>
</tr>
<tr>
<td>Reference value: 50 Hz max.</td>
<td>±[(maximum range rating)/(range rating)] × 0.001 × % of range] or less.</td>
<td></td>
</tr>
<tr>
<td>External input: Peak value is 5 times the range or less.</td>
<td>0.1% or more; the unit f in accuracy expressions is kHz.</td>
<td></td>
</tr>
<tr>
<td>Instantaneous maximum allowable input</td>
<td>±(0.1% of rdg + 1 digit)</td>
<td></td>
</tr>
<tr>
<td>Instantaneous maximum allowable input</td>
<td>≤45 Hz</td>
<td></td>
</tr>
<tr>
<td>Frequency ranges: 10 Hz to 50 kHz</td>
<td>≤45 Hz</td>
<td></td>
</tr>
<tr>
<td>Operating principle: Reciprocal counting method</td>
<td>≤45 Hz</td>
<td></td>
</tr>
<tr>
<td>Minimum input is more than 30% of rated range.</td>
<td>≤45 Hz</td>
<td></td>
</tr>
<tr>
<td>When an input frequency is less than 200 Hz, FILTER must be ON to obtain the specification accuracy.</td>
<td>≤45 Hz</td>
<td></td>
</tr>
<tr>
<td>Minimum input frequency is more than 20% of frequency measurement range.</td>
<td>≤45 Hz</td>
<td></td>
</tr>
</tbody>
</table>

15.2 Measurement Functions

<table>
<thead>
<tr>
<th>Item</th>
<th>Voltage/current</th>
<th>Effective power</th>
</tr>
</thead>
<tbody>
<tr>
<td>Method</td>
<td>DC, 10 Hz to 50 kHz</td>
<td>&quot;3&quot; at rated input</td>
</tr>
<tr>
<td>Frequency range</td>
<td>Digital sampling method, summation averaging method</td>
<td></td>
</tr>
<tr>
<td>Crest factor</td>
<td>Reference value: 0.2% of range is added if the 0.5/1 A range is selected.</td>
<td></td>
</tr>
<tr>
<td>Display accuracy</td>
<td>&quot;0.2% of range&quot; is added if the 0.5/1 A range is selected.</td>
<td></td>
</tr>
<tr>
<td>Accuracy (within 3 months after calibration) (Conditions)</td>
<td>Reference data: (up to 50 kHz) add ±0.2% of range</td>
<td></td>
</tr>
<tr>
<td>Temperature: 23 ±5°C</td>
<td>±[0.16 × (10)²% of range]</td>
<td></td>
</tr>
<tr>
<td>Humidity: 30% to 75% R.H.</td>
<td>±[0.25 × (10)²% of range]</td>
<td></td>
</tr>
</tbody>
</table>
| Supply voltage: Specified Voltage ±5% | "DC: ±0.2% of range is added if the 0.5/1 A range is selected."
| Input waveform: Sine wave | "DC: ±0.2% of range is added if the 0.5/1 A range is selected."
| Common mode voltage: 0 V DC | "DC: ±0.2% of range is added if the 0.5/1 A range is selected."
| Filler: ON at 200 Hz or less | "DC: ±0.2% of range is added if the 0.5/1 A range is selected."
| Scaling: OFF | "DC: ±0.2% of range is added if the 0.5/1 A range is selected."
| This accuracy are guaranteed by YOKOGAWA calibration system. | "DC: ±0.2% of range is added if the 0.5/1 A range is selected."
| Note: The unit in accuracy expressions is kHz | "DC: ±0.2% of range is added if the 0.5/1 A range is selected."

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 |

15.4 Communication

<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Mechanical specifications: IEEE Std 488.2-1987</td>
<td>Interface function: SH1, AH1, TL, LA, SR1, RL1, PP0, DC1, DT1, C0</td>
</tr>
<tr>
<td>RS-232-C:</td>
<td>Transmission mode: Start stop synchronization</td>
</tr>
<tr>
<td>Baud rate: 75, 150, 300, 600, 1200, 2400, 4800, 3600 bps</td>
<td></td>
</tr>
</tbody>
</table>
Chapter 15 Specifications

15.3 Computing Functions

<table>
<thead>
<tr>
<th>Function (ln)</th>
<th>Apparent Power (VA)</th>
<th>Reactive Power (var)</th>
<th>Power Factor (PF)</th>
<th>Phase Angle (deg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-phase 2-wire</td>
<td>W = VA = V A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>VA = VA</td>
<td>var</td>
<td>PF</td>
<td>θ</td>
</tr>
<tr>
<td>3</td>
<td>W = W = W</td>
<td>= cos</td>
<td>= W</td>
<td></td>
</tr>
<tr>
<td></td>
<td>= VA</td>
<td>VA</td>
<td>var</td>
<td>var</td>
</tr>
<tr>
<td></td>
<td>ΣW</td>
<td>ΣW</td>
<td>ΣVA</td>
<td>ΣVA</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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 and deg will be displayed as an error.

Note 3: The Lead and Lag are displayed for V and A input at 5% or more. The selected lead and lag accuracy is ±5 degrees over the frequency range of 20 Hz to 2 kHz.

15.4 Display Functions

Display type: 7-segment LED
Number of displays: 3

<table>
<thead>
<tr>
<th>Display Function</th>
<th>Maximum Reading</th>
</tr>
</thead>
<tbody>
<tr>
<td>A V, A, W, VA, var</td>
<td>Maximum Reading</td>
</tr>
<tr>
<td>B V, A, W, PF, dep (each element), % contents ratio in %, THD</td>
<td>Wh, Ah: 99999</td>
</tr>
<tr>
<td>C V, A, W, V Hz, (wh, sh) (each element)</td>
<td>VA, A, W: 9999</td>
</tr>
</tbody>
</table>

Var, Apk, and MATH are supported only for ROM versions 2.01 or later.

Unit: m, k, M, V, A, W, VA, var, Hz, deg, %

Display update rate: 4 times/s
Response time: Approximately 0.5 s (time for displayed value to settle within accuracy specifications after value change from 0% to 100%, or 0% to 0% of rated range)
Display scaling: Significant digits: Selected automatically according to significant digits in the voltage and current ranges
Resolution (power factor ±0.0005)

15.5 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 counter counts above 999999 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.

15.6 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 the following data: measurement setting mode, measurement range, V, A, W, Wh, Wh, Ah, Wh, elapsed time and frequency
Writing intervals: 250 ms and 1 to 99:59 min: 99 s
Reading intervals: 250 ms and 1 to 99:59 min: 99 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 PS (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

<table>
<thead>
<tr>
<th>Frequency</th>
<th>D/A output Approx. 7.0V</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0.5V</td>
</tr>
<tr>
<td>250 ms</td>
<td>2.5V</td>
</tr>
<tr>
<td>500 ms</td>
<td>5.0V</td>
</tr>
<tr>
<td>1 s</td>
<td>7.5V</td>
</tr>
<tr>
<td>5 s</td>
<td>140% input of the rated value</td>
</tr>
</tbody>
</table>

• Integration

<table>
<thead>
<tr>
<th>Integration</th>
<th>D/A output Approx. 7.0V</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0.5V</td>
</tr>
<tr>
<td>250 ms</td>
<td>2.5V</td>
</tr>
<tr>
<td>500 ms</td>
<td>5.0V</td>
</tr>
<tr>
<td>1 s</td>
<td>7.5V</td>
</tr>
<tr>
<td>5 s</td>
<td>140% input of the rated value</td>
</tr>
</tbody>
</table>

• Other Items

<table>
<thead>
<tr>
<th>Other Items</th>
<th>D/A output Approx. 7.0V</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0.5V</td>
</tr>
<tr>
<td>250 ms</td>
<td>2.5V</td>
</tr>
<tr>
<td>500 ms</td>
<td>5.0V</td>
</tr>
<tr>
<td>1 s</td>
<td>7.5V</td>
</tr>
<tr>
<td>5 s</td>
<td>140% input of the rated value</td>
</tr>
</tbody>
</table>
### 15.10 External Input (optional)

**Ether/EX1 or /EX2 can be selected as a voltage-output type current sensor.**

<table>
<thead>
<tr>
<th>Specifications</th>
<th>Refer to item “Input.”</th>
</tr>
</thead>
<tbody>
<tr>
<td>IEX1</td>
<td>2.5/5/10 V</td>
</tr>
<tr>
<td>IEX2</td>
<td>50/100/200 mV</td>
</tr>
</tbody>
</table>

### 15.11 Comparator Output (optional)

**Output method:** Normally open and normally closed relay contact outputs (one pair)

**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,
- INTEO-BUSY

**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:** 2000 m or below

**Power supply:** Any power supply voltage between 100 and 240 V; frequency: 50/60 Hz

**External dimensions:** WT110:Approx. W 8-3/8 × D 4-3/4 × H 3-1/2 (inch); WT130:W 8-3/8 × D 4-3/4 × H 3-1/2 (inch)

**Weight:** WT110:6.3 lbs; WT130:8.8 lbs

**Cable Condition:**
- Measuring Input
  - 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 Sensor Input (installed /EX1 or /EX2 option)
  - 500 mm max
- External Input/Output Signals (installed /D/A, /DA12, /CMP option)
  - To use shielded wires

### 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

**Input 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 %.**

**Sampling speed:** The sampling speeds depend on the fundamental frequency to be input:

<table>
<thead>
<tr>
<th>Input frequency range</th>
<th>Sampling frequency</th>
<th>Window up to the n'th harmonic</th>
<th>Order</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤ 64 Hz</td>
<td>f = 128 Hz</td>
<td>f = 64 Hz</td>
<td>6</td>
</tr>
<tr>
<td>64Hz ≤ f &lt; 128 Hz</td>
<td>f = 256 Hz</td>
<td>f = 128 Hz</td>
<td>6</td>
</tr>
<tr>
<td>128 Hz ≤ f &lt; 256 Hz</td>
<td>f = 512 Hz</td>
<td>f = 256 Hz</td>
<td>6</td>
</tr>
<tr>
<td>256 Hz ≤ f &lt; 512 Hz</td>
<td>f = 1k Hz</td>
<td>f = 512 Hz</td>
<td>6</td>
</tr>
</tbody>
</table>

**FFT number of points:** 512 points FFT

**FFT calculation accuracy:** 32 bits

**Window:** Rectangular window

**Display update interval:** Approx. 3 s

**Accuracy:** ±3% of range is added to the normal display accuracy.
15.15 External Dimensions

WT110(253401)

Unit:mm

Rear

Unless otherwise specified, tolerance is ±3% (However, tolerance is ±0.3mm when below 10mm)
Unless otherwise 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

AA<m<terminator>

“m” indicates auto range ON/OFF

m=0: auto range OFF (fixed range)

1: auto range ON

Query

Example

Description

AA? <terminator>

• 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.

• While recalling is in progress, execution error 19 will occur.

AV/AV?

Sets the voltage auto range ON or OFF/inquires about the voltage setting.

Syntax

AV<m<terminator>

“m” indicates auto range ON/OFF

m=0: auto range OFF (fixed range)

1: auto range ON

Query

Example

Description

AV? <terminator>

• 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.

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

AC<m<terminator>

“m” indicates attenuation constant

m=1:8

2:16

3:32

4:64

5:128

8:256

Query

Example

Description

AC? <terminator>

• 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

AG<m<terminator>

“m” indicates if averaging is ON or OFF

m=0: OFF

1: ON

Query

Example

Description

AG? <terminator>

• 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.

AT/AT?

Sets averaging type (exponential or moving)/inquires about the current setting.

Syntax

AT<m<terminator>

“m” indicates averaging type

m=0: Exponential averaging

1: Moving averaging

Query

Example

Description

AT? <terminator>

• 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.

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

CM<m<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

Example

Description

CM? <terminator>

• 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

DA<m<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

Example

Description

DA? <terminator>

DA1

• 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.

DB/DB?

Sets the function for display B/inquires about the current setting.

Syntax

DB<m<terminator>

“m” indicates one of the following functions.

• in case of normal measurement

m=1: voltage (V)

2: current (A)

3: power (W)

Query

Example

Description

DB? <terminator>

DA1

• Parameter error 12 will occur if “m” is set to an illegal value.
### Appendix 1.1 Commands

<table>
<thead>
<tr>
<th>Number</th>
<th>Description</th>
<th>Syntax</th>
<th>Example</th>
<th>Query</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>Power factor (PF)</td>
<td>DFM</td>
<td>E1</td>
<td>DFM</td>
<td>Parameter error 12 will occur if “m” is set to an illegal value.</td>
</tr>
<tr>
<td>11</td>
<td>Phase angle (deg)</td>
<td>DFM</td>
<td>E2</td>
<td>DFM</td>
<td>Parameter error 12 will occur if “m” is set to an illegal value.</td>
</tr>
</tbody>
</table>

#### DC/DC?

Sets the function for display C/inquires about the current setting.

**Syntax**

```
DCm <terminator>
```

“m” indicates one of the following functions.

- 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

**Query**

```
DB? <terminator>
```

**Example**

```
DB1
```

**Description**

- Parameter error 12 will occur if “m” is set to an illegal value.

#### DL/DL?

Sets the terminator for communication output data/inquires about the current setting.

**Syntax**

```
DL <terminator>
```

“m” indicates terminator.

- 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.

- 0: Cancels the range display and returns to measurement display
- 1: Displays voltage, current and shunt value of element 1, 2 and 3 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

- 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**

```
EAm <terminator>
```

“m” indicates element.

- 1: Element 1
- 2: Element 2 (for model 253503 only)
- 3: Element 3 (for WT130 only)
- 4: \(\sum\) (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**

```
EBm <terminator>
```

“m” indicates element.

- 1: Element 1
- 2: Element 2 (for model 253503 only)
- 3: Element 3 (for WT130 only)
- 4: \(\sum\) (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**

```
ECm <terminator>
```

“m” indicates element.

- 1: Element 1
- 2: Element 2 (for model 253503 only)
- 3: Element 3 (for WT130 only)
- 4: \(\sum\) (for WT130 only)
### Syntax
```
EC m <terminator>
```

*“m” indicates element.*

<table>
<thead>
<tr>
<th>m</th>
<th>Element</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Normal</td>
</tr>
<tr>
<td>1</td>
<td>Element 1</td>
</tr>
<tr>
<td>2</td>
<td>Element 2</td>
</tr>
<tr>
<td>3</td>
<td>Element 3</td>
</tr>
<tr>
<td>4</td>
<td>Element 4</td>
</tr>
<tr>
<td>5</td>
<td>Element 5</td>
</tr>
<tr>
<td>6</td>
<td>Element 6</td>
</tr>
<tr>
<td>7</td>
<td>Element 7</td>
</tr>
<tr>
<td>8</td>
<td>Element 8</td>
</tr>
<tr>
<td>9</td>
<td>Element 9</td>
</tr>
<tr>
<td>10</td>
<td>Element 10</td>
</tr>
<tr>
<td>11</td>
<td>Element 11</td>
</tr>
<tr>
<td>12</td>
<td>Element 12</td>
</tr>
<tr>
<td>13</td>
<td>Element 13</td>
</tr>
<tr>
<td>14</td>
<td>Element 14</td>
</tr>
<tr>
<td>15</td>
<td>Element 15</td>
</tr>
</tbody>
</table>

### Example
```
EC? <terminator>
```

### Description
A parameter error will occur if “m” is set to an illegal value.

### Syntax
```
HA m <terminator>
```

*“m” indicates whether or not to add a header.*

### Example
```
HA 1 <terminator>
```

### Description
- Parameter error will occur if “m” is set to an illegal value.
- While recalling or storing is in progress, execution error 19 will occur.

### Syntax
```
HE m <terminator>
```

*“m” indicates the element of the harmonic analysis function.*

### Example
```
HE? <terminator>
```

### Description
- Parameter error will occur if “m” is set to an illegal value.
- While recalling or storing is in progress, execution error 19 will occur.

### Syntax
```
IC m <terminator>
```

*“m” indicates one of the following integration modes.*

<table>
<thead>
<tr>
<th>m</th>
<th>Mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Normal</td>
</tr>
<tr>
<td>1</td>
<td>Continuous</td>
</tr>
<tr>
<td>2</td>
<td>Integration</td>
</tr>
<tr>
<td>3</td>
<td>Syntax</td>
</tr>
<tr>
<td>4</td>
<td>Syntax</td>
</tr>
<tr>
<td>5</td>
<td>Syntax</td>
</tr>
<tr>
<td>6</td>
<td>Syntax</td>
</tr>
<tr>
<td>7</td>
<td>Syntax</td>
</tr>
<tr>
<td>8</td>
<td>Syntax</td>
</tr>
<tr>
<td>9</td>
<td>Syntax</td>
</tr>
<tr>
<td>10</td>
<td>Syntax</td>
</tr>
<tr>
<td>11</td>
<td>Syntax</td>
</tr>
<tr>
<td>12</td>
<td>Syntax</td>
</tr>
<tr>
<td>13</td>
<td>Syntax</td>
</tr>
<tr>
<td>14</td>
<td>Syntax</td>
</tr>
<tr>
<td>15</td>
<td>Syntax</td>
</tr>
</tbody>
</table>

### Example
```
IC1 <terminator>
```

### Description
- Parameter error will occur if “m” is set to an illegal value.

### Syntax
```
IM m <terminator>
```

*“m” is assigned as follows (0 ≤ m ≤ 15).*

<table>
<thead>
<tr>
<th>m</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>:Normal integration</td>
</tr>
<tr>
<td>1</td>
<td>:Continuous integration</td>
</tr>
<tr>
<td>2</td>
<td>:Integration end</td>
</tr>
<tr>
<td>3</td>
<td>:Syntax error</td>
</tr>
<tr>
<td>4</td>
<td>:Syntax error</td>
</tr>
<tr>
<td>5</td>
<td>:Syntax error</td>
</tr>
<tr>
<td>6</td>
<td>:Syntax error</td>
</tr>
<tr>
<td>7</td>
<td>:Syntax error</td>
</tr>
<tr>
<td>8</td>
<td>:Syntax error</td>
</tr>
<tr>
<td>9</td>
<td>:Syntax error</td>
</tr>
<tr>
<td>10</td>
<td>:Syntax error</td>
</tr>
<tr>
<td>11</td>
<td>:Syntax error</td>
</tr>
<tr>
<td>12</td>
<td>:Syntax error</td>
</tr>
<tr>
<td>13</td>
<td>:Syntax error</td>
</tr>
<tr>
<td>14</td>
<td>:Syntax error</td>
</tr>
<tr>
<td>15</td>
<td>:Syntax error</td>
</tr>
</tbody>
</table>

### Example
```
IM15 <terminator>
```

### Description
- Parameter error 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).

### Syntax
```
IP <terminator>
```

*“m” indicates whether or not to stop integration.*

### Example
```
IP <terminator>
```

### Description
- 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.
Appendix 1.1 Commands

**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 ≤ n ≤ 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:  
- KV1.000
- KA2.000
- KW3.000

**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**  
When CM0 is set:  
- MN? <terminator>

**Example**  
When CM0 is set:  
- MN1 <terminator>

**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.

**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 the WT130)

**Query**  
When CM0 is set:  
- MT? <terminator>

**Example**  
When CM0 is set:  
- 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 ≤ m1 ≤ 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)*
  - 3: Peak current value (Apk)*
  - 13: Computation result (MATH)*
  - 14: Positive watt-hour (Wh+)
  - 24: Negative watt-hour (Wh–)
  - 25: Positive ampere-hour (Ah+)
  - 26: Negative ampere-hour (Ah–)
  - 27: Positive ampere-hour (Ah–)

* Applies to WT110/WT130 with ROM version 2.01 or later.

**Example**  
When CM0 is set:  
- OA1,1,0 <terminator>

**Description**  
- Parameter error 12 will occur if “m” is set to an illegal value.
### Appendix 1.1 Commands

**OE Requests output of error codes via communications.**

<table>
<thead>
<tr>
<th>Syntax</th>
<th>Example</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>OE &lt;terminator&gt;</td>
<td>ERR11</td>
<td>Error codeDescription</td>
</tr>
<tr>
<td></td>
<td></td>
<td>11 Command error</td>
</tr>
<tr>
<td></td>
<td></td>
<td>12 Parameter error</td>
</tr>
<tr>
<td></td>
<td></td>
<td>13 Attempted to change settings which cannot be changed while integration was in progress</td>
</tr>
<tr>
<td></td>
<td></td>
<td>14 Attempted to set auto range mode while external sensor range was selected.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>15 Attempted to execute a command that was protected.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>16 Attempted to execute a command that was protected while harmonic analysis was being performed.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>17 Time-out in print output.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>18 Not in printing mode, or no data available.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>19 Attempted to execute commands while recalling/storing is in progress.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>20 File data failure</td>
</tr>
<tr>
<td></td>
<td></td>
<td>31 File is damaged</td>
</tr>
<tr>
<td></td>
<td></td>
<td>32 Not stored in internal memory.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>33 No data to be stored in internal memory.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>41 Attempted to start integration when integration had been stopped due to an irregularity.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>42 Attempted to start integration during integration.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>43 Measurement stopped due to overflow during integration or due to a power failure.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>44 Attempted to stop integration while integration was interrupted.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>45 Attempt made to reset integration while integration was in progress.</td>
</tr>
</tbody>
</table>

**OD**

Requests output of measurement data.

<table>
<thead>
<tr>
<th>Syntax</th>
<th>Example</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>OD &lt;terminator&gt;</td>
<td></td>
<td>Syntax</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&quot;m&quot; indicates default no.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>m=2: Select mode</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0: Default for normal measurement</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1: Default for integration</td>
</tr>
</tbody>
</table>

**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.

<table>
<thead>
<tr>
<th>Syntax</th>
<th>Example</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>OAD m &lt;terminator&gt;</td>
<td></td>
<td>&quot;m&quot; indicates default no.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>m=2: Select mode</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0: Default for normal measurement</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1: Default for integration</td>
</tr>
</tbody>
</table>

**OD**

Requests output of error codes via communications.

<table>
<thead>
<tr>
<th>Syntax</th>
<th>Example</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>OE &lt;terminator&gt;</td>
<td>ERR11</td>
<td>Error codeDescription</td>
</tr>
<tr>
<td></td>
<td></td>
<td>11 Command error</td>
</tr>
<tr>
<td></td>
<td></td>
<td>12 Parameter error</td>
</tr>
<tr>
<td></td>
<td></td>
<td>13 Attempted to change settings which cannot be changed while integration was in progress</td>
</tr>
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<td></td>
<td></td>
<td>14 Attempted to set auto range mode while external sensor range was selected.</td>
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<tr>
<td></td>
<td></td>
<td>15 Attempted to execute a command that was protected.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>16 Attempted to execute a command that was protected while harmonic analysis was being performed.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>17 Time-out in print output.</td>
</tr>
<tr>
<td></td>
<td></td>
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<tr>
<td></td>
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<td>19 Attempted to execute commands while recalling/storing is in progress.</td>
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<tr>
<td></td>
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<td>31 File is damaged</td>
</tr>
<tr>
<td></td>
<td></td>
<td>32 Not stored in internal memory.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>33 No data to be stored in internal memory.</td>
</tr>
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<td></td>
<td></td>
<td>41 Attempted to start integration when integration had been stopped due to an irregularity.</td>
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<td></td>
<td>42 Attempted to start integration during integration.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>43 Measurement stopped due to overflow during integration or due to a power failure.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>44 Attempted to stop integration while integration was interrupted.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>45 Attempt made to reset integration while integration was in progress.</td>
</tr>
</tbody>
</table>

**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.

<table>
<thead>
<tr>
<th>Syntax</th>
<th>Example</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>OFD m &lt;terminator&gt;</td>
<td></td>
<td>&quot;m&quot; indicates default no.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>m=2: Select mode</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0: Default for normal measurement</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1: Default for integration</td>
</tr>
</tbody>
</table>

**OF/OF?**

Sets communication output information types/inquires about the current settings. Up to 14 measured data can be selected and output.

<table>
<thead>
<tr>
<th>Syntax</th>
<th>Example</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>OF m1,m2,m3 &lt;terminator&gt;</td>
<td></td>
<td>&quot;m1&quot; indicates communication output channel, and must be set within the following range.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 ≤ m1 ≤ 14</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&quot;m2&quot; indicates output type no.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>m2=0: No output</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1: Voltage (V)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2: Current (A)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3: Power (W)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4: Reactive power (var)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5: Apparent power (VA)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6: Power factor (PF)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>7: Input voltage frequency (V Hz)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8: Input current frequency (A Hz)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>9: Watt-hour (Wh)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10: Ampere-hour (Ah)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>11: Phase angle (deg)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>12: Peak voltage value (Vpk)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>13: Peak current value (Apk)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>14: Computation result (MATH)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>15: Integration time</td>
</tr>
<tr>
<td></td>
<td></td>
<td>24: Positive watt-hour (Wh+)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>25: Negative watt-hour (Wh–)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>26: Positive ampere-hour (Ah+)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>27: Negative ampere-hour (Ah–)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>* Applies to WT110/WT130 with ROM version 2.01 or later</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&quot;m3&quot; indicates element, and must be set within the following range.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 ≤ m3 ≤ 4</td>
</tr>
</tbody>
</table>

**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.

<table>
<thead>
<tr>
<th>Syntax</th>
<th>Example</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>OFD? &lt;terminator&gt;</td>
<td></td>
<td>Description</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Parameter error 12 will occur if &quot;m1&quot;, &quot;m2&quot; or &quot;m3&quot; is set to an illegal value.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• 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).</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• &quot;No output&quot; and &quot;computation result&quot; have no relation to the element, but when using them with the &quot;OA&quot; command, set m3=1.</td>
</tr>
</tbody>
</table>

Errors

<table>
<thead>
<tr>
<th>Error Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Attempt made to start integration when peak overflow was detected.</td>
</tr>
<tr>
<td>2</td>
<td>Measurement data overflow occurred. &quot;--. ol.&quot; is displayed.</td>
</tr>
<tr>
<td>3</td>
<td>Voltage peak overflow occurred.</td>
</tr>
<tr>
<td>4</td>
<td>Current peak overflow occurred.</td>
</tr>
<tr>
<td>5</td>
<td>Power factor exceeded &quot;2&quot;. &quot;PFErr&quot; is displayed.</td>
</tr>
<tr>
<td>6</td>
<td>Parameter error 12 will occur if &quot;m&quot; is set to an illegal value.</td>
</tr>
<tr>
<td>7</td>
<td>Frequency input level was too low or below measurement range. &quot;ErrLo&quot; is displayed.</td>
</tr>
<tr>
<td>8</td>
<td>Frequency was above the measurement range. &quot;ErrHi&quot; is displayed.</td>
</tr>
<tr>
<td>9</td>
<td>Computation overflow occurred. &quot;—OF—&quot; is displayed.</td>
</tr>
<tr>
<td>10</td>
<td>When harmonic analysis is carried out, &quot;FreqErr&quot; is displayed.</td>
</tr>
<tr>
<td>11</td>
<td>Attempt made to start integration during integration.</td>
</tr>
<tr>
<td>12</td>
<td>Measurement data overflow occurred. &quot;--. ol.&quot; is displayed.</td>
</tr>
<tr>
<td>13</td>
<td>Attempt made to start integration during integration.</td>
</tr>
<tr>
<td>14</td>
<td>Attempt made to stop integration while integration was interrupted.</td>
</tr>
<tr>
<td>15</td>
<td>Attempt made to stop integration while integration was interrupted.</td>
</tr>
<tr>
<td>16</td>
<td>Attempt made to reset integration while integration was in progress.</td>
</tr>
</tbody>
</table>

### Communication Commands 1

*Applies to WT110/WT130 with ROM version 2.01 or later*
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.
- **“m2”** indicates element

- in case of print mode
  - m1=1 : (V) outputs voltage analysis value and relative harmonic content as a numerical value
  - m1=2 : (A) outputs current analysis value and relative harmonic content as a numerical value
  - m1=3 : (W) outputs active power analysis value and relative harmonic content as a numerical value
  - m1=4 : (deg) outputs the phase angle as a numerical value
  - m1=5 : (GV) outputs voltage analysis value as numerical value
  - m1=6 : (GA) outputs current analysis value as numerical value
  - m1=7 : (GW) outputs active power analysis value as numerical value
  - m1=8 : (GVD) outputs the phase angle as a numerical value
  - m1=9 : (GAD) outputs the phase angle

- in case of any other mode
  - m1=1 : (V) outputs voltage analysis value and relative harmonic content as a numerical value
  - m1=2 : (A) outputs current analysis value and relative harmonic content as a numerical value
  - m1=3 : (W) outputs active power analysis value and relative harmonic content as a numerical value
  - m1=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

**Query**

```
OH? <terminator>
```

**Example**

```
OH13,1 <terminator>
```

**Description**

- Parameter error 12 will occur if “m1” or “m2” is set to an illegal value.

**OR/OR?**

Desgnates 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 <terminator>
```

**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**

```
MODEL253503 <terminator>
```

**Line 1**

- Model name

```
RV9;AV1 <terminator>
```

**Line 2**

- Voltage range

```
RA9;AA1;SA50.00 <terminator>
```

**Line 3**

- Current range

```
RA9;AA1;SA1,50.00;SA2,50.00;SA3,50.00 <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:
KV1,0.000;KA1,0.000;KW1,0.000
<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/inquiries 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)
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)
4: ∑ (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

“m5” indicates prefix
m5=0: m(E-3)
1: (E+0)
2: k(E+3)
3: M(E+6)

**Query**

OYH3? <terminator>

Example
OYH3,1,1,1,200,2

**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 m=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)
4: ∑ (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
OYH3,1,1,1,200,2

**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.
Appendix 1.1 Commands

<table>
<thead>
<tr>
<th>Syntax</th>
<th>PS m &lt;terminator&gt;</th>
<th>m</th>
<th>&quot;m&quot; indicates the input as the PLL source</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1</td>
<td>V1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
<td>A1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3</td>
<td>V2 (for model 253503 only)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4</td>
<td>A2 (for model 253503 only)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5</td>
<td>V3 (for WT130 only)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6</td>
<td>A3 (for WT130 only)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Query</th>
<th>PS? &lt;terminator&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Example</td>
<td>PS1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Description</th>
<th>Parameter error 12 will occur if any illegal value is set.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>While recalling or storing is in progress, execution error 19 will occur.</td>
</tr>
</tbody>
</table>

RA/RA?

<table>
<thead>
<tr>
<th>Syntax</th>
<th>RA m &lt;terminator&gt;</th>
<th>m</th>
<th>“m” indicates current range.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>4</td>
<td>0.5 A range</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5</td>
<td>1 A range</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6</td>
<td>2 A range</td>
</tr>
<tr>
<td></td>
<td></td>
<td>7</td>
<td>2.5 V range</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8</td>
<td>10 A range</td>
</tr>
<tr>
<td></td>
<td></td>
<td>9</td>
<td>20 A range</td>
</tr>
<tr>
<td></td>
<td></td>
<td>15</td>
<td>50 mV range (only when equipped with option EX2)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>16</td>
<td>100 mV range (only when equipped with option EX2)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>17</td>
<td>200 mV range (only when equipped with option EX2)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>18</td>
<td>2.5 V range (only when equipped with option EX1)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>19</td>
<td>5 V range (only when equipped with option EX1)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>20</td>
<td>10 V range (only when equipped with option EX1)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Query</th>
<th>RA? &lt;terminator&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Example</td>
<td>RA9</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Description</th>
<th>Parameter error 12 will occur if “m” is set to an illegal value.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Changing of the current range is not allowed while integration is in progress; execution error 13 will occur.</td>
</tr>
<tr>
<td></td>
<td>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.</td>
</tr>
<tr>
<td></td>
<td>While recalling or storing is in progress, execution error 19 will occur.</td>
</tr>
</tbody>
</table>

RC

<table>
<thead>
<tr>
<th>Syntax</th>
<th>RC &lt;terminator&gt;</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>RO/RO?</th>
<th>Sets the recall function ON/OFF or inquires about the current setting.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Syntax</td>
<td>RO m &lt;terminator&gt;</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Query</th>
<th>RO? &lt;terminator&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Example</td>
<td>RO1</td>
</tr>
</tbody>
</table>

| Description | Parameter error 12 will occur if “m” is set to an illegal value. |

<table>
<thead>
<tr>
<th>RR/RR?</th>
<th>Sets the recall interval/inquires about the current setting.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Syntax</td>
<td>RR m1,m2,m3 &lt;terminator&gt;</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Query</th>
<th>RR? &lt;terminator&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Example</td>
<td>RR0,0,0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Description</th>
<th>Parameter error 12 will occur if “m” is set to an illegal value.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>While recalling or storing is in progress, execution error 19 will occur.</td>
</tr>
</tbody>
</table>

RT/RT?

Sets the rated integration time when integrated values are to be output as an analog signal/inquires about the current setting.

<table>
<thead>
<tr>
<th>Syntax</th>
<th>RT m1,m2 &lt;terminator&gt;</th>
<th>m1</th>
<th>“m1” indicates hour, and must be set within the following range.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>0</td>
<td>≤ m1 ≤ 999</td>
</tr>
<tr>
<td></td>
<td></td>
<td>m2</td>
<td>“m2” indicates minute, and must be set within the following range.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0</td>
<td>≤ m2 ≤ 59</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Query</th>
<th>RT? &lt;terminator&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Example</td>
<td>RT1,0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Description</th>
<th>Parameter error 12 will occur if an illegal value is set.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>While recalling or storing is in progress, execution error 19 will occur.</td>
</tr>
</tbody>
</table>

RV/RV?

Sets voltage range/inquires about the current setting.

<table>
<thead>
<tr>
<th>Syntax</th>
<th>RV m &lt;terminator&gt;</th>
<th>m</th>
<th>“m” indicates voltage range.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>3</td>
<td>15V range</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4</td>
<td>30 V range</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5</td>
<td>60 V range</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6</td>
<td>100 V range</td>
</tr>
<tr>
<td></td>
<td></td>
<td>7</td>
<td>150 V range</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8</td>
<td>300 V range</td>
</tr>
<tr>
<td></td>
<td></td>
<td>9</td>
<td>600 V range</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Query</th>
<th>RV? &lt;terminator&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Example</td>
<td>RV9</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Description</th>
<th>Parameter error 12 will occur if an illegal value is set.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Changing of the voltage range is not allowed while integration is in progress; execution error 13 will occur.</td>
</tr>
<tr>
<td></td>
<td>While recalling or storing is in progress, execution error 19 will occur.</td>
</tr>
</tbody>
</table>

SA/SA?

Sets the external sensor scaling value/inquires about the current setting.

<table>
<thead>
<tr>
<th>Syntax</th>
<th>When CM0 is set:  SA n &lt;terminator&gt;</th>
<th>n</th>
<th>“n” indicates element.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>When CM1 is set:  SA m,n &lt;terminator&gt;</td>
<td>m</td>
<td>Setting not allowed during inquiry</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0</td>
<td>All elements</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1</td>
<td>Element 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
<td>Element 2 (only for model 253503)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3</td>
<td>Element 3 (only for the WT130)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.001</td>
<td>≤ n ≤ 1000</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Query</th>
<th>When CM0 is set:  SA? &lt;terminator&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Example</td>
<td>SA0,0,0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Description</th>
<th>Parameter error 12 will occur if “m” is set to an illegal value.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>While recalling or storing is in progress, execution error 19 will occur.</td>
</tr>
</tbody>
</table>

SA/SA?

Sets the external sensor scaling value/inquires about the current setting.

<table>
<thead>
<tr>
<th>Syntax</th>
<th>SA n &lt;terminator&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Setting not allowed during inquiry</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Query</th>
<th>SA? &lt;terminator&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Example</td>
<td>SA0,0,0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Description</th>
<th>Parameter error 12 will occur if an illegal value is set.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>While recalling or storing is in progress, execution error 19 will occur.</td>
</tr>
</tbody>
</table>
### Appendix 1.1 Commands

<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
<th>Syntax</th>
<th>Example</th>
<th>Query</th>
</tr>
</thead>
<tbody>
<tr>
<td>SC/SC?</td>
<td>Determines whether or not to use the scaling function/inquires about the current setting.</td>
<td>SC ( m ) &lt;terminator&gt;</td>
<td>SC1 &lt;terminator&gt;</td>
<td>SC? &lt;terminator&gt;</td>
</tr>
<tr>
<td>SO/SO?</td>
<td>Sets the store function ON/OFF or inquires about the current setting.</td>
<td>SO ( m ) &lt;terminator&gt;</td>
<td>SO1 &lt;terminator&gt;</td>
<td>SO? &lt;terminator&gt;</td>
</tr>
<tr>
<td>SR/SR?</td>
<td>Sets the storage interval/inquires about the current setting.</td>
<td>SR ( m1,m2,m3 ) &lt;terminator&gt;</td>
<td>SR0,0,0 &lt;terminator&gt;</td>
<td>SR? &lt;terminator&gt;</td>
</tr>
<tr>
<td>SS</td>
<td>Stores set-up parameters into a selected file.</td>
<td>SS ( m ) &lt;terminator&gt;</td>
<td>SS &lt;terminator&gt;</td>
<td>SS? &lt;terminator&gt;</td>
</tr>
<tr>
<td>SRM?</td>
<td>Sets the display channel while the comparator function is ON/inquires about the current setting.</td>
<td>YC ( m ) &lt;terminator&gt;</td>
<td>YC1 &lt;terminator&gt;</td>
<td>YC? &lt;terminator&gt;</td>
</tr>
<tr>
<td>TM/TM?</td>
<td>Sets integration preset time/inquires about the current setting.</td>
<td>TM ( m1,m2 ) &lt;terminator&gt;</td>
<td>TM0,0 &lt;terminator&gt;</td>
<td>TM? &lt;terminator&gt;</td>
</tr>
<tr>
<td>WR/WR?</td>
<td>Sets the wiring system/inquires about the current setting.</td>
<td>WR ( m ) &lt;terminator&gt;</td>
<td>WR2 &lt;terminator&gt;</td>
<td>WR? &lt;terminator&gt;</td>
</tr>
<tr>
<td>YM/YM?</td>
<td>Sets the mode of the comparator function/inquires about the current setting.</td>
<td>YM ( m ) &lt;terminator&gt;</td>
<td>YM1 &lt;terminator&gt;</td>
<td>YM? &lt;terminator&gt;</td>
</tr>
<tr>
<td>YO/YO?</td>
<td>Sets the comparator function ON/OFF or inquires about the current setting.</td>
<td>YO ( m ) &lt;terminator&gt;</td>
<td>YO1 &lt;terminator&gt;</td>
<td>YO? &lt;terminator&gt;</td>
</tr>
</tbody>
</table>

**Parameters**
- \( m \): Indicates file no., and must be set within the following range. 
- \( m \leq 4 \)
- \( m1 \): Indicates the hour, \( 0 \leq m1 \leq 99 \)
- \( m2 \): Indicates the minutes, \( 0 \leq m2 \leq 59 \)
- \( m3 \): Indicates the seconds, \( 0 \leq m3 \leq 59 \)
- \( m \): Determines whether storage is ON or OFF. 
- \( m=0 \): OFF
- \( m=1 \): ON
- \( m \): Determines whether scaling is ON or OFF.
- \( m=0 \): OFF
- \( m=1 \): ON
- \( m \): Indicates file no., and must be set within the following range.
- \( m \leq 4 \)
- \( m \): Indicates whether the comparator function is ON/inquires about the current setting.
- \( m=0 \): Single mode
- \( m=1 \): Dual mode
- \( m \): Indicates the channel number for display.
- \( m=1 \): Display limit and measurement value on display 1
- \( m=2 \): Display limit and measurement value on display 2
- \( m=3 \): Display limit and measurement value on display 3
- \( m=4 \): Display limit and measurement value on display 4
- \( m=1 \): ON
- \( m=0 \): OFF
- \( m \): Indicates whether or not to use the comparator function.
- \( m=1 \): ON
- \( m=0 \): OFF
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

<table>
<thead>
<tr>
<th>Command</th>
<th>Parameter</th>
<th>Terminator</th>
</tr>
</thead>
<tbody>
<tr>
<td>DA</td>
<td>2</td>
<td>CR LF</td>
</tr>
</tbody>
</table>

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

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$ = "FOO"            ' Filter OFF
CALL IBWRT(WT%, CMD$): GOSUB ERRCHK

CMD$ = "SCO"            ' 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

CMD$ = "OFD0"           ' Output items for comm. = default setting for normal measurement
CALL IBWRT(WT%, CMD$): GOSUB ERRCHK

CMD$ = "DL0"            ' Delimiter for Comm. output = CR+LF+EOI
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
Appendix 1.2 Sample Program

`********************************************************************
`*  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$, BD%)
IF BD% < 0 THEN GOTO ERRDISP
CALL IBASIC(BD%): GOSUB ERRCHK
DEVICE$ = "WT": CALL IBFIND(DEVICES$, WT%)
IF WT% < 0 THEN GOTO ERRDISP
CALL IBCLR(WT%): GOSUB ERRCHK

DO
CLS
PRINT "Main menu for range adjustment"
PRINT "1:Range adjustment"
PRINT "2:Adjustment of ext. sensor range"
PRINT "0:End        ": LINE INPUT C$
IF C$ = "1" THEN
GOSUB RANGE
ELSEIF C$ = "2" THEN
GOSUB SHUNT
ELSEIF C$ = "0" THEN
EXIT DO
END IF
LOOP

RANGE:
CMD$ = "CAL1": CALL IBWRT(WT%, CMD$): GOSUB ERRCHK
DO
CLS
PRINT "Range adjustment"
PRINT "1: 30.00 V range"
PRINT "2: 300.0 V range"
PRINT "3: 1.000 A range"
PRINT "4: 10.00 A range"
PRINT "S: Adjustment values will be kept"
PRINT "C: Adjustment values will not be kept"
IF C$ = "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
Appendix 1.2 Sample Program

'********************************************************************************
'  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$, BD%) IF BD% < 0 THEN GOTO ERRDISP
CALL IBASIC(BD%): GOSUB ERRCHK
DEVICE$ = "WT": CALL IBFIND(DEVICE$, WT%) IF WT% < 0 THEN GOTO ERRDISP
CALL IBCLR(WT%): GOSUB ERRCHK

CMD$ = "CAL3": CALL IBWRT(WT%, CMD$): GOSUB ERRCHK
DO
  CLS
  PRINT "D/A output adjustment"
  PRINT "1-12 : Assigning D/A channel"
  PRINT "S    : Adjustment values will be kept"
  PRINT "C    : Adjustment values will not be kept"
  PRINT "Command >> "; : LINE INPUT CH$
  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$): GOSUB ERRCHK
  PRINT "+5V has been output to"; CH$; "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$): GOSUB ERRCHK
  PRINT "-5V has been output to"; CH$; "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.

<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DS</td>
<td>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.</td>
</tr>
<tr>
<td>MN/MN?</td>
<td>Sets the measurement mode/inquires about the current setting.</td>
</tr>
<tr>
<td>Syntax</td>
<td>MNm &lt;terminator&gt;</td>
</tr>
<tr>
<td>m stands for measurement mode.</td>
<td></td>
</tr>
<tr>
<td>0 : RMS</td>
<td></td>
</tr>
<tr>
<td>1 : V MEAN</td>
<td></td>
</tr>
<tr>
<td>2 : DC</td>
<td></td>
</tr>
<tr>
<td>Query</td>
<td>MN? &lt;terminator&gt;</td>
</tr>
<tr>
<td>Example</td>
<td>MN0</td>
</tr>
<tr>
<td>Description</td>
<td>Parameter error 12 will occur if “m” is set to an illegal value.</td>
</tr>
<tr>
<td>OL</td>
<td>Requests output of setting parameters. Output format differs from that of the 2533E</td>
</tr>
<tr>
<td>Syntax</td>
<td>OL &lt;terminator&gt;</td>
</tr>
<tr>
<td>Example</td>
<td>MODEL253503&lt;terminator&gt;</td>
</tr>
<tr>
<td>RV9:AV1&lt;terminator&gt;</td>
<td></td>
</tr>
<tr>
<td>RV9:AA1;SA50.00&lt;terminator&gt;</td>
<td></td>
</tr>
<tr>
<td>DA1;DB2;DC3&lt;terminator&gt;</td>
<td></td>
</tr>
<tr>
<td>EA1;EB1;EC1&lt;terminator&gt;</td>
<td></td>
</tr>
<tr>
<td>WR3;FL0;SC0;AG0;HD0;MT0&lt;terminator&gt;</td>
<td></td>
</tr>
<tr>
<td>KV1.000;KA1.000;KW1.000&lt;terminator&gt;</td>
<td></td>
</tr>
<tr>
<td>AT1;AC1&lt;terminator&gt;</td>
<td></td>
</tr>
<tr>
<td>IC0;TM0.0&lt;terminator&gt;</td>
<td></td>
</tr>
<tr>
<td>SO0;SR0.0;RO0;RR0.0&lt;terminator&gt;</td>
<td></td>
</tr>
<tr>
<td>PS1;HA0;OR1;HE1;DF0&lt;terminator&gt;</td>
<td></td>
</tr>
<tr>
<td>RT1.0&lt;terminator&gt;</td>
<td></td>
</tr>
<tr>
<td>Y00;YM1;DY1;YC1&lt;terminator&gt;</td>
<td></td>
</tr>
<tr>
<td>CM2&lt;terminator&gt;</td>
<td></td>
</tr>
<tr>
<td>END&lt;terminator&gt;</td>
<td></td>
</tr>
<tr>
<td>Description</td>
<td>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.</td>
</tr>
<tr>
<td>OS</td>
<td>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.</td>
</tr>
<tr>
<td>WR/WR?</td>
<td>Sets the wiring system/inquires about the current setting.</td>
</tr>
<tr>
<td>Syntax</td>
<td>WRm &lt;terminator&gt;</td>
</tr>
<tr>
<td>m stands for wiring system.</td>
<td></td>
</tr>
<tr>
<td>0 : 3Φ3W (for 253502, 253503 only)</td>
<td></td>
</tr>
<tr>
<td>1 : 3Φ4W (for 253503 only)</td>
<td></td>
</tr>
<tr>
<td>3 : 1Φ3W (for 253502, 253503 only)</td>
<td></td>
</tr>
<tr>
<td>4 : 3V3A (for 253503 only)</td>
<td></td>
</tr>
<tr>
<td>Query</td>
<td>WR? &lt;terminator&gt;</td>
</tr>
<tr>
<td>Example</td>
<td>WR0</td>
</tr>
<tr>
<td>Description</td>
<td>Parameter error 12 will occur if “m” is set to an illegal value.</td>
</tr>
</tbody>
</table>
Appendix 1.3 For Users Using Communication Commands of Digital Power Meter 2533E

Output Items
To read measurement data using the 2533E communication program, the WT110/130 addressable
mode B must be set. Output items do not 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.

<table>
<thead>
<tr>
<th>ch.1 header</th>
<th>ch.1 data</th>
<th>,</th>
<th>ch.2 header</th>
<th>ch.2 data</th>
<th>,</th>
<th>ch.3 header</th>
<th>ch.3 data</th>
</tr>
</thead>
</table>

• Header Section
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: _ : 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

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.

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 ⇒ 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.
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.

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
<th>Example</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;&gt;</td>
<td>Defined value</td>
<td>CHANNEL1&lt;2&gt; &lt;2&gt;=1, 2</td>
<td>CHANNEL2</td>
</tr>
<tr>
<td>{ }</td>
<td>One of the options in MODE {AND</td>
<td>OR}</td>
<td>MODE AND</td>
</tr>
<tr>
<td>[ ]</td>
<td>Exclusive OR</td>
<td>MODE {AND</td>
<td>OR}</td>
</tr>
<tr>
<td>[ ]</td>
<td>Abbreviated</td>
<td>:MEASure[1MODE] {&lt;NRf&gt;}</td>
<td>MODE AND</td>
</tr>
</tbody>
</table>

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> <PMT>
```

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>
```

<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.)
Appendix 2.2 Program Format

Program message unit format
The format of a program message unit is shown below.

```
<Program header> Space <Program data>
```

**<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>`

**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 header> Space <Response data>
```

**<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>`

**<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.

```
<RMT> Space <Response data>
```

**<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>`

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 is 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.

\[ * \langle \text{Mnemonic} \rangle ? \]

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.

\[ \langle \text{Mnemonic} \rangle : \]

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 “Funct”.

• 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 “FUNCTION?”.

• 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<PMT>

- 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.

<table>
<thead>
<tr>
<th>Form</th>
<th>Description</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;Decimal&gt;</td>
<td>Value expressed as a decimal number</td>
<td></td>
</tr>
<tr>
<td>Voltage]&lt;Current&gt;</td>
<td>Physical value</td>
<td></td>
</tr>
<tr>
<td>&lt;Register&gt;</td>
<td>Register value expressed as either binary, octal, decimal or hexadecimal</td>
<td></td>
</tr>
<tr>
<td>&lt;Character data&gt;</td>
<td>Specified character string (mnemonic)</td>
<td></td>
</tr>
<tr>
<td>&lt;Boolean&gt;</td>
<td>Indicates ON/OFF. Set to ON, OFF or value</td>
<td></td>
</tr>
<tr>
<td>&lt;Character string data&gt;</td>
<td>Arbitrary character string</td>
<td></td>
</tr>
</tbody>
</table>

<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.

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;NR1&gt;</td>
<td>Integer</td>
<td>±125</td>
</tr>
<tr>
<td>&lt;NR2&gt;</td>
<td>Fixed point number</td>
<td>±125.0</td>
</tr>
<tr>
<td>&lt;NR3&gt;</td>
<td>Floating point number</td>
<td>±125.0E+0</td>
</tr>
</tbody>
</table>
| <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.

<table>
<thead>
<tr>
<th>Form</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;NRf&gt;</td>
<td>5MV</td>
</tr>
<tr>
<td>&lt;NRf&gt;</td>
<td>5E-3V</td>
</tr>
<tr>
<td>&lt;NRf&gt;</td>
<td>5m</td>
</tr>
<tr>
<td>&lt;NRf&gt;</td>
<td>5E-3</td>
</tr>
</tbody>
</table>
Appendix 2.2  Program Format

**<Multiplier>**

Multipliers which can be used are shown below.

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Word</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>EX</td>
<td>Exa</td>
<td>10^18</td>
</tr>
<tr>
<td>PE</td>
<td>Peta</td>
<td>10^15</td>
</tr>
<tr>
<td>T</td>
<td>Tera</td>
<td>10^12</td>
</tr>
<tr>
<td>G</td>
<td>Giga</td>
<td>10^9</td>
</tr>
<tr>
<td>MA</td>
<td>Mega</td>
<td>10^6</td>
</tr>
<tr>
<td>K</td>
<td>Kilo</td>
<td>10^3</td>
</tr>
<tr>
<td>M</td>
<td>Mili</td>
<td>10^-3</td>
</tr>
<tr>
<td>U</td>
<td>Micro</td>
<td>10^-6</td>
</tr>
<tr>
<td>N</td>
<td>Nano</td>
<td>10^-9</td>
</tr>
<tr>
<td>P</td>
<td>Pico</td>
<td>10^-12</td>
</tr>
<tr>
<td>F</td>
<td>Femto</td>
<td>10^-15</td>
</tr>
</tbody>
</table>

**<Unit>**

Units which can be used are shown below.

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Word</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>V</td>
<td>Volt</td>
<td>Voltage</td>
</tr>
<tr>
<td>A</td>
<td>Ampere</td>
<td>Current</td>
</tr>
</tbody>
</table>

<Multiplier> and <Unit> are not case sensitive. "U" is used to indicate "µ".

"M" is used for Mega (M) to distinguish it from Mili. However, when using "mA" for current, Mili-ampere will be valid; therefore use "mA" 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.

<table>
<thead>
<tr>
<th>Form</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>#H</td>
<td>#0F</td>
</tr>
<tr>
<td>#Q</td>
<td>#777</td>
</tr>
<tr>
<td>#B</td>
<td>#001100</td>
</tr>
</tbody>
</table>

<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.

<table>
<thead>
<tr>
<th>Form</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>{RMS</td>
<td>VMEan</td>
</tr>
</tbody>
</table>

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.

<table>
<thead>
<tr>
<th>Form</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>[ON</td>
<td>OFF]&lt;NRf&gt;</td>
</tr>
</tbody>
</table>

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 (").

<table>
<thead>
<tr>
<th>Form</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;ABC&quot;</td>
<td>&quot;IEEE488.2-1987&quot;</td>
</tr>
</tbody>
</table>

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 a query is made about the measurement data, it may occur that regardless whether the measurement data have been updated, \texttt{MEASure[:NORMAL]:VALue?} will be executed. The display becomes “——” (no data) and “9.91E+37 (Not a number)” will be output.

\begin{verbatim}
[CONFIGure]:VOLTage:RANGe 60V;:MEASure[:NORMAL]:VALue?<PMT>
\end{verbatim}

In this case, synchronization with the time at which the update of measurement data is completed must be accomplished, as shown next.

**Using \texttt{STATus:CONDition?} query**

A \texttt{“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).

\begin{verbatim}
Example \texttt{STATus:FILTer1 FALL;STATus:EESE 1;EESR?; *
SRE8;[CONFIGure]:VOLTage:RANGe 60V<PMT> (Service request is awaited.)}
\texttt{MEASure[:NORMAL]:VALue?<PMT>}
\end{verbatim}

“\texttt{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”. “\texttt{STATus:EESE 1}” is a command used only to reflect the status of bit 0 of the extended event register in the status byte. “\texttt{STATus:EESR?}” is used to clear the extended event register. The “\texttt{*SRE}” command is used to generate a service request caused solely by the extended event register. “\texttt{MEASure[:NORMAL]:VALue?}” will not be executed until a service request is generated.

**Using the \texttt{COMMunicate:WAIT} command**

The \texttt{“COMMunicate:WAIT”} command halts communications until a specific event is generated.

\begin{verbatim}
Example \texttt{STATus:FILTer1 FALL;STATus:EESE 1;EESR?; } 
[:CONFIGure]:VOLTage:RANGe 60V<PMT>
(\texttt{Response to \texttt{STATus:EESR?} is decoded.})
\texttt{COMMunicate:WAIT 1;:MEASure[:NORMAL]:VALue?<PMT>}
\end{verbatim}

For a description of “\texttt{STATus:FILTer 1 FALL}” and “\texttt{STATus:EESR?}”, refer to “Using the extended event register” on this page. “\texttt{COMMunicate:WAIT 1}” means that communications is halted until bit 0 of the extended event register is set to “1”. “\texttt{MEASure[:NORMAL]:VALue?}” will not be executed until bit 0 of the extended event register is set to “1”.

"\texttt{COMMunicate:WAIT 1;:MEASure[:NORMAL]:VALue?}"

The "COMMunicate:WAIT" command halts communications until a specific event is generated.
## Appendix 2.3 Commands

### 2.3.1 Command List

<table>
<thead>
<tr>
<th>Command Group</th>
<th>Command</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>AOUTput Group</strong></td>
<td>:AOUTput?</td>
<td>Queries all settings related to D/A output.</td>
<td>App. 2-11</td>
</tr>
<tr>
<td></td>
<td>:AOUTput:CHANnel&lt;x&gt;</td>
<td>Sets/queries the D/A output item.</td>
<td>App. 2-11</td>
</tr>
<tr>
<td></td>
<td>:AOUTput:IRTime</td>
<td>Sets/queries the preset integration time for D/A output of integrated values.</td>
<td>App. 2-11</td>
</tr>
<tr>
<td></td>
<td>:AOUTput:PRESet</td>
<td>Sets the default value as D/A output items.</td>
<td>App. 2-11</td>
</tr>
<tr>
<td><strong>COMMunicate Group</strong></td>
<td>:COMMunicate?</td>
<td>Queries all settings related to communication.</td>
<td>App. 2-12</td>
</tr>
<tr>
<td></td>
<td>:COMMunicate:READer</td>
<td>Sets/queries whether a header is to be added.</td>
<td>App. 2-12</td>
</tr>
<tr>
<td></td>
<td>:COMMunicate:LOCRout</td>
<td>Sets/cancels local lockout.</td>
<td>App. 2-12</td>
</tr>
<tr>
<td></td>
<td>:COMMunicate:REMote</td>
<td>Sets remote/local condition.</td>
<td>App. 2-12</td>
</tr>
<tr>
<td></td>
<td>:COMMunicate:STATus?</td>
<td>Queries the status of a specified circuit.</td>
<td>App. 2-13</td>
</tr>
<tr>
<td></td>
<td>:COMMunicate:VERBose</td>
<td>Sets/queries the response to be in full or abbreviated form.</td>
<td>App. 2-13</td>
</tr>
<tr>
<td></td>
<td>:COMMunicate:WAIT</td>
<td>Waits until one of the specified extended event occurs.</td>
<td>App. 2-13</td>
</tr>
<tr>
<td></td>
<td>:COMMunicate:WAIT?</td>
<td>Generates a response when on of the specified extended events occurs.</td>
<td>App. 2-13</td>
</tr>
<tr>
<td><strong>CONFigure Group</strong></td>
<td>:CONFigure?</td>
<td>Queries all settings related to the measurement conditions.</td>
<td>App. 2-15</td>
</tr>
<tr>
<td></td>
<td>[:CONFigure]:AVERaging?</td>
<td>Queries all settings related to the averaging function.</td>
<td>App. 2-15</td>
</tr>
<tr>
<td></td>
<td>[:CONFigure]:AVERaging[:STATE]</td>
<td>Sets/queries averaging ON/OFF.</td>
<td>App. 2-15</td>
</tr>
<tr>
<td></td>
<td>[:CONFigure]:AVERaging:TYPE</td>
<td>Sets/queries averaging type and constant.</td>
<td>App. 2-15</td>
</tr>
<tr>
<td></td>
<td>[:CONFigure]:CURRENT?</td>
<td>Queries all settings related to the current range.</td>
<td>App. 2-15</td>
</tr>
<tr>
<td></td>
<td>[:CONFigure]:CURRENT:AUTO</td>
<td>Sets/queries the current auto range ON/OFF.</td>
<td>App. 2-15</td>
</tr>
<tr>
<td></td>
<td>[:CONFigure]:CURRENT:ESCaling?</td>
<td>Queries all settings related to the external sensor.</td>
<td>App. 2-15</td>
</tr>
<tr>
<td></td>
<td>[:CONFigure]:CURRENT:ESCaling[:ALL]</td>
<td>Sets the scaling values for the external sensor for all elements at once.</td>
<td>App. 2-15</td>
</tr>
<tr>
<td></td>
<td>[:CONFigure]:CURRENT:ESCaling:ELEMent&lt;x&gt;</td>
<td>Sets/queries the scaling values for the external sensor for each element.</td>
<td>App. 2-15</td>
</tr>
<tr>
<td></td>
<td>[:CONFigure]:CURRENT:RANGE</td>
<td>Sets/queries the current range.</td>
<td>App. 2-15</td>
</tr>
<tr>
<td></td>
<td>[:CONFigure]:FILTER</td>
<td>Sets/queries the filter ON/OFF.</td>
<td>App. 2-15</td>
</tr>
<tr>
<td></td>
<td>[:CONFigure]:MODE</td>
<td>Sets/queries the measurement mode.</td>
<td>App. 2-15</td>
</tr>
<tr>
<td></td>
<td>[:CONFigure]:SCALing?</td>
<td>Queries all settings related to the scaling function.</td>
<td>App. 2-16</td>
</tr>
<tr>
<td></td>
<td>[:CONFigure]:SCALing:[PT</td>
<td>CT</td>
<td>SFACtor]?:</td>
</tr>
<tr>
<td></td>
<td>[:CONFigure]:SCALing:[PT</td>
<td>CT</td>
<td>SFACtor]:[:ALL]</td>
</tr>
<tr>
<td></td>
<td>[:CONFigure]:SCALing:[PT</td>
<td>CT</td>
<td>SFACtor]:ELEMent&lt;x&gt;</td>
</tr>
<tr>
<td><strong>DISPlay Group</strong></td>
<td>:DISPlay&lt;x&gt;?</td>
<td>Queries all the display settings.</td>
<td>App. 2-17</td>
</tr>
<tr>
<td></td>
<td>:DISPlay&lt;x&gt;:ELEMent</td>
<td>Sets/queries the element to be displayed.</td>
<td>App. 2-17</td>
</tr>
<tr>
<td></td>
<td>:DISPlay&lt;x&gt;:FUNCtion</td>
<td>Sets/queries the function to be displayed.</td>
<td>App. 2-17</td>
</tr>
<tr>
<td></td>
<td>:DISPlay&lt;x&gt;:MODE</td>
<td>Sets/queries the contents of the display.</td>
<td>App. 2-17</td>
</tr>
<tr>
<td><strong>HARMonics Group</strong></td>
<td>:HARMonics?</td>
<td>Queries all settings related to harmonic analysis.</td>
<td>App. 2-18</td>
</tr>
<tr>
<td></td>
<td>:HARMonics:DISPLAY?</td>
<td>Queries all settings related to the display in case of harmonic analysis.</td>
<td>App. 2-18</td>
</tr>
<tr>
<td></td>
<td>:HARMonics:DISPLAY:ORDer</td>
<td>Sets/queries the order of the harmonic component to be shown on display B.</td>
<td>App. 2-18</td>
</tr>
<tr>
<td></td>
<td>:HARMonics:ELEMENT</td>
<td>Sets/queries the element for harmonic analysis.</td>
<td>App. 2-18</td>
</tr>
<tr>
<td></td>
<td>:HARMonics[:STATE]</td>
<td>Sets/queries the harmonic analysis mode ON/OFF.</td>
<td>App. 2-18</td>
</tr>
<tr>
<td></td>
<td>:HARMonics:SYNChronize</td>
<td>Sets/queries the input to be used as PLL source.</td>
<td>App. 2-18</td>
</tr>
<tr>
<td></td>
<td>:HARMonics:TTHD</td>
<td>Sets/queries the computation method for harmonic distortion.</td>
<td>App. 2-18</td>
</tr>
</tbody>
</table>
Appendix 2.3 Commands

<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>INTEGrate Group</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>:INTEGrate?</td>
<td>Queries all settings related to integration.</td>
<td>App. 2-19</td>
</tr>
<tr>
<td>:INTEGrate:MODE</td>
<td>Sets/queries the integration mode.</td>
<td>App. 2-19</td>
</tr>
<tr>
<td>:INTEGrate:RESET</td>
<td>Resets the integration values.</td>
<td>App. 2-19</td>
</tr>
<tr>
<td>:INTEGrate:START</td>
<td>Starts integration.</td>
<td>App. 2-19</td>
</tr>
<tr>
<td>:INTEGrate:STOP</td>
<td>Stops integration.</td>
<td>App. 2-19</td>
</tr>
<tr>
<td>:INTEGrate:TIMer</td>
<td>Sets/queries the integration timer.</td>
<td>App. 2-19</td>
</tr>
<tr>
<td><strong>MATH Group (applies to WT110/WT130 with ROM version 2.01 or later)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>:MATH?</td>
<td>Queries all settings related to the computing function.</td>
<td>App. 2-20</td>
</tr>
<tr>
<td>:MATH:ARITHmetic</td>
<td>Sets/queries the computing equation of the four arithmetic operations.</td>
<td>App. 2-20</td>
</tr>
<tr>
<td>:MATH:CFACtor</td>
<td>Sets/queries the computing equation of the crest factor.</td>
<td>App. 2-20</td>
</tr>
<tr>
<td>:MATH:TYPE</td>
<td>Sets/queries the computing equation.</td>
<td>App. 2-20</td>
</tr>
<tr>
<td><strong>MEASure Group</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>:MEASure?</td>
<td>Queries all settings related to measurement/computation data.</td>
<td>App. 2-22</td>
</tr>
<tr>
<td>:MEASure:HARMonics?</td>
<td>Queries all settings related to harmonic analysis data.</td>
<td>App. 2-22</td>
</tr>
<tr>
<td>:MEASure:HARMonics:ITEM?</td>
<td>Queries all settings related to the output items of harmonic analysis data.</td>
<td>App. 2-22</td>
</tr>
<tr>
<td>:MEASure:HARMonics:ITEM:PRESet</td>
<td>Sets the ON/OFF pattern for all communication outputs of the harmonic analysis function.</td>
<td>App. 2-22</td>
</tr>
<tr>
<td>:MEASure:HARMonics:ITEM:{SYNChronize</td>
<td>&lt;harmonic analysis function&gt;}</td>
<td>Sets/queries the communication output item of harmonic analysis ON/OFF.</td>
</tr>
<tr>
<td>:MEASure[:NORMal]?</td>
<td>Queries all settings related to normal measured/computed data.</td>
<td>App. 2-22</td>
</tr>
<tr>
<td>:MEASure[:NORMal]:ITEM?</td>
<td>Queries all settings related to the output items of normal measured/computed data.</td>
<td>App. 2-23</td>
</tr>
<tr>
<td>:MEASure[:NORMal]:ITEM:PRESet</td>
<td>Sets the ON/OFF pattern for all communication outputs of the normal measurement function.</td>
<td>App. 2-23</td>
</tr>
<tr>
<td>:MEASure[:NORMal]:ITEM:{TIME</td>
<td>MATH}</td>
<td>Sets/queries the ON/OFF state of the communication output of {integration time</td>
</tr>
<tr>
<td>:MEASure[:NORMal]:ITEM:{normal measurement function}?</td>
<td>Queries communication output settings of the normal measurement function.</td>
<td>App. 2-23</td>
</tr>
<tr>
<td>:MEASure[:NORMal]:ITEM:{normal measurement function}:{ALL}</td>
<td>Sets the communication output items concerning all elements or S ON/OFF at once.</td>
<td>App. 2-23</td>
</tr>
<tr>
<td>:MEASure[:NORMal]:ITEM:{normal measurement function}:{ELEMent&lt;x&gt;}</td>
<td>Sets/queries the communication output items concerning each element ON/OFF.</td>
<td>App. 2-23</td>
</tr>
<tr>
<td>:MEASure[:NORMal]:ITEM:{normal measurement function}:SIGMA</td>
<td>Sets/queries the communication output items concerning S ON/OFF.</td>
<td>App. 2-23</td>
</tr>
<tr>
<td>:MEASure[:NORMal]:VALUE?</td>
<td>Queries normal measured/computed data set by commands other than “MEASure[:NORMal]:ITEM”</td>
<td>App. 2-23</td>
</tr>
<tr>
<td><strong>RECall Group</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>:RECall?</td>
<td>Queries all settings related to recalling data.</td>
<td>App. 2-27</td>
</tr>
<tr>
<td>:RECall:INTerval</td>
<td>Sets/queries the recalling interval.</td>
<td>App. 2-27</td>
</tr>
<tr>
<td>:RECall:FANEI</td>
<td>Retrieves the set-up parameters file.</td>
<td>App. 2-27</td>
</tr>
<tr>
<td>:RECall[:STATe]</td>
<td>Sets/queries recalling ON/OFF.</td>
<td>App. 2-27</td>
</tr>
</tbody>
</table>
### Appendix 2.3 Commands

<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>RELay Group</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>:RELay?</td>
<td>Queries all settings related to the comparator function.</td>
<td>App. 2-28</td>
</tr>
<tr>
<td>:RELay:DISPLAY</td>
<td>Sets/queries the comparator display OFF, or in case of ON, the channel to be displayed.</td>
<td>App. 2-28</td>
</tr>
<tr>
<td>:RELay:HChannel&lt;x&gt;?</td>
<td>Queries all settings related to relay output items in case of harmonic analysis.</td>
<td>App. 2-28</td>
</tr>
<tr>
<td>:RELay:HChannel&lt;x&gt;:FUNCTION</td>
<td>Sets/queries the function of the relay output item in case of harmonic analysis.</td>
<td>App. 2-29</td>
</tr>
<tr>
<td>:RELay:HChannel&lt;x&gt;:THreshold</td>
<td>Sets/queries the threshold level for the relay output item.</td>
<td>App. 2-29</td>
</tr>
<tr>
<td>:RELay:MODE</td>
<td>Sets/queries the mode of the comparator function.</td>
<td>App. 2-29</td>
</tr>
<tr>
<td>:RELay:NChannel&lt;x&gt;?</td>
<td>Queries all settings related to the relay output items in case of normal measurement.</td>
<td>App. 2-29</td>
</tr>
<tr>
<td>:RELay:NChannel&lt;x&gt;:FUNCTION</td>
<td>Sets/queries the function of the relay output in case of normal measurement.</td>
<td>App. 2-29</td>
</tr>
<tr>
<td>:RELay:NChannel&lt;x&gt;:THreshold</td>
<td>Sets/queries the threshold level for the relay output item.</td>
<td>App. 2-29</td>
</tr>
<tr>
<td>:RELay:STATE</td>
<td>Sets/queries the comparator function ON/OFF.</td>
<td>App. 2-29</td>
</tr>
<tr>
<td><strong>SAMPle Group</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>:SAMPle?</td>
<td>Queries all settings related to sampling.</td>
<td>App. 2-30</td>
</tr>
<tr>
<td>:SAMPle:HOLD</td>
<td>Sets/queries to hold the output of data (display, communication).</td>
<td>App. 2-30</td>
</tr>
<tr>
<td><strong>STATus Group</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>:STATus?</td>
<td>Queries all settings related to the status of communication.</td>
<td>App. 2-31</td>
</tr>
<tr>
<td>:STATus:CONDITION?</td>
<td>Queries the contents of the condition filter and clears it at the same time.</td>
<td>App. 2-31</td>
</tr>
<tr>
<td>:STATus:ESE</td>
<td>Sets/queries the extended event register.</td>
<td>App. 2-31</td>
</tr>
<tr>
<td>:STATus:ESR?</td>
<td>Queries the contents of the extended event register and clears it.</td>
<td>App. 2-31</td>
</tr>
<tr>
<td>:STATus:ERROR?</td>
<td>Queries the occurred error code and message.</td>
<td>App. 2-31</td>
</tr>
<tr>
<td>:STATus:FILTER&lt;x&gt;</td>
<td>Sets/queries the transit filter.</td>
<td>App. 2-31</td>
</tr>
<tr>
<td>:STATus:MESSage</td>
<td>Sets/queries whether or not to apply the corresponding message to the query &quot;STATus:ERROR?&quot;.</td>
<td>App. 2-31</td>
</tr>
<tr>
<td>:STATus:SPOLi?(Serial Poll)</td>
<td>Executes serial polling.</td>
<td>App. 2-31</td>
</tr>
<tr>
<td><strong>STORe Group</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>:STORe?</td>
<td>Queries all settings related to storing data.</td>
<td>App. 2-32</td>
</tr>
<tr>
<td>:STORe:INTERval</td>
<td>Sets/queries the interval for storing data.</td>
<td>App. 2-32</td>
</tr>
<tr>
<td>:STORe:PARameter</td>
<td>Saves the set-up parameters to a file.</td>
<td>App. 2-32</td>
</tr>
<tr>
<td>:STORe[:STATe]</td>
<td>Sets/queries the store function ON/OFF.</td>
<td>App. 2-32</td>
</tr>
<tr>
<td><strong>Common Command Group</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>*CLS</td>
<td>Clears the standard event register, extended event register and error queue.</td>
<td>App. 2-33</td>
</tr>
<tr>
<td>*ESE</td>
<td>Sets/queries the value of the standard event enable register.</td>
<td>App. 2-33</td>
</tr>
<tr>
<td>*ESR?</td>
<td>Sets/queries the value of the standard event register and clears it.</td>
<td>App. 2-33</td>
</tr>
<tr>
<td>*IDN?</td>
<td>Queries the instrument model.</td>
<td>App. 2-33</td>
</tr>
<tr>
<td>*OPC</td>
<td>This command is not supported by this instrument.</td>
<td>App. 2-33</td>
</tr>
<tr>
<td>*OPC?</td>
<td>This command is not supported by this instrument, and is always “1”.</td>
<td>App. 2-33</td>
</tr>
<tr>
<td>*OPT?</td>
<td>Queries installed options.</td>
<td>App. 2-34</td>
</tr>
<tr>
<td>*RSC</td>
<td>Sets/queries whether or not to clear some registers at power ON.</td>
<td>App. 2-34</td>
</tr>
<tr>
<td>*RST</td>
<td>Initializes the present settings.</td>
<td>App. 2-34</td>
</tr>
<tr>
<td>*SER</td>
<td>Sets/queries the value of the service request enable register.</td>
<td>App. 2-34</td>
</tr>
<tr>
<td>*STB?</td>
<td>Queries the value of the status byte register.</td>
<td>App. 2-34</td>
</tr>
<tr>
<td>*TRG</td>
<td>Executes the same operation as the TRIG(SHIFT+HOLD) key.</td>
<td>App. 2-34</td>
</tr>
<tr>
<td>*TST?</td>
<td>Executes a self-test and queries the results.</td>
<td>App. 2-34</td>
</tr>
<tr>
<td>*WAI</td>
<td>This command is not supported by this instrument.</td>
<td>App. 2-34</td>
</tr>
</tbody>
</table>
### 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?

#### 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: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

#### 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)`
- `<x>=1 to 4 (in case of /DA4)`
- `<normal measurement function>=V|A|W|VA|VAR|PF|DEGRee|VHZ|ARZ|WHR|WHP|AH|AHP|AHM|MATH|VPK|APK`

**Example**: AOUTPUT:CHANNEL1 V,1

**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, AH: current frequency, WH: watt hour, WHP: positive watt hour, WHP: 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>}
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>}
Example 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?`  

**Description**: The status condition for each bit is as follows.

<table>
<thead>
<tr>
<th>bit</th>
<th>GP-IB</th>
<th>RS-232-C</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>permanent parity error</td>
<td>communication error</td>
</tr>
<tr>
<td>1</td>
<td>always 0 framing error</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>always 0 break character occurrence</td>
<td></td>
</tr>
<tr>
<td>3 and up</td>
<td>always 0 always 0</td>
<td></td>
</tr>
</tbody>
</table>

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>`  

**Example**: `COMMUNICATE:VERBOSE ON`  

**Description**: For a description of synchronization using "`COMMunicate:WAIT`", refer to page App2-8.

---

**COMMunicate:WAIT**

**Function**: Waits until one of the specified extended events occurs.

**Syntax**: `COMMunicate:WAIT <Register>`  

**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>`  

**Example**: `COMMUNICATE:WAIT? 65535`  

**Description**: For a description of synchronization using "`COMMunicate:WAIT`", refer to page App2-8.
Appendix 2.3 Commands

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 valid if equipped with the external sensor option (/EX1 or /EX2).

[Diagram of CONFIGure group with various settings: Wiring, Mode, Voltage Range, Current Range, Scaling, Filter, and Averaging.]
### Configuration Commands

<table>
<thead>
<tr>
<th>Function</th>
<th>Description</th>
<th>Syntax</th>
<th>Example</th>
</tr>
</thead>
</table>
| **CONFigure?** | Queries all the settings related to the measurement conditions. | `CONFigure?` | `CONFigure?` → `CONFigure:WIRing P1W3;MODE RMS;`
| **CONFigure:AVERaging** | Sets the averaging type and constant, queries the current setting. | `CONFigure:AVERaging:TYPE {LINEar,8}` | `CONFigure:AVERaging:TYPE LINEAR,8` |
| **CONFigure:AVERaging:STATE?** | Sets averaging ON/OFF, or queries the current status. | `CONFigure:AVERaging:STATE?` | `CONFigure:AVERaging:STATE?` → `CONFigure:AVERaging:STATE OFF` |
| **CONFigure:CURRENT** | Sets the current range (external sensor input range), queries the current setting. | `CONFigure:CURRENT:RANGE {<current>|(EXTernal,<voltage>)}` | `CONFigure:CURRENT:RANGE 20A` |
| **CONFigure:CURRENT:AUTO** | Sets the current auto range ON/OFF, or queries the current setting. | `CONFigure:CURRENT:AUTO {<Boolean>}` | `CONFigure:CURRENT:AUTO 1` |
| **CONFigure:CURRENT:ESCaling** | Sets the scaling values for the external sensor for all elements at once. | `CONFigure:CURRENT:ESCaling[:ALL] {<NRf>}` | `CONFigure:CURRENT:ESCaling[:ALL] 50.00` |
| **CONFigure:CURRENT:ESCaling:ELEMent<x>** | Sets the scaling values for the external sensor for each element separately, queries the current setting. | `CONFigure:CURRENT:ESCaling:ELEMent<x> {<NRf>}` | `CONFigure:CURRENT:ESCaling:ELEMent1 50.00` |
| **CONFigure:CURRENT:RANGE** | Sets the current range (external sensor input range), queries the current setting. | `CONFigure:CURRENT:RANGE {<current>|(EXTernal,<voltage>)}` | `CONFigure:CURRENT:RANGE 20A` |
| **CONFigure:FILTER** | Sets the filter ON/OFF, queries the current setting. | `CONFigure:FILTER {<Boolean>}` | `CONFigure:FILTER OFF` |
| **CONFigure:MODE** | Sets the measurement mode of current and voltage, queries the current setting. | `CONFigure:MODE {RMS|VMean|DC}` | `CONFigure:MODE RMS` |

**Syntax Examples**

- `CONFigure:CURRENT:RANGE EXTERNAL, 50.00E+00` (external sensor input range)
- `CONFigure:CURRENT:RANGE?` (query)
- `CONFigure:FILTER?` (query)
- `CONFigure:MODE RMS` (set mode)

**Description**

- Setting values differ as described at `[CONFigure]: CURRENT: ESCaling[:ALL]`.
- Less than 1.000 : Three digits after the floating-point are valid.
- 1.000 to 1000 : The first five digits are valid.
Appendix 2.3 Commands

**[CONFigure]:SCALing?**

**Function**
Queries all settings relating to the scaling function.

**Syntax**
```
[CONFigure]:SCALing?
```

**Example**
```
[CONFIGURE]:SCALing?
```

**[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|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>}
```

**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>}
```

**Example**
```
[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>}
```

**Example**
```
[CONFIGURE]:SCALing:STATE ON
```

**[CONFigure]:VOLTage:AUTO**

**Function**
Sets the voltage auto range ON/OFF, queries the current setting.

**Syntax**
```
[CONFIGURE]:VOLTage:AUTO {<Boolean>}
```

**Example**
```
[CONFIGURE]:VOLTage:AUTO ON
```

**[CONFigure]:VOLTage:RANGe**

**Function**
Sets the voltage range/queries the current setting.

**Syntax**
```
[CONFIGURE]:VOLTage:RANGe {<voltage>}
```

**Example**
```
[CONFIGURE]:VOLTage:RANGe 600V
```

**[CONFigure]:WIRing**

**Function**
Sets the wiring method/queries the current setting.

**Syntax**
```
[CONFigure]:WIRing {P1W2|P1W3|P3W3|P3W4|V3A3}
```

**Example**
```
[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*

\[
\text{DISPlay<x>}\
\]

*Example*

\[
\text{DISPLAY1}?\rightarrow:\text{DISPLAY1:MODE VALUE;FUNCTION V;ELEMENT 1}
\]

**DISPlay<x>:ELEMent**

*Function* Sets the element to be displayed/queries the current setting.

*Syntax*

\[
\text{DISPlay<x>:ELEMent}<\text{<NRf>|SIGMa}>\
\]

*Example*

\[
\text{DISPLAY1:ELEMENT 1}\rightarrow:\text{DISPLAY1:ELEMENT 1}
\]

**DISPlay<x>:FUNCtion**

*Function* Sets the function to be displayed/queries the current setting.

*Syntax*

\[
\text{DISPlay<x>:FUNCtion}<\text{<display function>}>\
\]

*Example*

\[
\text{DISPLAY1:FUNCtion V}\rightarrow:\text{DISPLAY1:FUNCtion V}
\]

*Description*

For the meanings of the symbols of functions, see Note on page App2-11.
Appendix 2.3 Commands

2.3.6 HARMonics Group

The commands in the HARMonics group relate to the harmonic analysis function. This allows 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}
Example 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> | <NRf>, <NRf> = 0, 0 to 999, 59
<NString> = HH:MM HH:MM hour MM minute
Example INTEGRATE:TIMER 10, 0
INTEGRATE:TIMER → :INTEGRATE:TIMER 10, 0
Appendix 2.3 Commands

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?
```

**Description**

If [MATH:TYPE] is not set to [ARITHMETIC], this command will be meaningless. The computing equation selection is as follows:

- **ADD**: display \( A + B \)
- **SUB**: display \( A - B \)
- **MUL**: display \( A \times B \)
- **DIV**: display \( A / B \)
- **DIVA**: display \( A / (B^2) \)
- **DIVB**: display \( (A^2) / B \)

**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
```

**Description**

If [MATH:TYPE] is not set to [ARITHMETIC], this command will be meaningless. The computing equation selection is as follows:

- **ADD**: display \( A + B \)
- **SUB**: display \( A - B \)
- **MUL**: display \( A \times B \)
- **DIV**: display \( A / B \)
- **DIVA**: display \( A / (B^2) \)
- **DIVB**: display \( (A^2) / B \)

**MATH:CFACtor**

**Function** Sets/queries the computing equation of the crest factor

**Syntax**

```
MATH:CFACtor
{(V|A),(<NRf>|ELEMent<x>)}
```

**Example**

```
MATH:CFACtor V,1
MATH:CFACtor?
```

**Description**

If [MATH:TYPE] is not set to [CFACtor], this command will be meaningless.
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.
Appendix 2.3 Commands

**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)
```
MEASUREMENT:ITEM:V:ELEMENT1 1;
ELEMENT2 1;ELEMENT3 1;SIGMA 1;MEASURE:NORMAL:ITEM:V:
ELEMENT1 1;ELEMENT2 1;ELEMENT3 1;SIGMA 1;MEASURE:NORMAL:ITEM:W:
ELEMENT1 1;ELEMENT2 1;ELEMENT3 1;SIGMA 1;MEASURE:NORMAL:ITEM:VAR:
ELEMENT1 1;ELEMENT2 1;ELEMENT3 1;SIGMA 1;MEASURE:NORMAL:ITEM:PF:
ELEMENT1 0;ELEMENT2 0;SIGMA 0;MEASURE:NORMAL:ITEM:THD:
ELEMENT1 0;ELEMENT2 0;ELEMENT3 0;SIGMA 0;MEASURE:NORMAL:ITEM:TIME:
ELEMENT1 0;ELEMENT2 0;ELEMENT3 0;SIGMA 0;MEASURE:NORMAL:ITEM:VAR:
ELEMENT1 0;ELEMENT2 0;ELEMENT3 0;SIGMA 0;VDEG 0;ADEG 0
```

**MEASURE:HARMONICS?**

**Function**
Queries all settings related to harmonic analysis data.

**Syntax**
MEASURE:HARMONICS?

**Example**
```
MEASURE:HARMONICS:ITEM:PRESet {VPATTERN|APattern|DPattern|VPATTERN|APattern|DPattern|[ALL|CLEAR]}
```

**MEASURE:HARMONICS:ITEM**

**Function**
Sets the ON/OFF pattern for all communication outputs of the harmonic analysis function.

**Syntax**
MEASURE:HARMONICS:ITEM:PRESet {VPATTERN|APattern|DPattern|VPATTERN|APattern|DPattern|[ALL|CLEAR]}

**Example**
```
VPATTERN:SYNCronize/VTHD/V/W/CON→WON, others→OFF
APATTERN:SYNCronize/ATHD/A/CON→WON, others→OFF
DPATTERN:SYNCronize/VDEG/ADEG→WON, others→OFF
ALL :all items→ON
CLEAR :all items→OFF
```

**MEASURE:HARMONICS:ITEM:SYNChronize**

**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:ITEMS**

**Function**
Sets the communication output item of harmonic analysis ON/OFF, queries the current setting.

**Syntax**
MEASURE:HARMONICS:ITEM:SYNChronize

**Example**
```
HARMONICS:ITEM: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,
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.

**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:W:
ELEMENT1 1;ELEMENT2 1;ELEMENT3 1;SIGMA 1;MEASURE:NORMAL:ITEM:VAR:
ELEMENT1 1;ELEMENT2 1;ELEMENT3 1;SIGMA 1;MEASURE:NORMAL:ITEM:PF:
ELEMENT1 0;ELEMENT2 0;SIGMA 0;MEASURE:NORMAL:ITEM:THD:
ELEMENT1 0;ELEMENT2 0;ELEMENT3 0;SIGMA 0;MEASURE:NORMAL:ITEM:TIME:
ELEMENT1 0;ELEMENT2 0;ELEMENT3 0;SIGMA 0;VDEG 0;ADEG 0
```

**MEASURE:NORMAL:ITEM**

**Function**
Queries all settings related to the communication output items of harmonic analysis data.

**Syntax**
MEASURE:NORMAL:ITEM

**Example**
```
MEASURE:NORMAL:ITEM?→{Same result as for MEASURE:HARMONICS?}
```

**MEASURE:NORMAL:ITEM:PRESet**

**Function**
Sets the ON/OFF pattern for all communication outputs of the harmonic analysis function.

**Syntax**
MEASURE:HARMONICS:ITEM:PRESet {VPATTERN|APattern|DPattern|VPATTERN|APattern|DPattern|[ALL|CLEAR]}

**Example**
```
VPATTERN:SYNCronize/VTHD/V/W/CON→WON, others→OFF
APATTERN:SYNCronize/ATHD/A/CON→WON, others→OFF
DPATTERN:SYNCronize/VDEG/ADEG→WON, others→OFF
ALL :all items→ON
CLEAR :all items→OFF
```

**MEASURE:NORMAL:ITEM:SYNChronize**

**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:NORMAL:ITEMS**

**Function**
Sets the communication output item of harmonic analysis ON/OFF, queries the current setting.

**Syntax**
MEASURE:HARMONICS:ITEM:SYNChronize

**Example**
```
HARMONICS:ITEM:SYNChronize
```

**MEASURE:NORMAL: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,
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.

**MEASURE:NORMAL: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,
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.

**MEASURE:NORMAL: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,
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.

**MEASURE:NORMAL: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,
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.

**MEASURE:NORMAL: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,
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.
**MEASURE[:NORMAL]:ITEM?**

**Function**
Queries all settings related to the communication output items of normal measured/computed data.

**Syntax**

```plaintext
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**

```plaintext
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 ∑.

- **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 elapsed time|MATH} ON/OFF, queries about the current setting.

**Syntax**

```plaintext
MEASURE[:NORMAL]:ITEM:{TIME|MATH} {<Boolean>}
```

**Example**

```
MEASURE:NORMAL:ITEM:TIME OFF
```

**MEASURE[:NORMAL]:ITEM:<normal measurement function>?**

**Function**
Queries communication output settings of the normal measurement function.

**Syntax**

```plaintext
MEASURE[:NORMAL]:ITEM:<normal measurement function>?
```

**Example**

```
MEASURE:NORMAL:ITEM:V?
```

**Description**
For the meanings of the symbols of functions, see Note on page App2-11.

**MEASURE[:NORMAL]:ITEM:<normal measurement function>:ELEMent<x>?**

**Function**
Sets the communication output concerning each element ON/OFF, queries the current setting.

**Syntax**

```plaintext
MEASURE[:NORMAL]:ITEM:<normal measurement function>:ELEMent<x> {<Boolean>}
```

**Example**

```
MEASURE:NORMAL:ITEM:V:ELEMENT1 ON
```

**MEASURE[:NORMAL]:ITEM:<normal measurement function>:SIGMa**

**Function**
Sets the communication output concerning ∑ ON/OFF, queries the current setting.

**Syntax**

```plaintext
MEASURE[:NORMAL]:ITEM:<normal measurement function>:SIGMa {<Boolean>}
```

**Example**

```
MEASURE:NORMAL:ITEM:V:SIGMA ON
```

**MEASURE[:NORMAL]:VALUE?**

**Function**
Queries normal measured/computed data set by commands other than "MEASURE[:NORMAL]:ITEM".

**Syntax**

```plaintext
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 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 normal measured/computed data, refer to page App2-24.
- When the harmonic analysis function is ON, harmonic analysis data will be returned.
Appendix 2.3 Commands

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 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 elapsed 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 elapsed
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 → V∑
2. A1 → A2 → A3 → A∑
3. W1 → W2 → W3 → W∑
4. VA1 → VA2 → VA3 → VA∑
5. VAR1 → VAR2 → VAR3 → VAR∑
6. PF1 → PF2 → PF3 → PF∑
7. DEGR1 → DEGR2 → DEGR3 → DEGR∑
8. VHZ1 → VHZ2 → VHZ3 → VHZ∑
9. AHZ1 → AHZ2 → AHZ3 → AHZ∑
10. WH1 → WH2 → WH3 → WH∑
11. WHP1 → WHP2 → WHP3 → WHP∑
12. WHM1 → WHM2 → WHM3 → WHM∑
13. AH1 → AH2 → AH3 → AH∑
14. AHP1 → AHP2 → AHP3 → AHP∑
15. AHM1 → AHM2 → AHM3 → AHM∑
16. TIME (integration elapsed 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 V3:10.03E+00 V∑: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) 
```plaintext
MEASURE:NORMAL:ITEM:PRESET INTEGRATE
MEASURE:NORMAL:VALUE?
```

(Received data) 
```plaintext
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)

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, ADEG: 50(or 30) data
  Phase angle between the 1st 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 the 1st 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>.
Appendix 2.3 Commands

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)
```plaintext
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+00,0.41E+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): 0.00E+00 (%)
- Harmonic relative content (50th order): 0.00E+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
Appendix 2.3 Commands

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: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}`

Example: `RELAY:DISPLAY 1
RELAY:DISPLAY?
→:RELAY:DISPLAY 1
RELAY:DISPLAY?→:RELAY:DISPLAY OFF`

**RELay:HChannel<x>?**

Function: Queries all settings related to relay output items in case of harmonic analysis.

Syntax: `RELay:HChannel<x>?`

Example: `RELAY:HChannel1?→: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`
**Appendix 2.3  Commands**

### 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}\n<harmonic analysis function>({VTHD|V|VCON|ATHD|A|ACON|PF|W|WCON|VDEG|ADEG})\nATHD|A|ACON|PF|W|WCON|VDEG|ADEG\n
**Example**
RELAY:HCHANNEL1:FUNCTION V,1,1\nRELAY:HCHANNEL2:FUNCTION OFF\nRELAY: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: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}\n<normal measurement function>({V|A|W|VAR|VA|VAR|PF|DEGRee|VHZ|AHZ|WH|WHP|WH|VHP|AB|MPH|AR|ABM|MATe|VPR|APR})\n
**Example**
RELAY:NCHANNEL3:FUNCTION W,1\nRELAY:NCHANNEL4: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: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>}\n
**Example**
RELAY:HCHANNEL1:THRESHOLD 600.0E+00\nRELAY:HCHANNEL1:THRESHOLD?\n
**Description**
The mantissa of the setting value is rounded as 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: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>}\n
**Example**
RELAY:NCHANNEL3:THRESHOLD 1.200E+03\nRELAY:NCHANNEL3:THRESHOLD?\n
**Description**
The mantissa of the setting value is rounded as 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}\nRELay:MODE?\n
**Example**
RELAY:MODE DUAL\nRELAY:STATE ON\nRELAY:STATE?\n
**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: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>}\n
**Example**
RELAY:NCHANNEL3:THRESHOLD 20.00E+00\nRELAY:NCHANNEL3:THRESHOLD?\n
**Description**
The mantissa of the setting value is rounded as 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>}\nRELay:STATE?\n
**Example**
RELAY ON\nRELAY:STATE ON\nRELAY:STATE?\n
**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.
Appendix 2.3 Commands

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 the 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>}

**Example** SAMPLE:HOLD ON

SAMPLE:HOLD? → SAMPle:HOLD 1
## Appendix 2.3 Commands

### 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 App2.4 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 App2.4 for details on the extended event register.

### STATus:EESR+ Function
Queries the occurred error code and message.

**Syntax**
```
STATus:EESR?
```

**Example**
```
```

### 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: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? Function
Executes serial polling.

**Syntax**
```
STATus:SPOLL?
```

**Example**
```
STATUS:SPOLL? → STATUS:SPOLL 0
```

**Description**
Only to be used for RS-232-C interface.
Appendix 2.3 Commands

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;INTERVAL 0,0,0`

**STORe:INTerval**
Function Sets the interval for storage/queries the current setting.
Syntax `STORe:INTerval {<NRf>,<NRf>,<NRf>|<String>}`
Example `STORE:INTERVAL 0,0,0` → `STORe:INTERVAL?` → `STORE:INTERVAL 0,0,0`

- 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>}`
Example `STORE:PANEL 1`

**STORe[:STATE]**
Function Sets store ON/OFF, queries the current setting.
Syntax `STORe[:STATE] {<Boolean>}`
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?
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?
Description: • Each bit is expressed as a decimal number.
• It is possible to ascertain the type of event which has occurred, while SRQ is occurring.
• 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?
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?
Appendix 2.3 Commands

**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`
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

<table>
<thead>
<tr>
<th>Name</th>
<th>Function</th>
<th>Writing</th>
<th>Reading</th>
</tr>
</thead>
<tbody>
<tr>
<td>Status byte</td>
<td>—</td>
<td>—</td>
<td>Serial poll (RQS), *STB? (MSS)</td>
</tr>
<tr>
<td>Service request enable register</td>
<td>Masks status byte, *ESR</td>
<td>*ESR?</td>
<td>*ESR?</td>
</tr>
<tr>
<td>Standard event register</td>
<td>Event in the instrument (1)</td>
<td>—</td>
<td>*ESR?</td>
</tr>
<tr>
<td>Standard event enable register</td>
<td>Masks standard event register</td>
<td>*ESR</td>
<td>*ESR?</td>
</tr>
<tr>
<td>Extended event register</td>
<td>Event in the instrument (2)</td>
<td>—</td>
<td>STATUS:ESR?</td>
</tr>
<tr>
<td>Extended event enable register</td>
<td>Masks extended event register</td>
<td>STATUS:EESE</td>
<td>STATUS:EESE?</td>
</tr>
<tr>
<td>Condition register</td>
<td>Current instrument status</td>
<td>—</td>
<td>STATUS:CONDITION?</td>
</tr>
<tr>
<td>Transition filter</td>
<td>Extended event occurrence conditions</td>
<td>STATUS:FILTER</td>
<td>STATUS:FILTER?</td>
</tr>
<tr>
<td>Output queue</td>
<td>Stores response message to a query</td>
<td>All executable queues</td>
<td></td>
</tr>
<tr>
<td>Error queue</td>
<td>Stores error Nos. and messages</td>
<td>—</td>
<td>STATUS:ERROR?</td>
</tr>
</tbody>
</table>

### 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

<table>
<thead>
<tr>
<th>RQS</th>
<th>7</th>
<th>6</th>
<th>ESB</th>
<th>MAV</th>
<th>EES</th>
<th>EAV</th>
<th>1</th>
<th>0</th>
</tr>
</thead>
<tbody>
<tr>
<td>MSS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### 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

<table>
<thead>
<tr>
<th>Bit</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>PON (Power ON)</td>
</tr>
<tr>
<td>6</td>
<td>URQ (User Request)</td>
</tr>
<tr>
<td>5</td>
<td>CME (Command Error)</td>
</tr>
<tr>
<td>4</td>
<td>EXE (Execution Error)</td>
</tr>
<tr>
<td>3</td>
<td>DDE (Device Dependent Error)</td>
</tr>
<tr>
<td>2</td>
<td>QYE (Query Error)</td>
</tr>
<tr>
<td>1</td>
<td>RQC (Request Control)</td>
</tr>
<tr>
<td>0</td>
<td>OPC (Operation Complete)</td>
</tr>
</tbody>
</table>

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.
Appendix 2.4 Status Report

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.

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.

| Condition register | Bit 15 | Bit 14 | Bit 13 | Bit 12 | Bit 11 | Bit 10 | Bit 9  | Bit 8  | Bit 7  | Bit 6  | Bit 5  | Bit 4  | Bit 3  | Bit 2  | Bit 1  | Bit 0  |
|--------------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| :STATus:CONDition?| 15     | 14     | 13     | 12     | 11     | 10     | 9      | 8      | 7      | 6      | 5      | 4      | 3      | 2      | 1      |

| Transition filter | Bit 15 | Bit 14 | Bit 13 | Bit 12 | Bit 11 | Bit 10 | Bit 9  | Bit 8  | Bit 7  | Bit 6  | Bit 5  | Bit 4  | Bit 3  | Bit 2  | Bit 1  | Bit 0  |
|-------------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| :STATus:FILTER<*> | 15     | 14     | 13     | 12     | 11     | 10     | 9      | 8      | 7      | 6      | 5      | 4      | 3      | 2      | 1      |

| Extended event register | Bit 15 | Bit 14 | Bit 13 | Bit 12 | Bit 11 | Bit 10 | Bit 9  | Bit 8  | Bit 7  | Bit 6  | Bit 5  | Bit 4  | Bit 3  | Bit 2  | Bit 1  | Bit 0  |
|-------------------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| :STATus:ESR?            | 15     | 14     | 13     | 12     | 11     | 10     | 9      | 8      | 7      | 6      | 5      | 4      | 3      | 2      | 1      |

The transition filter is applied to each bit of the condition register separately, 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).

The meaning of each bit of the condition register is as follows.

- **Bit 0**: USP (Updating) - Set to “1” during updating of measurement data.
- **Bit 1**: ITG (Integrate busy) - Set to “1” during integration. (See figure below)
- **Bit 2**: OVRS (Σ results overflow) - Set to “1” when the integration results of Σ overflow. (Display shows “oF”)
- **Bit 3**: FOV (Frequency over) - Set to “1” when the frequency lies outside the measurement range. (Display shows “ErrLo” or “FrqEr”)
- **Bit 4**: SRB (Store/Recall busy) - Set to “1” while storing or recalling is in progress.
- **Bit 5**: POA1 (Element 1; current peak over) - Set to “1” when the current value of element 1 exceeds the peak value.
- **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 shows “oF”, “oL”, “PFErr” or “dEGE”)
- **Bit 7**: FOV1 (Element 1; voltage peak over) - Set to “1” when the voltage value of element 1 exceeds the peak value.
- **Bit 8**: POA2 (Element 1; current peak over) - Set to “1” when the current value of element 2 exceeds the peak value.
- **Bit 9**: OVR2 (Element 1; measured data over) - Set to “1” when the measurement/computed data of element 2 overflow, or when an error occurs. (Display shows “oF”, “oL”, “PFErr” or “dEGE”)
- **Bit 10**: POV1 (Element 2; voltage peak over) - Set to “1” when the voltage value of element 2 exceeds the peak value.
- **Bit 11**: POA3 (Element 1; current peak over) - Set to “1” when the current value of element 3 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 shows “oF”, “oL”, “PFErr” or “dEGE”)
- **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.
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 an IBM PC/AT and compatible system with National Instruments AT-GPIB/TN-IEEE-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$, BD%)
IF BD% < 0 THEN GOTO ERRDISP
CALL IBSCI(BD%): GOSUB ERRCHK
DEVICE$ = "WT": CALL IBFIND(DEVICE$, WT%)
IF WT% < 0 THEN GOTO ERRDISP
CALL IBCLR(WT%): GOSUB ERRCHK
V% = 1: CALL IBISET(BD%, V%)
CLS
' Setting measurement conditions
' Hold OFF, Measurement mode = RMS, Filter OFF, Scaling OFF, Averaging OFF
CMD$ = "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$): GOSUB ERRCHK
' Sets display C to VHz1 in order to measure the voltage frequency of element 1
CALL IBWRT(WT%, CMD$): 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:VHZ1: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$(20)
' Reads the measurement data and displays them (10 times)
FOR I = 1 TO 10
CMD$ = "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?": CALL IBWRT(WT%, CMD$): GOSUB ERRCHK
CALL IBWRT(WT%, CMD$): GOSUB ERRCHK
CALL IBWRT(WT%, CMD$): GOSUB ERRCHK
CALL IBWRT(WT%, CMD$): GOSUB ERRCHK
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
' ' 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 2.5 Sample Program

```
'*********************************************************************
'  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
'*********************************************************************

REM $INCLUDE: 'qbdecl4.bas'

N = 53
DIM DS(N)  ' Array DS(53) is prepared for receiving data
BORD$ = "GPIB0": CALL IBFIND(BORD$, BD%)
IF BD% < 0 THEN GOTO ERRDISP
CALL IBSCIC(BD%): GOSUB ERRCHK

DEVICE$ = "WT": CALL IBFIND(DEVICE$, WT%)
IF WT% < 0 THEN GOTO ERRDISP
CALL IBCLR(WT%): GOSUB ERRCHK

V% = 1: CALL IBSLRE(BD%, V1)
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 IBWR(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 IBWR(WT%, CMD$): GOSUB ERRCHK

CMD$ = "MEASURE:HARMONICS:ITEM:SYNCHRONIZE ON;ATHD ON;A ON"
CALL IBWR(WT%, CMD$): GOSUB ERRCHK

' Sets the filter to detect the end of data updating
CMD$ = "STATUS:FILTER1 FALL"
CALL IBWR(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 IBWR(WT%, CMD$): GOSUB ERRCHK

  BUF$ = SPACE$(255)
  CALL IBRD(WT%, BUF$): GOSUB ERRCHK

  ' Waiting until data are finished updating
  CMD$ = "COMMUNICATE:WAIT 1"
  CALL IBWR(WT%, CMD$): GOSUB ERRCHK

  CMD$ = "MEASURE:VALUE?"  ' Requests output of analysis data
  CALL IBWR(WT%, CMD$): GOSUB ERRCHK

  BUF$ = SPACE$(1000)
  CALL IBRD(WT%, BUF$): GOSUB ERRCHK

  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 current

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

' 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 character codes are given below.

<table>
<thead>
<tr>
<th>Command</th>
<th>Address</th>
<th>Universal Command</th>
<th>Listener Address</th>
<th>Talker Address</th>
<th>Secondary Command</th>
</tr>
</thead>
</table>

**Example**

- **Octal**: 25
- **PPU**: NAK
- **GP-IB code**: ASCII character code
- **Hexadecimal**: F

<table>
<thead>
<tr>
<th>Command</th>
<th>Address</th>
<th>Universal Command</th>
<th>Listener Address</th>
<th>Talker Address</th>
<th>Secondary Command</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASCII</td>
<td>NUL</td>
<td>DEL</td>
<td>SP</td>
<td>0</td>
<td>@</td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>

**Example**

- **Octal**: 25
- **PPU**: NAK
- **GP-IB code**: ASCII character code
- **Hexadecimal**: F

<table>
<thead>
<tr>
<th>Command</th>
<th>Address</th>
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<th>Talker Address</th>
<th>Secondary Command</th>
</tr>
</thead>
</table>

**Example**

- **Octal**: 25
- **PPU**: NAK
- **GP-IB code**: ASCII character code
- **Hexadecimal**: F
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 communication commands (100 to 199)

<table>
<thead>
<tr>
<th>Code</th>
<th>Message</th>
<th>Action</th>
<th>Reference Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>102</td>
<td>Syntax error</td>
<td>Incorrect syntax</td>
<td>App. 2.2, App. 2.3</td>
</tr>
<tr>
<td>103</td>
<td>Invalid separator</td>
<td>Insert a comma between data items to separate them.</td>
<td>App2-3</td>
</tr>
<tr>
<td>104</td>
<td>Data type error</td>
<td>Refer to pages App2-6, 2-7 and enter data using the correct data format.</td>
<td>App2-6, App2-7</td>
</tr>
<tr>
<td>105</td>
<td>GET not allowed</td>
<td>GET is not supported as a response to an interface message.</td>
<td>–</td>
</tr>
<tr>
<td>108</td>
<td>Parameter not allowed</td>
<td>Check the number of parameters.</td>
<td>App2-6, App. 2.3</td>
</tr>
<tr>
<td>109</td>
<td>Missing parameter</td>
<td>Enter the required number of parameters.</td>
<td>App2-6, App. 2.3</td>
</tr>
<tr>
<td>111</td>
<td>Header separator error</td>
<td>Insert a space between the header and the data to separate them.</td>
<td>App2-3</td>
</tr>
<tr>
<td>112</td>
<td>Program mnemonic too long</td>
<td>Check the mnemonic (character string consisting of letters and numbers).</td>
<td>App. 2.3</td>
</tr>
<tr>
<td>113</td>
<td>Undefined header</td>
<td>Check the header.</td>
<td>App. 2.3</td>
</tr>
<tr>
<td>114</td>
<td>Header suffix out of range</td>
<td>Check the header.</td>
<td>App. 2.3</td>
</tr>
<tr>
<td>120</td>
<td>Numeric data error</td>
<td>Mantissa must be entered before the numeric value in &lt;NRf&gt; format.</td>
<td>App2-6</td>
</tr>
<tr>
<td>123</td>
<td>Exponent too large</td>
<td>Use a smaller exponent in &lt;NR3&gt; format.</td>
<td>App2-6, App. 2.3</td>
</tr>
<tr>
<td>124</td>
<td>Too many digits</td>
<td>Limit the number of digits to 255 or less.</td>
<td>App2-6, App. 2.3</td>
</tr>
<tr>
<td>128</td>
<td>Numeric data not allowed</td>
<td>Enter in a format other than &lt;NRf&gt; format.</td>
<td>App2-6, App. 2.3</td>
</tr>
<tr>
<td>131</td>
<td>Invalid suffix</td>
<td>Check the units for &lt;Voltage&gt; and &lt;Current&gt;.</td>
<td>App. 2.7</td>
</tr>
<tr>
<td>134</td>
<td>Suffix too long</td>
<td>Check the units for &lt;Voltage&gt; and &lt;Current&gt;.</td>
<td>App. 2.7</td>
</tr>
<tr>
<td>138</td>
<td>Suffix not allowed</td>
<td>No units are allowed other than &lt;Voltage&gt; and &lt;Current&gt;.</td>
<td>App. 2.7</td>
</tr>
<tr>
<td>141</td>
<td>Invalid character data</td>
<td>Enter one of the character strings in {...|...|...}.</td>
<td>App. 2.3</td>
</tr>
<tr>
<td>144</td>
<td>Character data too long</td>
<td>Check the character strings in [...]|...].</td>
<td>App. 2.3</td>
</tr>
<tr>
<td>148</td>
<td>Character data not allowed</td>
<td>Enter in a format other than one of those in [...]|...].</td>
<td>App. 2.3</td>
</tr>
<tr>
<td>150</td>
<td>String data error</td>
<td>&lt;Character string&gt; must be enclosed by double quotation marks or single quotation marks.</td>
<td>App2-7</td>
</tr>
<tr>
<td>151</td>
<td>Invalid string data</td>
<td>&lt;Character string&gt; is too long or contains characters which cannot be used.</td>
<td>App. 2.3</td>
</tr>
<tr>
<td>158</td>
<td>String data not allowed</td>
<td>Enter in a data format other than &lt;Character string&gt;,</td>
<td>App. 2.3</td>
</tr>
<tr>
<td>161</td>
<td>Invalid block data</td>
<td>&lt;Block data&gt; is not allowed.</td>
<td>–</td>
</tr>
<tr>
<td>168</td>
<td>Block data not allowed</td>
<td>&lt;Block data&gt; is not allowed.</td>
<td>–</td>
</tr>
<tr>
<td>171</td>
<td>Invalid expression</td>
<td>Equation is not allowed.</td>
<td>App. 2.3</td>
</tr>
<tr>
<td>178</td>
<td>Expression data not allowed</td>
<td>Equation is not allowed.</td>
<td>App. 2.3</td>
</tr>
<tr>
<td>181</td>
<td>Invalid outside macro definition</td>
<td>Does not conform to the macro definition specified in IEEE488.2.</td>
<td>–</td>
</tr>
</tbody>
</table>
### Appendix 2.7 Communication-related Error Messages

#### Errors in communications execution (200 to 299)

<table>
<thead>
<tr>
<th>Code</th>
<th>Message</th>
<th>Action</th>
<th>Reference Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>221</td>
<td>Setting conflict</td>
<td>Check the relevant setting.</td>
<td>App.2.3</td>
</tr>
<tr>
<td>222</td>
<td>Data out of range</td>
<td>Check the setting range.</td>
<td>App.2.3</td>
</tr>
<tr>
<td>223</td>
<td>Too much data</td>
<td>Check the data byte length.</td>
<td>App.2.3</td>
</tr>
<tr>
<td>224</td>
<td>Illegal parameter value</td>
<td>Check the setting range.</td>
<td>App.2.3</td>
</tr>
<tr>
<td>241</td>
<td>Hardware missing</td>
<td>Check availability of options.</td>
<td>—</td>
</tr>
<tr>
<td>260</td>
<td>Expression error</td>
<td>Equation is not allowed.</td>
<td>—</td>
</tr>
<tr>
<td>270</td>
<td>Macro error</td>
<td>Does not conform to the macro definition specified in IEEE488.2.</td>
<td>—</td>
</tr>
<tr>
<td>272</td>
<td>Macro execution error</td>
<td>Does not conform to the macro definition specified in IEEE488.2.</td>
<td>—</td>
</tr>
<tr>
<td>273</td>
<td>Illegal macro label</td>
<td>Does not conform to the macro definition specified in IEEE488.2.</td>
<td>—</td>
</tr>
<tr>
<td>275</td>
<td>Macro definition too long</td>
<td>Does not conform to the macro definition specified in IEEE488.2.</td>
<td>—</td>
</tr>
<tr>
<td>276</td>
<td>Macro recursion error</td>
<td>Does not conform to the macro function specified in IEEE488.2.</td>
<td>—</td>
</tr>
<tr>
<td>277</td>
<td>Macro redefinition not allowed</td>
<td>Does not conform to the macro definition specified in IEEE488.2.</td>
<td>—</td>
</tr>
<tr>
<td>278</td>
<td>Macro header not found</td>
<td>Does not conform to the macro definition specified in IEEE488.2.</td>
<td>—</td>
</tr>
</tbody>
</table>

#### Error in communication Query (400 to 499)

<table>
<thead>
<tr>
<th>Code</th>
<th>Message</th>
<th>Action</th>
<th>Reference Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>410</td>
<td>Query INTERRUPTED</td>
<td>Check transmission/reception order.</td>
<td>App2-3</td>
</tr>
<tr>
<td>420</td>
<td>Query UNTERMINATED</td>
<td>Check transmission/reception order.</td>
<td>App2-3</td>
</tr>
<tr>
<td>430</td>
<td>Query DEADLOCKED</td>
<td>Limit the length of the program message including &lt;PMT&gt; to 1024 bytes or less.</td>
<td>App2-4</td>
</tr>
<tr>
<td>440</td>
<td>Query UNTERMINATED after indefinite response</td>
<td>Do not enter any query after *IDN? and *OPT?.</td>
<td>—</td>
</tr>
</tbody>
</table>

#### Errors in Execution (800 to 899)

<table>
<thead>
<tr>
<th>Codes</th>
<th>Message</th>
<th>Action</th>
<th>Reference Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>813 to 819</td>
<td>Invalid operation</td>
<td>Refer to 14.4</td>
<td>14-11</td>
</tr>
<tr>
<td>830 to 833</td>
<td>Internal memory access error</td>
<td>Refer to 14.4</td>
<td>14-11</td>
</tr>
<tr>
<td>841 to 847</td>
<td>Integrator execute error</td>
<td>Refer to 14.4</td>
<td>14-11</td>
</tr>
</tbody>
</table>

#### Error in System Operation (912)

<table>
<thead>
<tr>
<th>Code</th>
<th>Message</th>
<th>Action</th>
<th>Reference Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>912</td>
<td>Fatal error in Communication driver</td>
<td>Service is required.</td>
<td>—</td>
</tr>
</tbody>
</table>

#### Warnings (350, 390)

<table>
<thead>
<tr>
<th>Codes</th>
<th>Message</th>
<th>Action</th>
<th>Reference Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>350</td>
<td>Queue overflow</td>
<td>Read out the queue.</td>
<td>App2-39</td>
</tr>
<tr>
<td>390</td>
<td>Overrun error</td>
<td>Adjust the baud rate.</td>
<td>—</td>
</tr>
</tbody>
</table>

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.
Index

Symbols

<Boolean> ................................................................. App2-6
<ESC> ............................................................................. 12-7
<PMT> ................................................................................. App2-2
<RMT> ................................................................................. App2-3
488.2 mode (GP-IB) .................................................. 11-1
488.2 mode (RS-232-C) ........................................... 12-1
7-segment LED .......................................................... 7

A
A/D converter .............................................................. 1-1
accessories ........................................................................ 3
active power display ..................................................... 5-1
active power integration ............................................. 7-1
address setting ............................................................. 11-9
addressable mode ....................................................... 11-1
adjustment ........................................................................ 14-1
aliasing ........................................................................... 8-2
ampere hour ................................................................. 7-1
apparant power display ............................................... 6-1
ASCII character code .................................................. App2-42
attenuation constant .................................................... 4-11
auto range ...................................................................... 4-4
averaging function ....................................................... 4-11
averaging function (harmonic analysis) ....................... 8-2
averaging sample number ............................................. 4-11

B
back-up of set-up parameters ..................................... 13-1
backup (integration) ..................................................... 7-8
baud rate ........................................................................ 12-6
block diagram ............................................................. 1-1
BNF notation (Backus-Naur Form) ................................ App2-2
boolean ........................................................................... App2-6

calibration ...................................................................... 14-4
clamp filter ...................................................................... 3
command (RS-232-C) ................................................ 12-7
communication command (IEEE488.2-1987) .......... App2-8
communication commands (before IEEE488.2-1987) . App1-1
communication commands (model 2533) .................. App1-15
communication function ............................................. 1-4
comparator display ...................................................... 10-15
comparator function .................................................. 1-3, 10-7
comparator function ON .............................................. 10-16
comparator mode ....................................................... 10-7
computation method of harmonic distortion ............ 8-4
computation over display .......................................... 2-4
computation over display (harmonics analysis) ....... 8-2
computing function ...................................................... 1-2
condition register ....................................................... App2-36, App2-38
connector (RS-232-C) ................................................. 12-2
connector’s pin sequence ....................................... 10-1
contact relay output ................................................. 10-7

content .............................................................................. 8
continuous integration mode ....................................... 7-2
continuous maximum allowable input ...................... 5-2
controlling ................................................................. 10-2
corrective action ....................................................... 14-11
CPU .............................................................................. 1-1
crest factor ................................................................. 1-3, 4-15, 5-4
CT .................................................................................. 4-7
current display ............................................................ 5-1
current frequency display ......................................... 5-3
current integration ..................................................... 7-1
current integration method ........................................ 7-2
current transformer .................................................. 4-7

d
D/A output ................................................................. 10-4
D/A output function .................................................... 1-3
D/A output voltage ..................................................... 10-6
data format (RS-232-C) ............................................. 12-6
DC .................................................................................. 4-1
dCL (device clear) ......................................................... App2-3
digital character ......................................................... 1-5
digital numbers .......................................................... 1-5
digital printer ............................................................... 3
display ............................................................................ 2-2, 2-4
display function ........................................................ 1-2
display resolution for integrated values ................... 7-3
displayed character ................................................... 7
dot display (harmonic analysis) ................................. 8-2
dSP .................................................................................. 1-1
dual mode ................................................................. 10-8

e
effect of aliasing ............................................................ 8-2
ero error code ............................................................... 14-11
ero error display (harmonics analysis) .................... 8-2
ero error message (communication) ....................... App2-43
ero error queue .......................................................... App2-36, App2-39
ESC .............................................................................. 12-7
example of an operating procedure ....................... 7
exponential averaging ............................................... 4-11
extended event enable register ................................ App2-36
extended event register ............................................ App2-36, App2-38
external connection ................................................... 5
external dimensions .................................................. 15-4
external sensor scaling value ................................... 4-9

f
ferrite core ................................................................. 3
filter .............................................................................. 4-3
foreword ......................................................................... 1
frequency measurement function ....................... 1-2
front panel ................................................................. 2-1
function ...................................................................... 1-2
fuse ............................................................................... 5
fuse rating ................................................................. 14-13
**Index**

**G**

- GET (group execute trigger) .................................................. 11-2
- GP-IB interface ........................................................................ 11-1
- GP-IB interface specifications .................................................. 11-1
- GTL (go to local) ...................................................................... 11-2

**H**

- handshaking ........................................................................... 12-5
- harmonic analysis function ....................................................... 1-3
- harmonic component .................................................................. 8-1
- harmonic distortion ................................................................... 8-4
- harmonics analysis function ...................................................... 8-1
- harmonics order ........................................................................ 8-6
- header interpretation rule .......................................................... App2-4

**I**

- IEEE 488.2-1987 ................................................................. App2-1
- IFC (interface clear) ............................................................... 11-2
- initial menu ............................................................................. 1-5
- initializing set-up parameters .................................................. 13-2
- input circuit ............................................................................. 1-1
- input function .......................................................................... 1-2
- instrument number .................................................................. 2
- integrated value display ......................................................... 7-5
- integration elapsed time .......................................................... 7-1
- integration hold ........................................................................ 7-7
- integration method ................................................................. 7-2
- integration mode ...................................................................... 7-1
- integration preset time ............................................................ 10-5
- integration reset ...................................................................... 7-7
- integration timer ...................................................................... 7-4
- integrator function ................................................................... 1-3, 7-1
- interruption during measurement ............................................. 2-4
- interval (talk-only mode) .......................................................... 12-6

**L**

- LLO (local lockout) ................................................................. 11-2

**M**

- malfunctioning ........................................................................ 14-10
- manual integration mode ......................................................... 7-1
- manual range .......................................................................... 4-4
- maximum allowable input ....................................................... 5-2
- measurement mode .................................................................. 4-1
- measurement range ................................................................. 4-4
- messages ................................................................................ App2-2
- mnemonic ............................................................................... App2-4
- model ...................................................................................... 2
- moving averaging .................................................................... 4-11

**N**

- NC (normally closed) ............................................................ 10-7
- NO (normally open) .............................................................. 10-7
- normal mode .......................................................................... 12-1
- notes ...................................................................................... 1

**O**

- operating restriction (integration) ............................................ 7-8
- option ................................................................................... 2
- optional equipment ............................................................... 3
- output (printing) mode ........................................................... 10-18
- output format (D/A output) .................................................... 10-4
- output format (error code) ..................................................... 11-8
- output format (harmonic analysis data) ................................ 11-7, App2-25
- output format (model 2533) .................................................. App1-16
- output format (normal measured/computed data) .............. 11-4, App2-24
- output format (set-up parameter) .......................................... 11-8
- output function ...................................................................... 1-4
- output queue .......................................................................... App2-36, App2-39
- overlap command .................................................................. App2-7
- overrange display ................................................................... 2-4
- overview of IEEE 488.2-1987 ................................................ App2-1

**P**

- package ................................................................................. 2
- peak over display ................................................................... 2-4
- phase angle display .............................................................. 6-2
- phase lag ............................................................................... 6-2
- phase lead ............................................................................. 6-2
- phase locked loop ................................................................... 8-4
- pin assignment ...................................................................... 10-1
- PLL source ............................................................................ 8-4
- PMT ..................................................................................... App2-2
- potential transformer ............................................................ 4-7
- power cord ............................................................................ 2-5
- power display ......................................................................... 5-1
- power factor ......................................................................... 4-7
- power factor display ............................................................. 6-1
- power integration method ...................................................... 7-2
- power range .......................................................................... 4-5
- power supply ......................................................................... 5
- preset time for integration ..................................................... 7-1
- print mode (GP-IB) ............................................................... 11-1
- print mode (RS-232-C) ......................................................... 12-1
- printing mode ......................................................................... 10-18
- program format (IEEE488.2-1987) ....................................... App2-2
- program messages .............................................................. App2-2
- protective grounding ............................................................ 5
- PT ......................................................................................... 4-7
<table>
<thead>
<tr>
<th>Index</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>R</td>
<td></td>
</tr>
<tr>
<td>range</td>
<td>4-4</td>
</tr>
<tr>
<td>rated integration time</td>
<td>10-5</td>
</tr>
<tr>
<td>reactive power display</td>
<td>6-1</td>
</tr>
<tr>
<td>rear panel</td>
<td>2-1</td>
</tr>
<tr>
<td>recalling</td>
<td>1-3</td>
</tr>
<tr>
<td>recalling interval</td>
<td>9-3</td>
</tr>
<tr>
<td>recalling measured data</td>
<td>9-3</td>
</tr>
<tr>
<td>recalling set-up parameters</td>
<td>9-5</td>
</tr>
<tr>
<td>relay output</td>
<td>10-7</td>
</tr>
<tr>
<td>relay specifications</td>
<td>10-7</td>
</tr>
<tr>
<td>relay status</td>
<td>10-8</td>
</tr>
<tr>
<td>remote control</td>
<td>10-2</td>
</tr>
<tr>
<td>remote control function</td>
<td>1-4</td>
</tr>
<tr>
<td>REN (remote enable)</td>
<td>11-2</td>
</tr>
<tr>
<td>repeat integration</td>
<td>7-2</td>
</tr>
<tr>
<td>replacing the fuse (only for WT130)</td>
<td>14-13</td>
</tr>
<tr>
<td>response messages</td>
<td>App2-3</td>
</tr>
<tr>
<td>responses to interface messages</td>
<td>11-2</td>
</tr>
<tr>
<td>RMS</td>
<td>4-1</td>
</tr>
<tr>
<td>RMT</td>
<td>App2-3</td>
</tr>
<tr>
<td>RS-232-C interface</td>
<td>12-1</td>
</tr>
<tr>
<td>RS-232-C interface specifications</td>
<td>12-1</td>
</tr>
<tr>
<td>rubber feed</td>
<td>3</td>
</tr>
<tr>
<td>S</td>
<td></td>
</tr>
<tr>
<td>safety precaution</td>
<td>4</td>
</tr>
<tr>
<td>sample number</td>
<td>4-11</td>
</tr>
<tr>
<td>sample program (before IEEE488.2-1987)</td>
<td>App1-10</td>
</tr>
<tr>
<td>sample program (IEEE488.2-1987)</td>
<td>App2-40</td>
</tr>
<tr>
<td>scaling function</td>
<td>4-7</td>
</tr>
<tr>
<td>scaling function with external sens</td>
<td>4-9</td>
</tr>
<tr>
<td>scaling value</td>
<td>4-7</td>
</tr>
<tr>
<td>SDC (selective device clear)</td>
<td>11-2</td>
</tr>
<tr>
<td>sequential command</td>
<td>App2-7</td>
</tr>
<tr>
<td>service request enable register</td>
<td>App2-36</td>
</tr>
<tr>
<td>setting the comparator limit values</td>
<td>10-12</td>
</tr>
<tr>
<td>setting the comparator mode</td>
<td>10-9</td>
</tr>
<tr>
<td>signal direction</td>
<td>12-2</td>
</tr>
<tr>
<td>signal names (RS-232-C)</td>
<td>12-2</td>
</tr>
<tr>
<td>single mode</td>
<td>10-7</td>
</tr>
<tr>
<td>specifications</td>
<td>15-1</td>
</tr>
<tr>
<td>SRQ</td>
<td>11-3</td>
</tr>
<tr>
<td>standard accessories</td>
<td>3</td>
</tr>
<tr>
<td>standard event enable register</td>
<td>App2-36, App2-37</td>
</tr>
<tr>
<td>standard event register</td>
<td>App2-36, App2-37</td>
</tr>
<tr>
<td>standard integration mode</td>
<td>7-1</td>
</tr>
<tr>
<td>starting of the harmonic analysis</td>
<td>8-5</td>
</tr>
<tr>
<td>status byte</td>
<td>App2-36</td>
</tr>
<tr>
<td>status byte format (before IEEE 488.2-1987)</td>
<td>11-3</td>
</tr>
<tr>
<td>status report</td>
<td>App2-35</td>
</tr>
<tr>
<td>storage</td>
<td>1-3</td>
</tr>
<tr>
<td>storage interval</td>
<td>9-2</td>
</tr>
<tr>
<td>storing measurement data</td>
<td>9-2</td>
</tr>
<tr>
<td>storing set-up parameters</td>
<td>9-5</td>
</tr>
<tr>
<td>suffix code</td>
<td>2</td>
</tr>
<tr>
<td>switching (remote and local mode)</td>
<td>11-2</td>
</tr>
<tr>
<td>symbol mark</td>
<td>4-7</td>
</tr>
<tr>
<td>system configuration</td>
<td>1-1</td>
</tr>
<tr>
<td>T</td>
<td></td>
</tr>
<tr>
<td>talk-only function</td>
<td>11-9</td>
</tr>
<tr>
<td>talk-only mode (GP-IB)</td>
<td>11-1</td>
</tr>
<tr>
<td>talk-only mode (RS-232-C)</td>
<td>12-1</td>
</tr>
<tr>
<td>terminator</td>
<td>11-9</td>
</tr>
<tr>
<td>top view</td>
<td>App2-3, App2-38</td>
</tr>
<tr>
<td>turning the comparator function ON</td>
<td>10-16</td>
</tr>
<tr>
<td>V</td>
<td></td>
</tr>
<tr>
<td>V MEAN</td>
<td>4-1</td>
</tr>
<tr>
<td>verifying the range</td>
<td>4-5</td>
</tr>
<tr>
<td>voltage display</td>
<td>5-1</td>
</tr>
<tr>
<td>voltage frequency display</td>
<td>5-3</td>
</tr>
<tr>
<td>W</td>
<td></td>
</tr>
<tr>
<td>watt hour</td>
<td>7-1</td>
</tr>
<tr>
<td>waveform type</td>
<td>4-2</td>
</tr>
</tbody>
</table>