HIOKI

INSTRUCTION MANUAL

9605-01

HARMONIC MEASUREMENTS UNIT

HIOKI E. E. CORPORATION

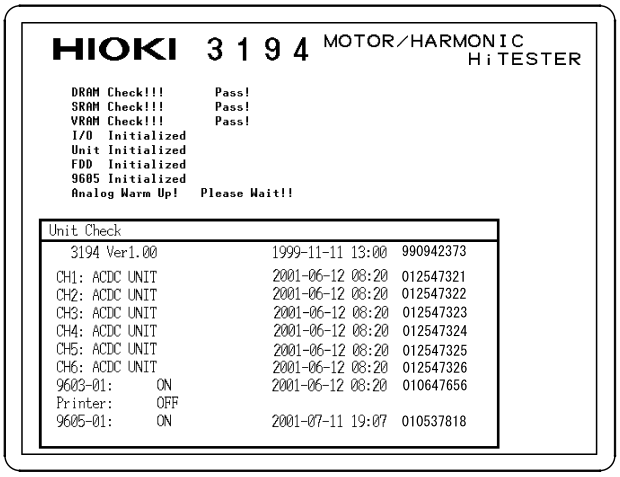
Contents

Introduction

Thank you for purchasing the HIOKI "9605-01 HARMONIC MEASUREMENTS UNIT." To obtain maximum performance from the product, please read this manual first, and keep it handy for future reference.

NOTE

- The 3194 must be upgraded to support the 9605-01.
- This product is designed for installation in the 3194 MOTOR/HARMONIC HiTESTER to enable harmonic analysis. For details on operation of the 3194, please refer to its instruction manual.
- This product is a factory-fitted option. When the 3194 product is powered on, you can check the installation on the screen. (Same as the 9605.)
- For operating environment, maintenance, and disposal at end of life, the same conditions apply as to the main 3194 product.
- Because of differences in measurement principle, frequency response, and accuracy, the values measured by the 9605-01 (effective voltage value, effective current value, active power, and phase difference) may not agree with values measured by 9600/9601/9602 products installed in the same 3194 product.
- The 9605-01 does not save analysis data if there is a power failure. All data values from before the power failure are treated as zero.
- The D/A output is not possible for the analyzed data by the 9605-01.



Before use Before using the product, inspect it and check the operation to make sure that the product was not damaged due to poor storage or transport conditions. If damage is found, contact your dealer or HIOKI representative.

Safety Notes

DANGER

This product is designed to conform to IEC 61010 Safety Standards, and has been thoroughly tested for safety prior to shipment. However, mishandling during use could result in injury or death, as well as damage to the product. Be certain that you understand the instructions and precautions in the manual before use. We disclaim any responsibility for accidents or injuries not resulting directly from product defects.

This Instruction Manual provides information and warnings essential for operating this equipment in a safe manner and for maintaining it in safe operating condition. Before using this equipment, be sure to carefully read the following safety notes.
Read the Instruction Manual supplied with the 3194 product very carefully, and follow the indications given under "DANGER," "WARNING," "CAUTION," and "NOTE."

Safety Symbols

- This symbol is affixed to locations on the equipment where the operator should consult corresponding topics in this manual (which are also marked with the ⚠ symbol) before using relevant functions of the equipment.
- In the manual, this mark indicates explanations which it is particularly important that the user read before using the equipment.

The following symbols are used in this Instruction Manual to indicate the relative importance of cautions and warnings.

DANGER	Indicates that incorrect operation presents extreme danger of accident resulting in death or serious injury to the user.
WARNING	Indicates that incorrect operation presents significant danger of accident resulting in death or serious injury to the user.
⚠ CAUTION	Indicates that incorrect operation presents possibility of injury to the user or damage to the equipment.
NOTE	Denotes items of advice related to performance of the equipment or to its correct operation.

Chapter 1
Overview and Features

1.1 Product Overview

Installing the 9605-01 HARMONIC MEASUREMENTS UNIT in a 3194 MOTOR/HARMONIC HiTESTER enables voltage, current, and power harmonic analysis to be carried out on the voltage and current waveforms captured by an input unit, for single phase to three-phase four-wire lines. It also provides list, a range of display options, including graph and vector displays.

1.2 Features

Installing the 9605-01 HARMONIC MEASUREMENTS UNIT in a 3194 MOTOR/HARMONIC HiTESTER adds the following functions to the basic functions of the 3194.

(1) Support for range of power lines

Harmonic analysis of voltage, current, and power can be carried out on lines from single phase to three-phase four-wire. If the frequencies are the same, up to three single phase lines can be analyzed simultaneously.
(On screen; however, the amount of data displayed on one page is limited to 50 records)

(2) A maximum of 3000th of analysis

A maximum of 3000th of high frequency analysis on basic frequency is possible. Analysis of the secondary inverter including carrier frequency can also be done.

(3) High frequency analysis using external synchronization signals

High frequency analysis using external synchronization signals as the base standard is possible. For this reason, measurement of the phase change amount against the base standard signals can also be done.

(4) Range of display options

The amplitude value, proportions, phase angle, and distortion of each harmonic for voltage, current, and power can be found. The analysis results can be displayed in a list, as a bar graph, or as a vector display.

(5) Floppy disk support

The analysis data can be saved to the floppy disk drive in the 3194, and a periodic automatic save function is also available.

(6) Built-in printer (option)

This can be used to print required data, and for periodic automatic printing. There is also a screen copy function.

NOTE The IEC61000-3-2 analysis method is not supported.

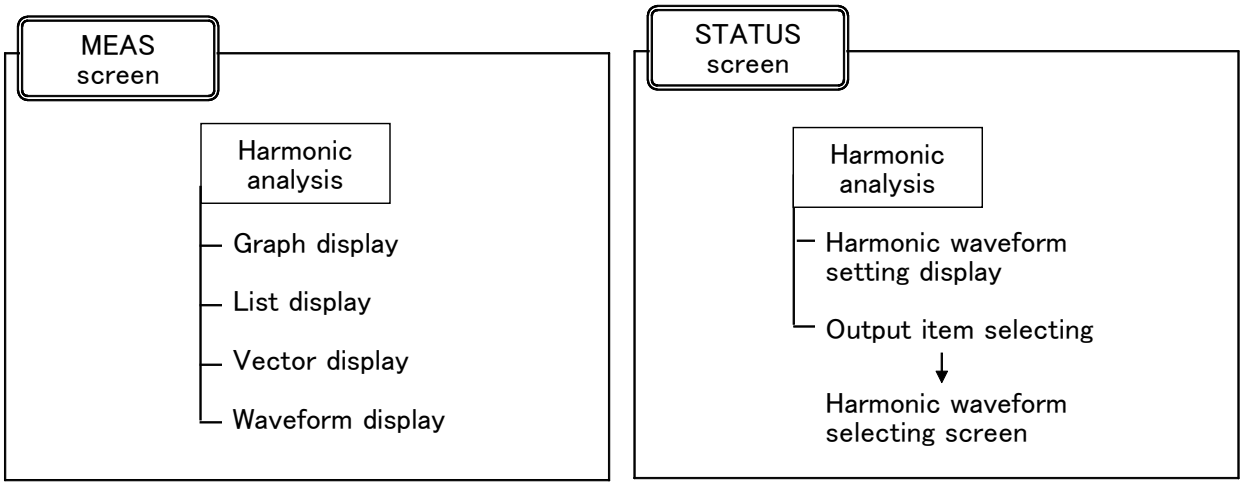
Chapter 2
Key Operations and the Screen Configuration

2.1 Key Operations

For details on how to operate keys of the 3194, refer to Chapter 2 "Name and Functions of Parts" in the instruction manual of the 3194.

2.2 Screen Configuration

When the 9605-01 HARMONIC MEASUREMENTS UNIT is installed in the 3194, the following screen is added to the 3194 functionality.
Refer to Section 2.3.1, "Screen Configuration" in the instruction manual of the 3194.



NOTE

- In the Selection screen, the distortion (THD-R, THD-F) produced by 9605-01 analysis can be displayed, but not other data.
- No waveform and graph colors change is possible.

Chapter 3
Setting the Basic Functions

This chapter describes the function settings when using the 9605-01.
For other functions, refer to the Instruction Manual supplied with the 3194 product.

NOTE

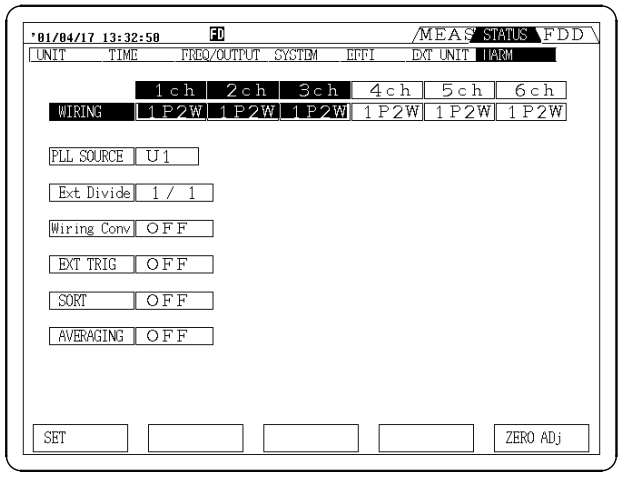
The following settings have no effect on harmonic analysis.
Selecting RMS/MEAN value, setting the phase polarity discrimination filter, switching the waveform peak value, setting the response, setting the equation for reactive power/apparent power, and setting the indications for out-of range inputs

3.1 Setting the Wiring Mode (1P2W to 3P4W)

Set the wiring mode of the 3194.
For details, refer to Section 4.1, "Setting the Wiring Mode" in the instruction manual of the 3194.

3.2 Analysis Channel Selection

You can select three input unit channels for harmonic analysis from the input units (maximum three channels) in the 3194. If the frequencies are the same, analysis on three single-phase channels is possible.



1. Press the **STATUS** key, then use the **PAGE** keys to move the cursor to "HARM," to display the harmonic measurement setting screen. This displays the selected wiring mode.
2. Use the **CURSOR** keys to select the "WIRING" item.
3. Move the cursor to the channel to be analyzed with the **CURSOR** keys, then press the **F1** "SET" key to complete the setting.

NOTE

- The channel selection is always of adjacent input units, corresponding to the wiring modes set on the 3194 product. If the 3194 product wiring mode is set to 3P3W for each of channels 1 and 2 and channels 3 and 4, then the selection becomes channels 1, 2, and 3. In this case, the third channel is treated as single phase for analysis.
- Up to three channels can be selected; a single-channel analysis specification is not possible.

Wiring mode and selected channels

	1ch	2ch	3ch	4ch	5ch	6ch	Using channels
①	1P2W	1P2W	1P2W	1P2W	1P2W	1P2W	1+2+3, 2+3+4, 3+4+5, 4+5+6
②	1P3W/3P3W		1P2W	1P2W	1P2W	1P2W	12+3, 3+4+5, 4+5+6
③	1P3W/3P3W		1P3W/3P3W		1P2W	1P2W	12+3, 34+5, 4+5+6
④	1P3W/3P3W		1P3W/3P3W		1P3W/3P3W		12+3, 34+5, 56
⑤	3V3A/3P4W			1P2W	1P2W	1P2W	123, 4+5+6
⑥	3V3A/3P4W			1P3W/3P3W		1P2W	123, 45+6
⑦	3V3A/3P4W			3V3A/3P4W			123, 456

3.3 PLL Source Setting

A PLL source is required for analysis, and may be provided in one of the following three ways.

(1) Input voltage or current serves as the source:

Waveforms are sampled at a frequency synchronized with the measured voltage or current waveform to facilitate correct measurement.

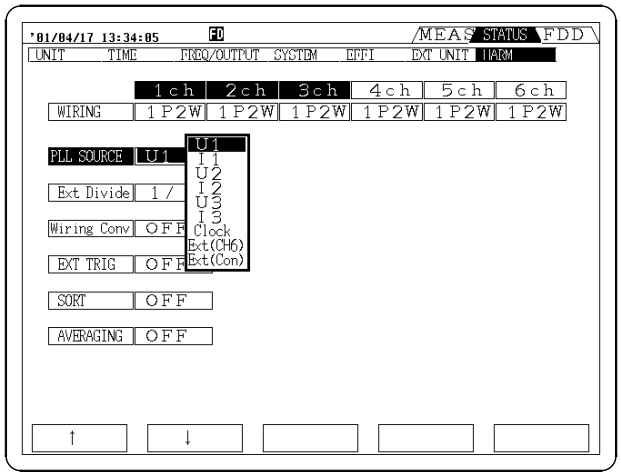
(2) Internal fixed clock [Clock] frequency serves as the source:

Use this options when the input signal is not suitable as a source of PLL synchronization, and the fundamental frequency of the signal for analysis is 50 Hz. In this case, measurement accuracy cannot be assured at frequencies other than integer multiples of 50 Hz.

(3) An external sync signal [Ext(CH6) or Ext(Con)] serves as the source:

PLL-synchronized measurements for harmonic analysis can be made using an external signal other than the input voltage or current waveform. Refer to Section 4.7, "Measurement using an External Sync Signal."

The PLL indicator at the upper right of the screen appears when the PLL is unlocked, and is not visible when the PLL is locked. The source setting for frequency measurement shares the same indicator.



1. Press the STATUS key, then use the PAGE keys to move the cursor to "HARM," to display the harmonic measurement setting screen.
2. Moving the cursor to "PLL SOURCE" with the CURSOR keys displays the settings available for the PLL source in a window.
3. Use the F1 ″↓″ and F2 ″↑″ key to specify the required item.

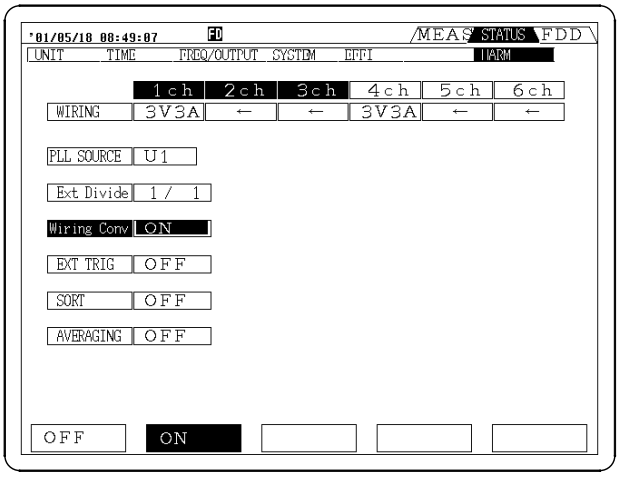
NOTE

- If the signal selected for the source setting is very distorted, if the level is low for the range setting, or the signal frequency is not stable, the PLL circuit may not function. In such cases accurate analysis is not possible.
- If the three channels selected in Section 3.2 are separate systems with different signal frequencies, the analysis results are only valid for the channel for which the PLL source is set.

3.4 Wiring Conversion Function

This function calculates equivalencies for 3V3A and 3P4W wiring (refer to Appendices 6 and 7).

- For 3V3A wiring, calculates Δ-Y conversion to 3ϕ4W equivalent wiring.
- For 3P4W wiring, calculates Y-Δ conversion to 3ϕ3W equivalent wiring.



Press the **STATUS** key, then use the **PAGE** keys to move the cursor to "HARM," to display the harmonic measurement setting screen.

NOTE

- Δ-Y conversion calculation uses a virtual neutral point.
- High-harmonic analysis can begin after waveforms have been converted.

3.5 Setting the Coupling Mode

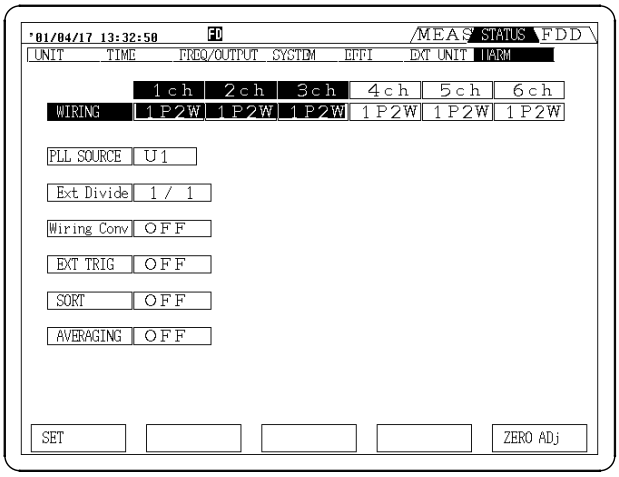
For the channel of which the analysis results are shown on the screen only, press the SHIFT key then use the CURSOR ◀ key to switch.
It is also possible to change the setting in the STATUS/Units screen.
Refer to Section 4.2, "Setting the Coupling Mode" in the instruction manual of the 3194.

NOTE

- When AC mode (coupling mode) is selected on the 3194 product, a DC blocking filter is required on the input unit. Therefore, if the measurement frequency is 10 Hz or below, or the waveform has a superimposed DC component (e.g. a half-wave rectified signal), errors may become large.
- Analysis results in the DC mode and analysis results in the AC+DC mode are the same.
- When the AC+DC or DC mode is selected, a value is shown with a harmonic index of "0." This shows the DC component included in the analysis data. However, the polarity is not displayed for the voltage and current since the effective value is converted.

3.6 Zero Adjustment Operation

Zero adjustment must be carried out after warming up.



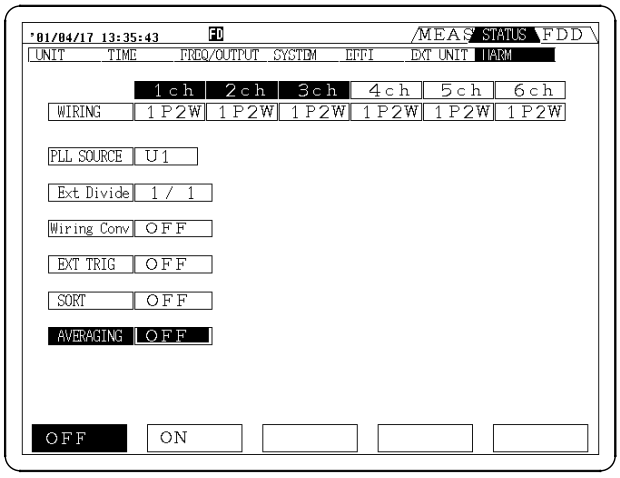
1. Press the **STATUS** key, then use the **PAGE** keys to move the cursor to "HARM," to display the harmonic measurement setting screen.
2. Move the cursor to "WIRING."
3. Press the **F5** "ZERO ADj" key to start zero adjustment.

NOTE

- The operation is carried out for 3 channels simultaneously.
- The operation takes about 3 seconds.
- Carry out the operation with no inputs on either voltage or current.
- Carry out the operation after degaussing (DMAG) when using the 9600 or 9602.

3.7 Averaging Setting

Analysis data is averaged in the 9605-01.

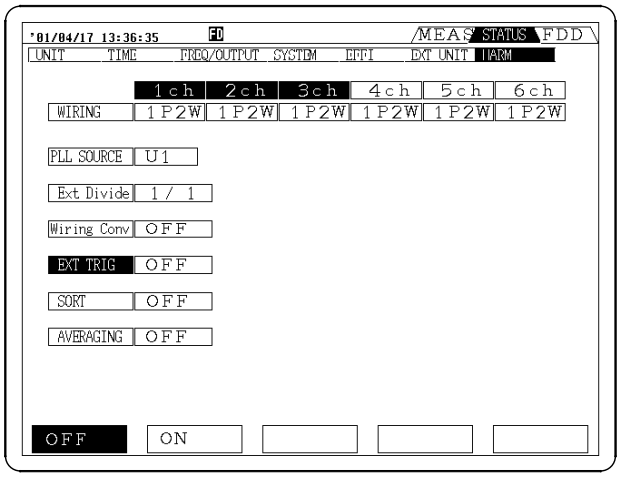


1. Press the **STATUS** key, then use the **PAGE** keys to move the cursor to "HARM," to display the harmonic measurement setting screen.
2. Move the cursor to "AVERAGE"
3. Select the item (amplitude or phase angle) to be averaged.

NOTE Data other that required on the 9605-01 is not affected.

3.8 Measurement by External Trigger

By setting an external trigger, analysis can be started when the trigger signal is input. One window of analysis data is displayed, then the process stops. By synchronizing the timing with an external device, a number of 3194 products can perform analysis simultaneously.



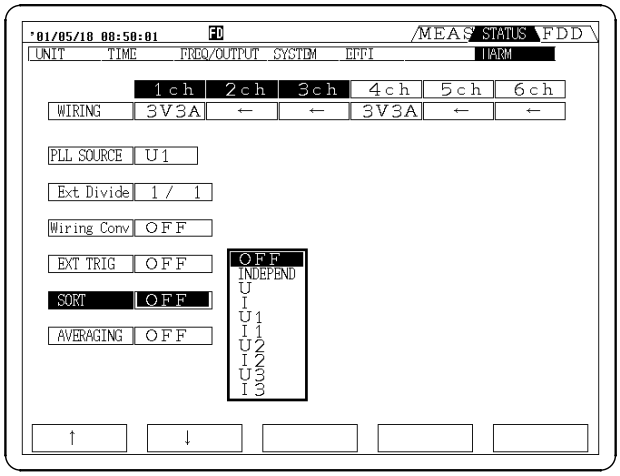
1. Press the **STATUS** key, then use the **PAGE** keys to move the cursor to "HARM," to display the harmonic measurement setting screen.
2. Use the **CURSOR** keys to select the "EXT TRIG" item.
3. Press the **F2** "ON" key, putting the product on hold for a trigger.
   When a trigger signal is input from the outside, analysis starts.

NOTE

- The analysis always starts from a point at which the PLL source waveform crosses the zero value, and there is therefore a delay of a maximum of one cycle of the waveform with respect to the trigger signal.
- This does not affect data on the 3194 product (other than the 9605-01).
- The PLL should be locked.

3.9 Sort Functions

All analyzed degrees are sorted by size from the largest, up to the 50th harmonic order. The following sort methods are available:



(1) Independ

All measurements are sorted independently. However, the P of each channel is set to the degree of the P_{sum} value.

(2) According to U

U values are sorted by channel, and I and P values are sorted by the respective degree for the respective channel, independently of P_{sum} values.

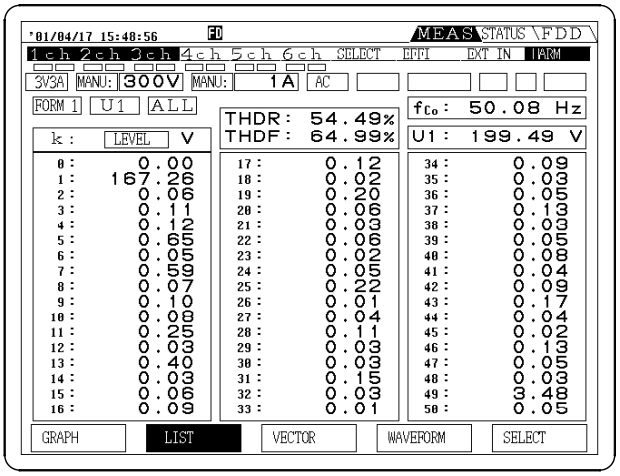
(3) According to I

U values are sorted by channel, and U and P values are sorted by the respective degree for the respective channel, independently of P_{sum} values.

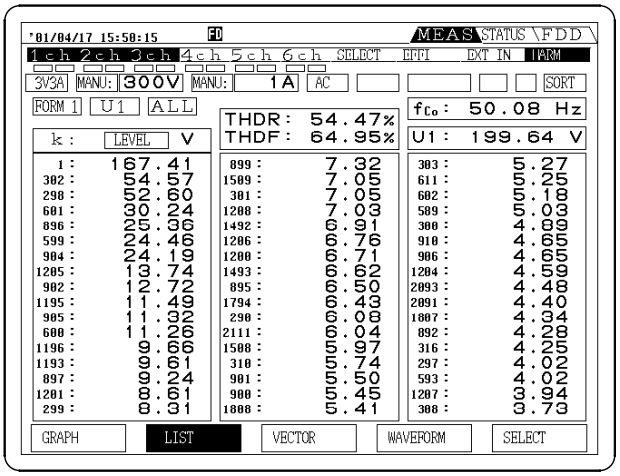
(4) According to U1/I1, U2/I2, U3/I3

Measurements are sorted by the specified parameter, and other parameters are sorted for the respective degree.

Unsorted



Sorted



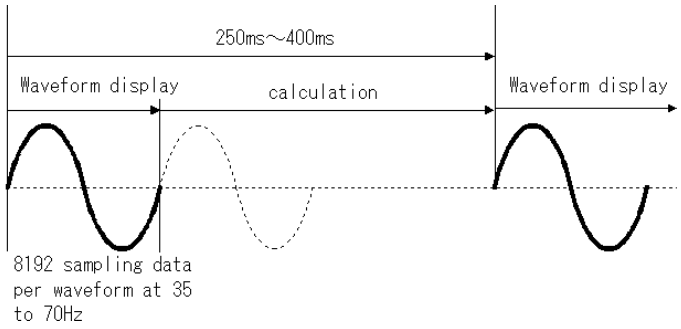
NOTE The graph, list and vector displays are by harmonic order rather than by degree. Therefore, in the vector display case, multiple degrees can be displayed on the same screen.

Chapter 4
Harmonic Measurement

This describes analysis using the 9605-01 HARMONIC MEASUREMENTS UNIT.
First refer to Chapter 3 "Preparations for Measurement" in the instruction manual of the 3194. Pay special attention to the precautions listed in this chapter.

4.1 Harmonic Measurement

The 9605-01 HARMONIC MEASUREMENTS UNIT applies FFT (Fast-Fourier Transform) analysis to waveforms from the A/D converter for each window, and can analyze voltage, current and power harmonics. Up to 3,000 degrees can be analyzed, and fundamental frequencies from 10 Hz to 4.5 kHz are supported.



NOTE

- Because of differences in measurement principle, frequency response, and accuracy, the values measured by the 9605-01 and 9600/9601/9602 products installed in the same 3194 product may not agree. Similarly, values may not agree with measurements made by other devices.
- If the PLL synchronization range is 10 Hz to 17.5 Hz or 17.5 Hz to 35 Hz, then the anti-aliasing filter of Fc ≒ 15 kHz is inserted. If the PLL synchronization range is 35 Hz or more, then the anti-aliasing filter of Fc ≒ 120 kHz is inserted.
- Although harmonics can be analyzed at up to 3,000 degrees, only a maximum of 50 items can be displayed on the screen.
- Because items not displayed are calculated internally at the same time, by switching to the hold state and switching the screen, it is possible to read simultaneous values for other analysis data.
- Be sure to carry this out with the PLL in the locked state.
- The harmonics which can be analyzed depend on the frequency of the PLL source. For details see the Specifications.
- Color specifications are not possible.
- The zeroth index is displayed when using a 9600/9602 with AC+DC or DC mode selected. This zeroth index is the DC component of the analyzed waveform. In the voltage/current mode, effective values are computed, and there is therefore no polarity. The accuracy of the zeroth index is not specified.
- When using 3P3W/3V3A mode, analysis results for power signify the total values (ΣP). The power analysis results are shown for each channel, but these have no significance. The total value (ΣP) is the same result for 3P3W and 3V3A.
- The phase angle indicates the phase angle of all data, taking the phase angle of the fundamental from the PLL source as 0°. For the total value (ΣP) , the phase angle is not displayed.
- The phase difference indicates the phase difference of the current with respect to the voltage on the same channel for each harmonic.
- At less than 0.1% of range, internal circuit noise may appear in the display.
- When the rms value of voltage or current exceeds 130% of range, or when the peak value of voltage or current exceeds crest factor, the value of analysis data and power analysis data is shown in red.

Term/meaning

Effective voltage value, effective current value, active power	Found from waveform sampling at a sampling frequency determined from the frequency of the fundamental. Includes harmonics above the analyzed number.
Fundamental (component, level)	Fourier coefficient of fundamental component
Harmonic (component, level)	Fourier coefficient second and subsequent harmonics
Harmonic content	Taking the fundamental component level as 100%, indicates the other harmonic components as proportions.
Harmonic phase angle	Generic term for harmonic voltage phase angle, harmonic current phase angle, and harmonic voltage current phase difference
Harmonic voltage phase angle, harmonic current phase angle	Taking the phase angle of the fundamental from the PLL source as 0°, indicates the phase difference of other voltage and current harmonics.
Harmonic voltage-current phase difference	The phase difference between the voltage and current for a particular harmonic
Total harmonic	The total value of the harmonics being analyzed (from 2nd to limit of analysis)
Total harmonic distortion	THD-F: total harmonic content as proportion of the fundamental. THD-R: total harmonic content as proportion of the effective voltage (current) value
PLL (Phase Locked Loop)	This generates a clock signal synchronized to the fundamental component of the measured waveform. The waveform is sampled using this clock signal. If the PLL does not function correctly, accurate harmonic analysis is not possible.
Anti-aliasing filter	When digital sampling is applied to signal waveforms, if over half of the frequency composition of the sampling frequency is included in the measurement signals, repeated skew (area sync) occurs and so correct frequency analysis cannot be done. This problem can be prevented by inserting a low pass filter that cuts the sampling frequency at the front section of the A/D converter by half. This filter is called an anti-aliasing filter.

4.2 Harmonic Analysis Procedure

1. Check that the line to be measured is shut off, and check that the 3194 product is powered off and the power cord disconnected from the outlet.

2. Connect the ground terminal to earth and connect the power cord to the 3P-outlet.

(Warming-up 1 hour or more
When using the 9600 or 9602,
carry out degaussing after warming-up.)

3. Turn the power on.

See Section 4.1 in the 3194 manual.

4. Make a connections and check there is no short circuit

See Section 3.2 in this manual.

5. Select the wiring mode on the STATUS "UNIT" screen.

See Section 3.2 in this manual.

6. Specify the channel for analysis on the harmonic screen.

See Section 3.3 in the 3194 manual.

9. Specify the output item on STATUS "freq/output" screen when the data is output on FD or printer.

10. Select voltage range and current range.

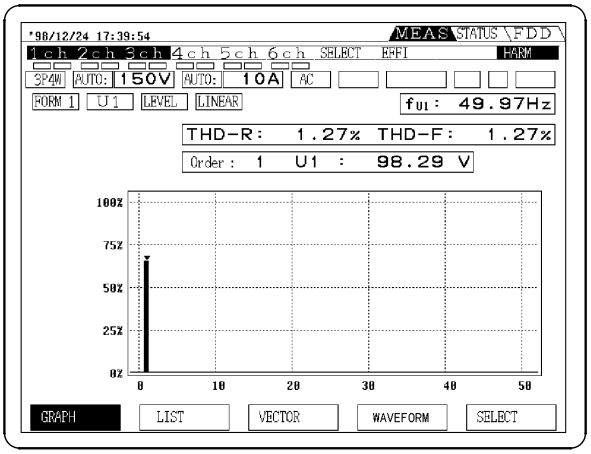
11. Carry out zero adjustment.

12. Check the connection of line being measured again, and turn on the power line.

13. Start the measurement.

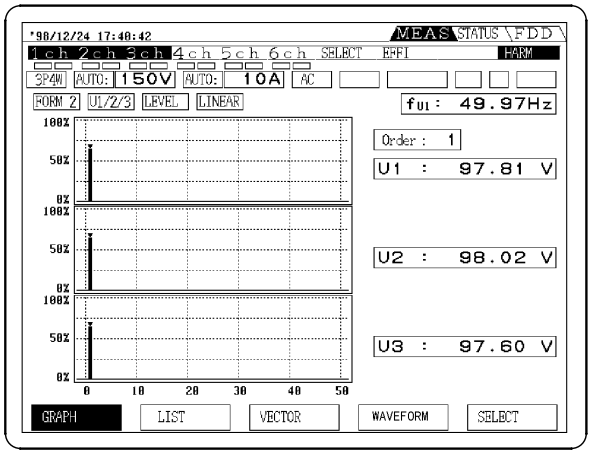
4.3 Graph Display of Harmonics

A harmonic graph can display the amplitude, proportion, or phase of each of the voltage, current, and power as a graph. There are three formats.



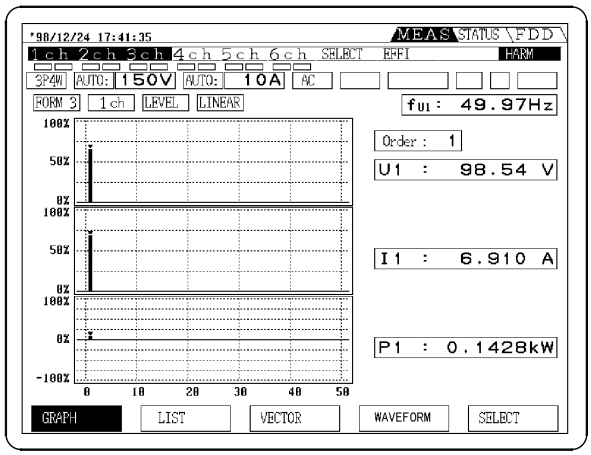
Format 1

One only of the analyzed voltage and current is displayed as a graph.



Format 2

The display is divided into three graphs. Voltage, current, and power are displayed for each channel.



Format 3

The display is divided into three graphs. In this case, the same item is displayed for each of the three systems.

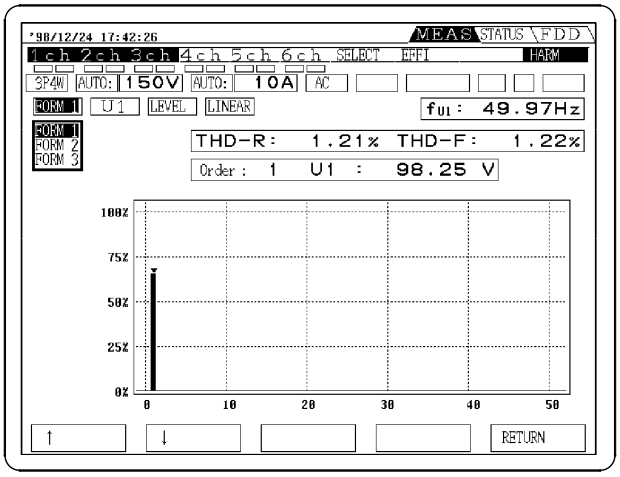
NOTE

- Distortion is not displayed.
- When sorting is enabled, the vertical axis is by harmonic order instead of degree.

(1) Displaying procedure

In harmonic mode, press the F1 "GRAPH", to switch to the graph screen.

(2) Selecting the display format (two methods)



Method 1

Press the SHIFT key, then press the F1 "GRAPH" key to to cycle through the format.

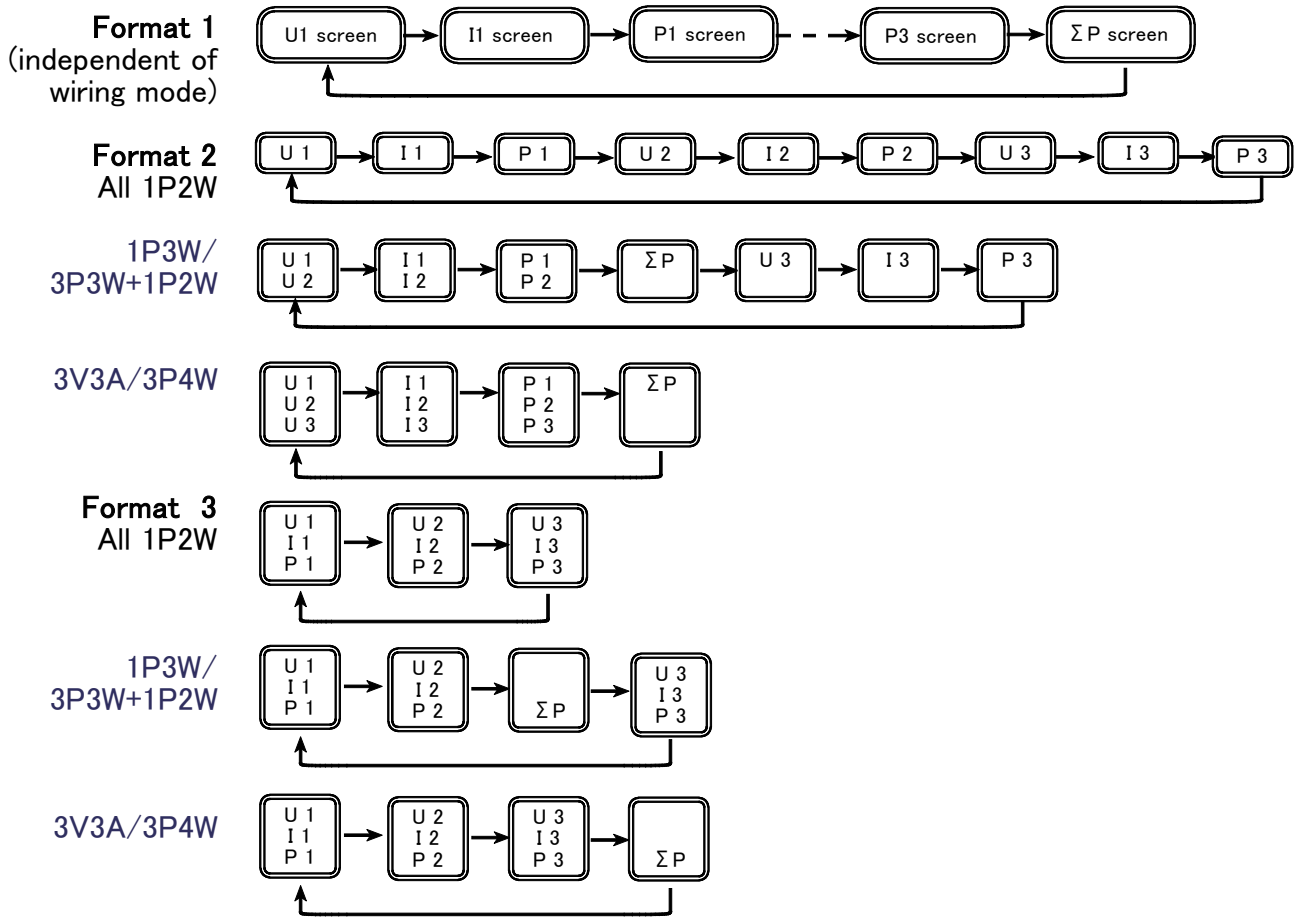
Method 2

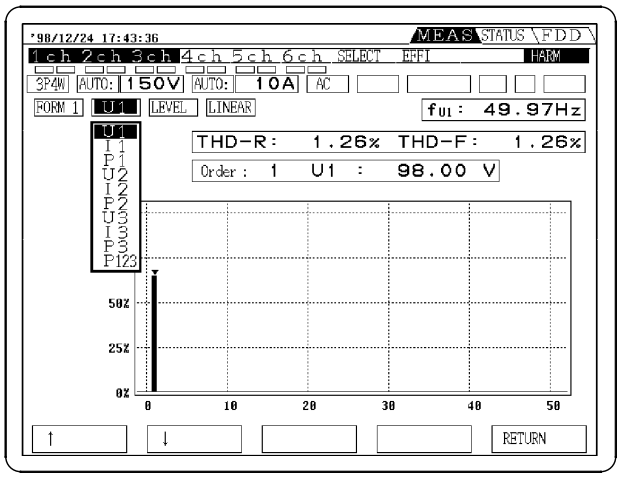
Press the F5 "SELECT" key.
Move the cursor to the display format box, and use the F1 "↑" and F2 "↓" keys to make a selection.
After specifying, press the F5 "RETURN" key.

(3) Specifying the item to display (two methods)

Method 1

Press the F1 "GRAPH" key to cycle through the display items (when channels 1, 2, and 3 are selected).



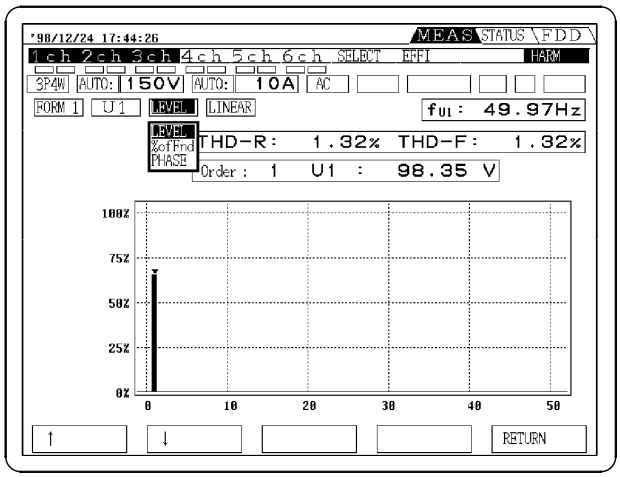


Method 2

Press the F5 "SELECT" key.
Move the cursor to the display item box, and use the F1 "↑" and F2 "↓" keys to make a selection.
After specifying, press the F5 "RETURN" key.

(4) Selecting the display analysis information

Select the information from the analysis from Amplitude, Proportion, and Phase.



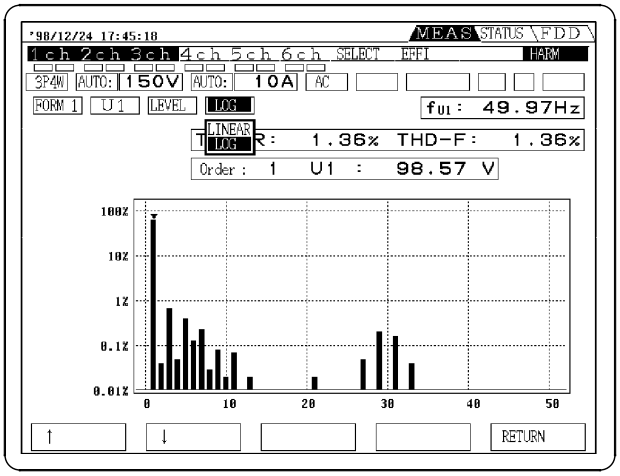
Press the F5 "SELECT" key.
Move the cursor to the analysis item box, and use the F1 "↑" and F2 "↓" keys to make a selection.
After specifying, press the F5 "RETURN" key.

NOTE

- This specification affects the list display in all screens.
- Selecting "PHASE" has the following significance:
  For voltage (*U*) or current (*I*), display the phase angle of the fundamental waveform with respect to the PLL source.
  For power (*P*), display the voltage-current phase difference

(5) Selecting the vertical axis

Select a linear (LINEAR) or logarithmic display (LOG) for the vertical axis.

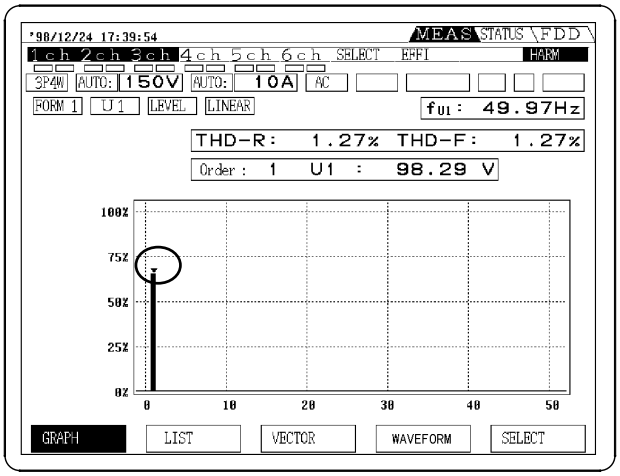


Press the **F5** "SELECT" key.
Move the cursor to the LINEAR/LOG box, and use the **F1** "↑" and **F2** "↓" keys to make a selection. After specifying, press the **F5** "RETURN" key.

NOTE

It is not possible to make individual LINEAR/LOG selections. The vector display also changes accordingly.

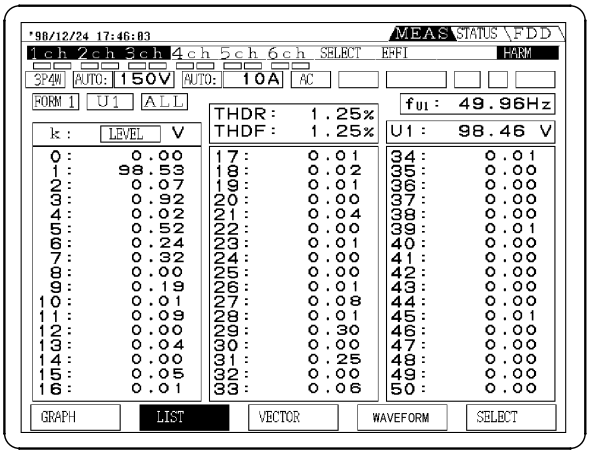
(6) Data read-out with the cursor



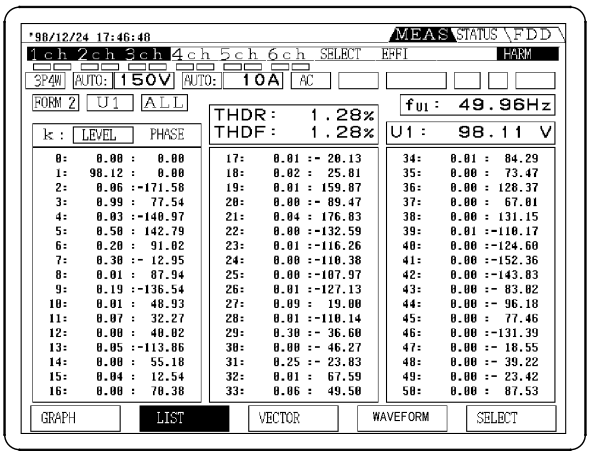
On a displayed graph, you can use the cursor to select the harmonics to be read. Use the **CURSOR** keys ◀ and ▶ to move the cursor ▼ on the screen, and display the selected data.

4.4 List Display of Harmonics

The harmonic list display shows the amplitude value, proportion, phase angle, and distortion for each harmonic of voltage, current, and power. There are two display formats: format 1 and format 2.



Format 1



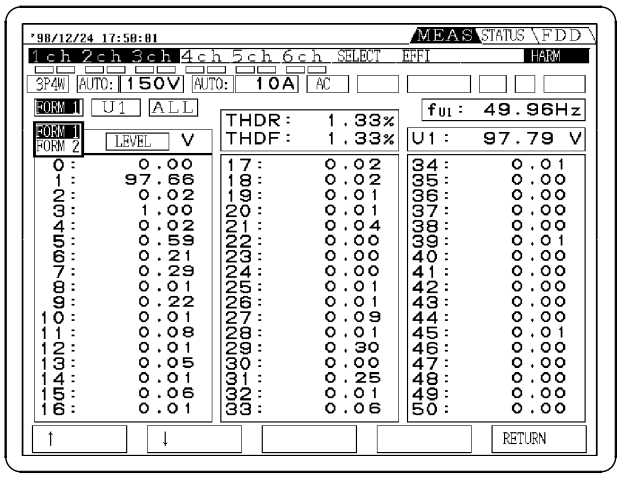
Format 2

Only the analysis data for the channel synchronized to the PLL source is valid.
When sorting is enabled, display order is by descending amplitude.

(1) Display procedure

In harmonic mode, press the F2 "LIST" key, to switch to the List screen.

(2) Selecting the display format (two methods)



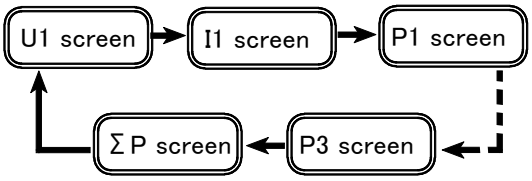
Method 1

Press the SHIFT key, then press the F2 "LIST" key to cycles through the format.

Method 2

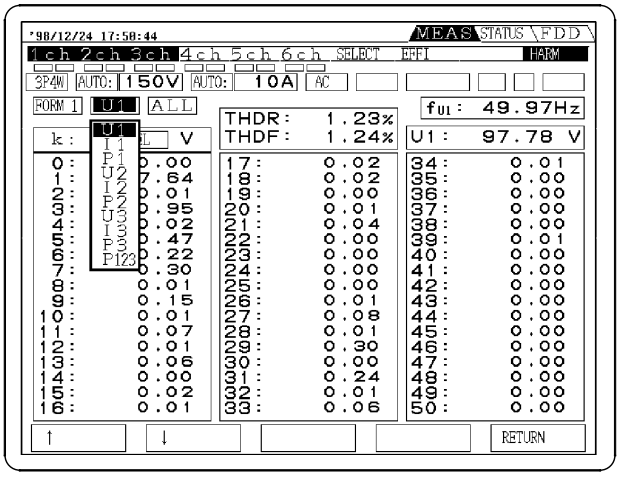
Press the F5 "SELECT" key.
Move the cursor to the display item box, and use the F1 "↑" and F2 "↓" keys to make a selection. After specifying, press the F5 "RETURN" key.

(3) Specifying the item to display (two methods)



Method 1

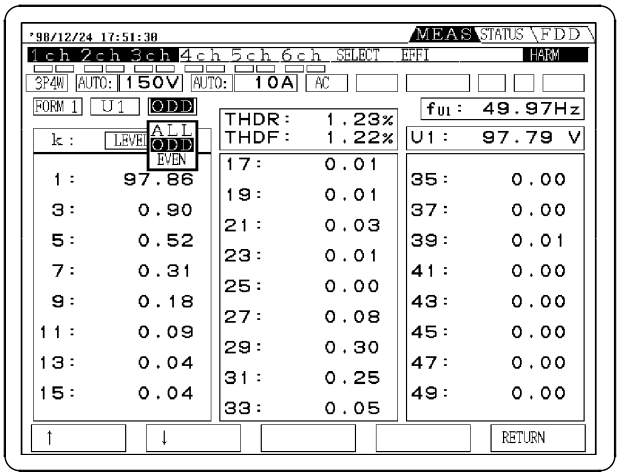
Press the F2 "LIST" key to cycle through the measurement items (voltage, current, and power).



Method 2

Press the F5 "SELECT" key.
Move the cursor to the display item box, and use the F1 "↑" and F2 "↓" keys to make a selection.
After specifying, press the F5 "RETURN" key.

(4) Specifying the display order



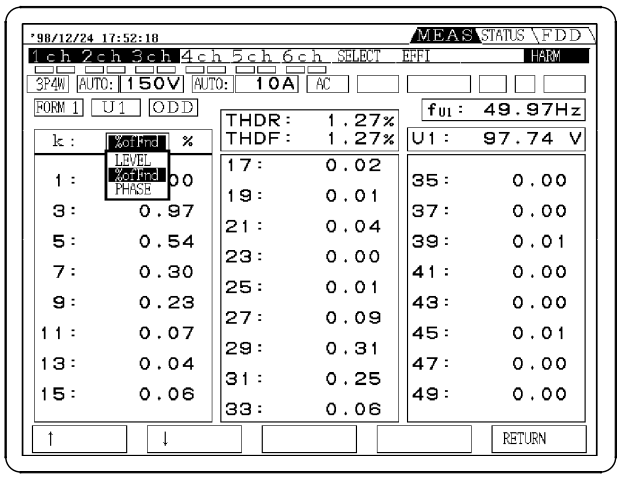
Select whether to display all harmonics, or only the even or odd harmonics.

NOTE

When sorting is enabled, the order alternates between even and odd harmonic orders.

(5) Specifying the analysis information

Specify information from the analysis to be displayed.



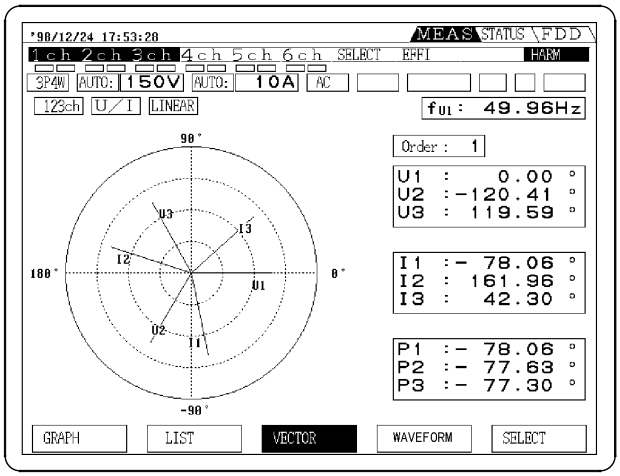
Press the F5 ″SELECT" key.
Move the cursor to the display item box, and use the F1 ″↑″ and F2 ″↓″ keys to make a selection.
After specifying, press the F5 ″RETURN″ key.

NOTE

- This specification affects the list display in all screens.
- Select the analysis information from the amplitude, proportion, and phase angle.
- Selecting "PHASE" has the following significance:
  For voltage (U) or current (I), display the phase angle of the fundamental waveform with respect to the PLL source.
  For power (P), display the voltage-current phase difference
- For the total value (ΣP) , the phase angle and total harmonic distortion are not displayed.

4.5 Vector Display of Harmonics

The harmonic vector display shows the voltage, current, and phase angle for each harmonic, making clear the phase relationship between voltage and current. The numeric values of the displayed harmonics also appear.
For details on wiring mode and vector display, see Appendix.



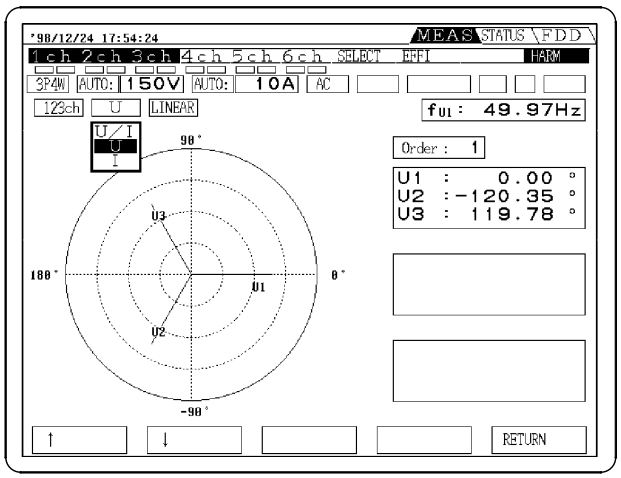
NOTE

- It is only possible to display the voltage and current for a single system on the screen. Again, only one harmonic can be selected for display. Therefore, for a single phase system two lines (voltage and current) appear, and for a three-phase four-wire system, six lines (voltage ×3, current ×3) are displayed.
- By setting the hold state, and switching the screen, it is possible to read other analysis data for the same time instant.
- The distortion is not displayed.
- The voltage/current phase angle indicates the phase angle taking the phase angle of the fundamental from the PLL source as 0°.
- The power phase difference indicates the phase difference of the current with respect to the voltage on the same channel for each harmonic.
- This reflects the harmonic selected on the harmonic graph display.
- When sorting is enabled, the same degree may not be displayed.

(1) Display procedure

In harmonic mode, press the F3 "VECTOR" key, to switch to the Vector display screen.
Pressing the F3 "VECTOR" key cycles through U/I, U, and I.

(2) Selecting the display item (U/I, U, I) (two methods)



Method 1

Press the F3 "VECTOR" key to cycles through the items (U/I, U, and I).

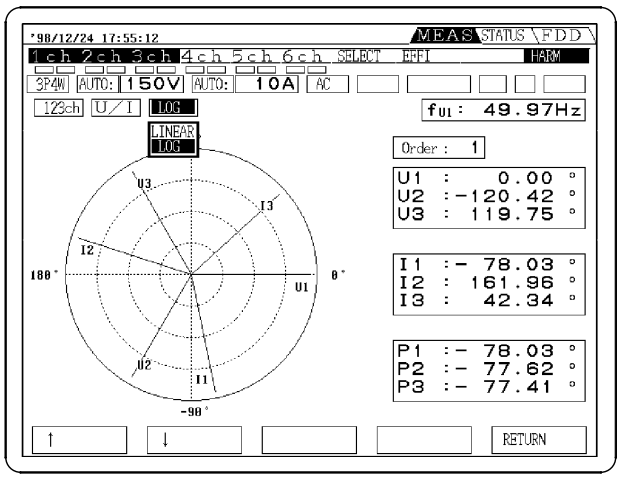
Method 2

Press the F5 "SELECT" key.
Move the cursor to the display format box, and use the F1 "↑" and F2 "↓" keys to make a selection. After specifying, press the F5 "RETURN" key.

(3) Specifying the display order

Pressing the CURSOR keys (◀ and ▶) cycles through the display order.

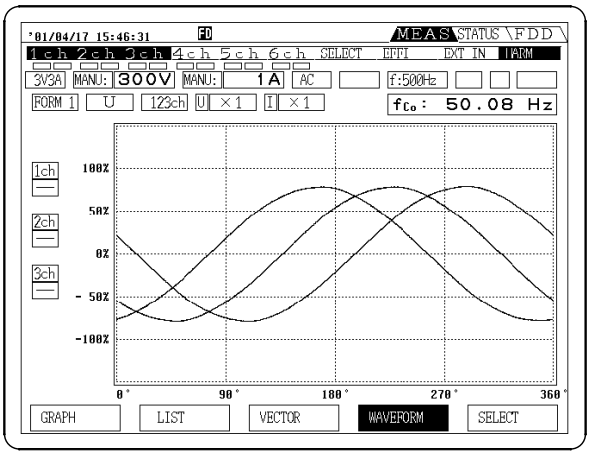
(4) Selecting the vertical axis:



Select a linear (LINER) or logarithmic display (LOG) for the vertical axis. Switch the display in the same way of the graph display.

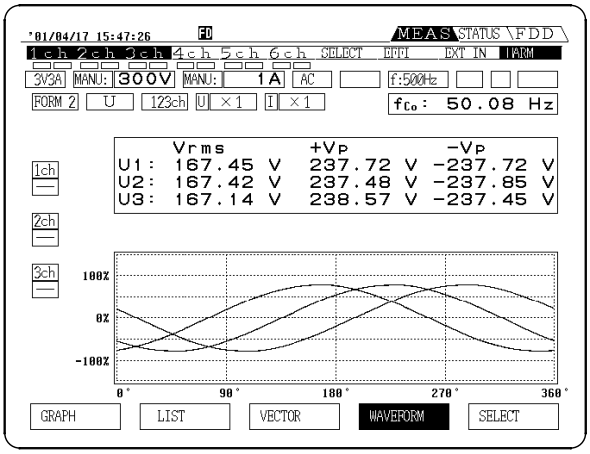
4.6 Waveform Display

The waveform display shows one cycle of the voltage and current waveforms being measured. There are five formats.



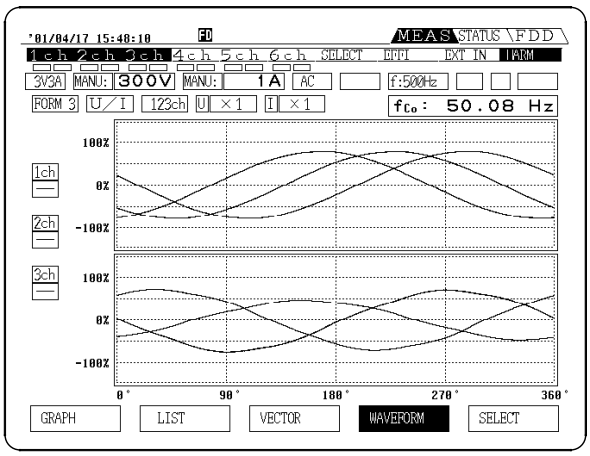
Format 1

Shown the waveforms (voltage or current) for each system being measured together.



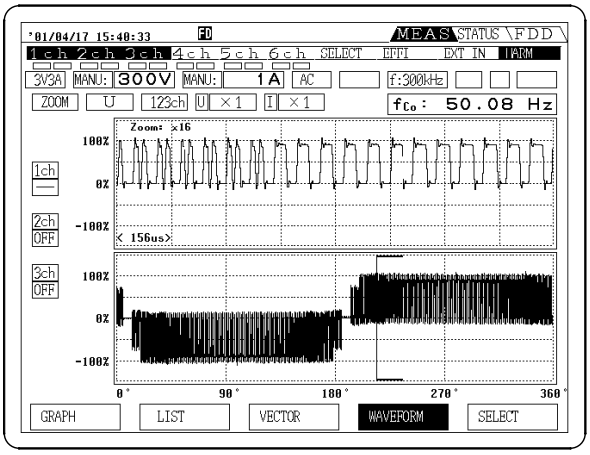
Format 2

Shown the waveforms (voltage or current) for each system being measured together. The display is smaller than the graph of format 1, but the effective and peak values are shown.



Format 3

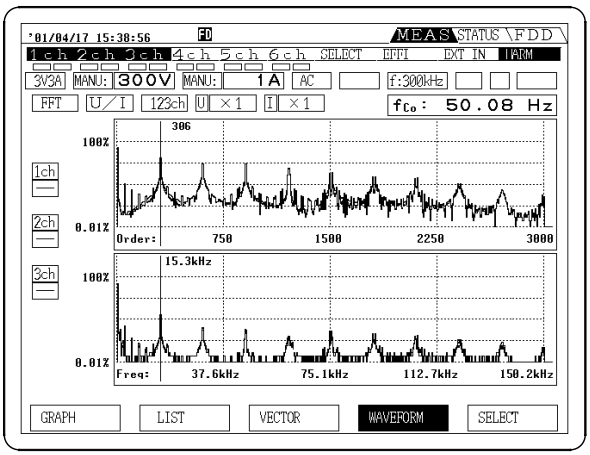
The display is divided into two, and the voltage waveform (above) and current waveform (below) for the system being measured are shown together.



ZOOM

Voltage and current waveforms can be zoomed. The zoom area can be panned by the left and right cursor keys, and the amount of magnification set by the up and down keys. Pressing the **F4** key switches between U and I.

10 to 70 Hz	X 16 max.
70 tp 140 Hz	X 8 max.
140 to 280 Hz	X 4 max.
280 to 560 Hz	X 2 max.
560 to 4500 Hz	X 1 max. (can not be changed)



FFT

All voltage and current waveform analysis data can be graphed. The upper part is voltage and the lower part is current. Degree and frequency can be read by the **CURSOR** ◀ and ▶ keys.

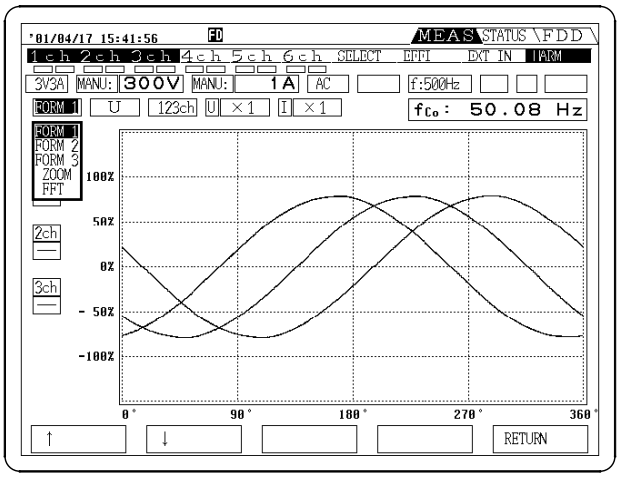
NOTE

- The cycle displayed in one screen is different depending on the PLL synchronization range. See Chapter 9, "Specifications" for more information.
- The waveform zero-crossing point is not correlated with frequencies.
- The waveform starts from a point at which the voltage waveform (or current waveform) specified as the PLL source waveform crosses the zero value, and displays the first cycle from the window being analyzed. The other waveforms are displayed for the same time interval as this waveform.
- It is not possible to select individual items for display.
- Because items not displayed are calculated internally at the same time, by switching to the hold state and switching the screen, it is possible to display simultaneous parts of other waveforms.
- The power waveform is not displayed.
- Only waveforms for channels synchronized to (at the same frequency as) the PLL source channel are valid.
- Cursors are not available for data readout.
- Effective power is not displayed.
- The vertical axis is fixed as LOG.
- FFT format can not be selected when sorting is enabled.
- The vertical axis is fixed as 100% when the FFT format is selected.

(1) Selecting the display format

Move the cursor to harmonic mode, and press the F4 "WAVEFORM", to switch to the waveform display screen. Each time you press the F4 "WAVEFORM" the waveform display switches to the next format. (when channels 1, 2, and 3 are selected).

(2) Selecting the display format (Expanded, compressed, two-screen, zoom, or FFT) (two methods)



Method 1

Press the SHIFT key, then press the F4 "WAVEFORM" key to cycle through the format.

Method 2

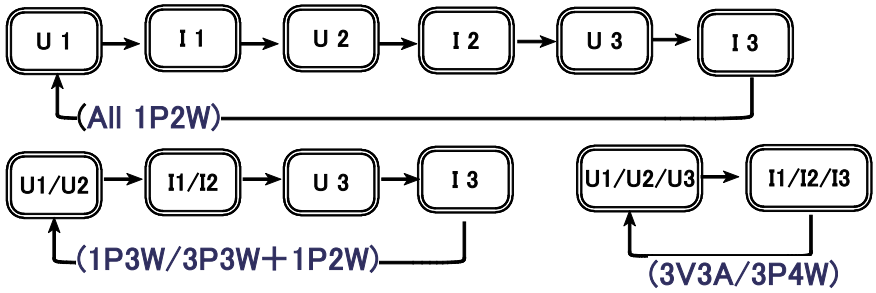
Press the F5 "SELECT" key.
Move the cursor to the display format box, and use the F1 "↑" and F2 "↓" key to make a selection. After specifying, press the F5 "RETURN" key.

(3) Specifying the item to display (Voltage, Current) (two methods)

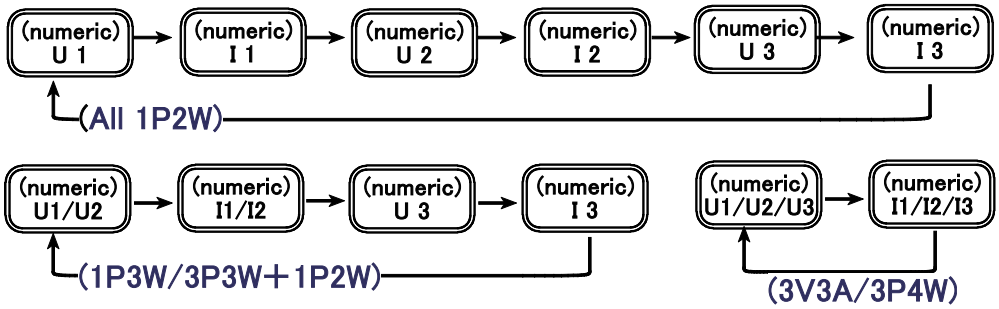
Method 1

Press the F4 "WAVEFORM" key to cycle through the display items.

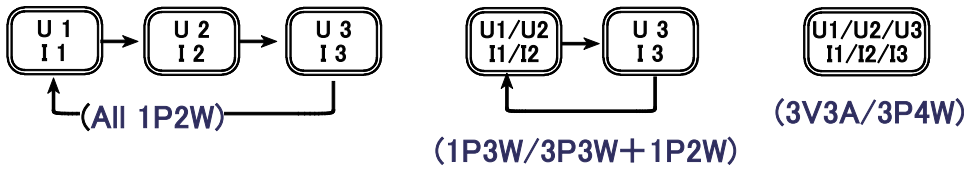
Magnification displays

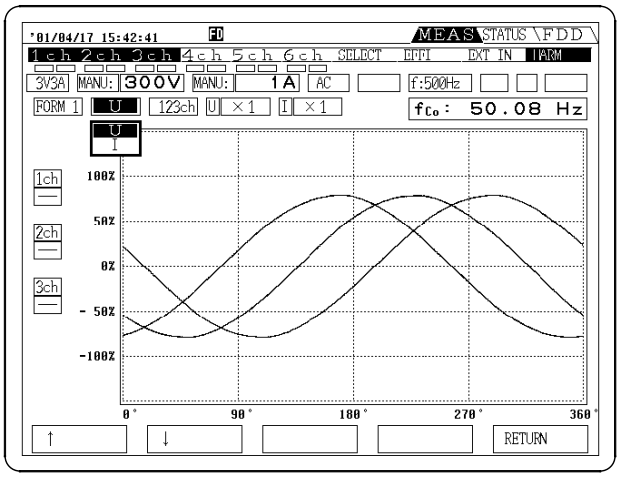


Compression displays



Dual displays

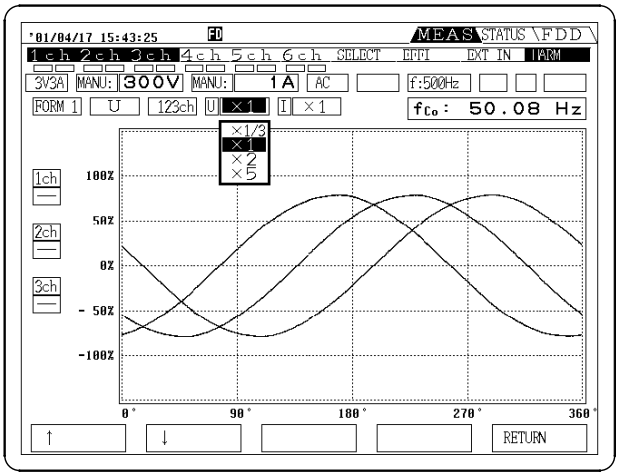




Method 2

Press the F5 ″SELECT″ key.
Move the cursor to the display item box, and use the F1 ″↑″ and F2 ″↓" keys to make a selection. After specifying, press the F5 ″RETURN" key.

(4) Vertical axis scaling setting:

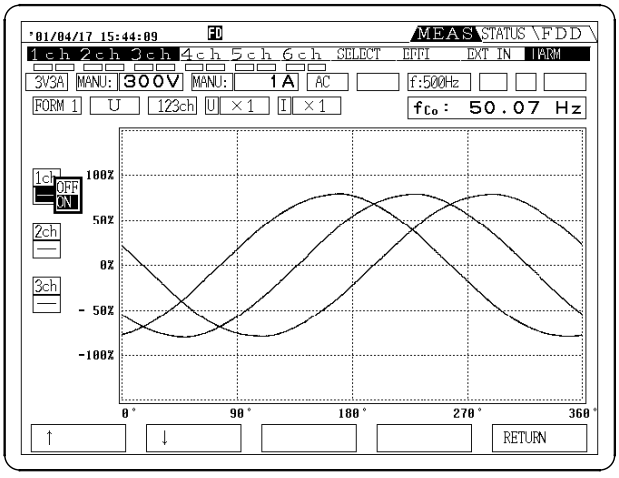


You can change the scaling ratio for the waveform vertical axis.
Press the F5 ″SELECT" key.
Move the cursor to the scaling factor box, and use the 1 ″↑″ and F2 ″↓″ keys to make a selection.
After specifying, press the F5 ″RETURN" key.

NOTE

- Select the scaling factor from ×1/3, ×1, ×2, and ×5. In this case, for example, using a scaling factor of ×5, the waveform is magnified by 5 times.
- There is no offset function for moving the position of the axis.

(5) Deleting the displayed channels



In 1P3W mode or above, more than one waveform is shown within the same graph. In this case you can switch off a waveform which is not required.

Press the F5 ″SELECT" key.
Move the cursor to the waveform setting box, and use the F1 ″↑″ and F2 ″↓″ keys to make a selection. After specifying, press the F5 ″RETURN" key.

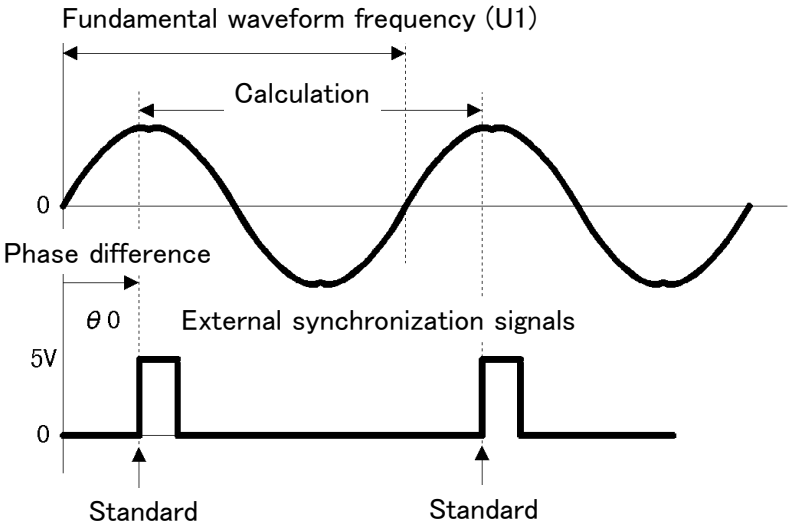
4.7 Measurement using an External Sync Signal

External signals can be synchronized with PLL for high frequency analysis of voltage, current, and electric power. Also, measurement of the phase amount change of voltage/current based on external signals is possible.

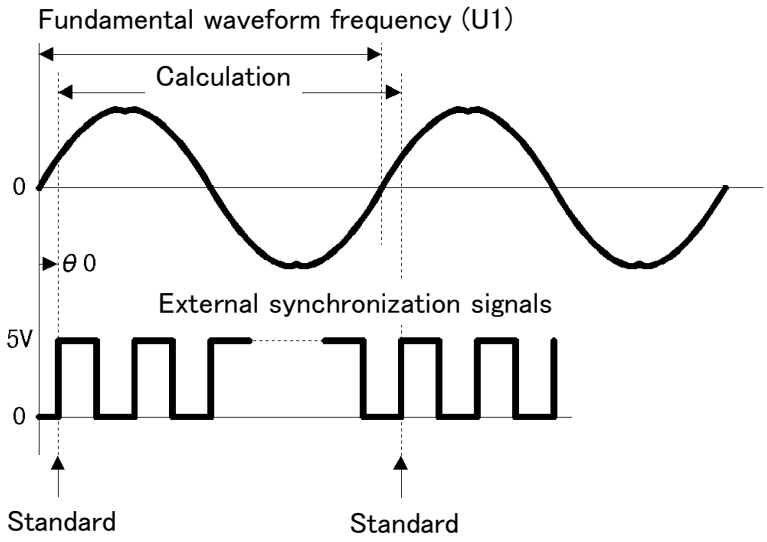
4.7.1 Theory of Operation

If the pulse count is a multiple of the fundamental waveform frequency, calculation is based on the rising edge of the pulse nearest the rising edge zero crossing of the U1 fundamental waveform component.
Pressing the **MEAS** key forces the phase difference (θ 0) between U1 and the standard to zero.

Single pulse



Multiple pulses

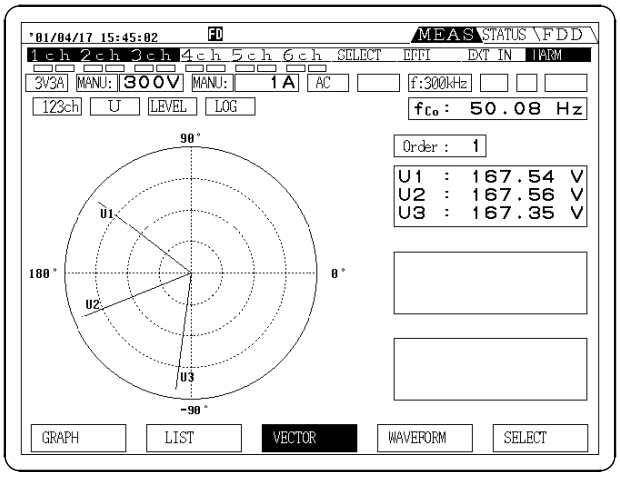


NOTE

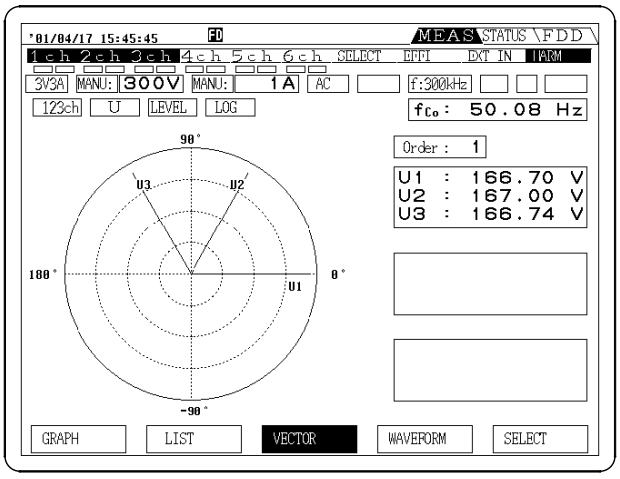
- The input connector for external synchronization signals is not insulated from the main product of the 3194.
- See the "EXT.CLOCK" item in Chapter 7, "External Control" for information on the pin assignment of the connector.
- Use Ext (ch6) when there is a need to insulate external synchronization signals from the 3194 main product. Because this requires use of a dedicated product, consult your local dealer for more information on how to obtain this product.
- As a condition, external synchronization signals require sine wave in the range of 1 to 10 Vrms. However, as other distorted waveforms are also possible, the PLL circuitry many not operate correctly, and measurement cannot be made as well.
- The phase difference between external synchronization signals and voltage/current includes the internal phase difference of θ. Because of this reason, the accuracy of the phase is determined as the variation amount. Also, accuracy is determined by the sine wave and frequency ratio (1/1).
- When the frequency of external synchronization signals changes, or the signals stop and then the PLL circuitry stops, the phase compensation value using the MEAS key becomes invalid.
- The frequency of external synchronization signals must be integer multiples (from 1 to 255 times) of the frequency of the voltage/current to measure.

4.7.2 Setting Procedure

The external synchronizing signal must be applied to the EXT CONTROL terminal before connecting input voltage and current for measurement.



Before Modification



After Modification

1. Set the PLL source to the voltage measured with the STATUS screen, and measure the frequency of the voltage from the "Harmonic" screen on the MEAS screen.
2. Set the PLL source to [Ext(Con)] from the "STATUS" screen, to measure the frequency of the external sync signal on the "MEAS" screen.
3. Divide the external sync signal frequency by the frequency of the displayed voltage, and enter the resulting value as the [Ext Divide]. For example, if the frequency of the displayed voltage is 50 Hz and the frequency of the external sync signal is 300 Hz, enter 1/6 as the [Ext Divide].
4. From this state, return to the "MEAS" screen and press the **MEAS** key again to phase lock with the synchronizing signal by zeroing out any UI phase difference, and to normalize the display.

Chapter 5
Hold Function

Press the panel HOLD key to freeze the display of all items on the screen. In this case, by switching the screen selection, you can view harmonic data for the same time interval which was not displayed.

Since internally the measurement continues, each time you press the HOLD key the values at that time are displayed. To end the hold function, hold down the SHIFT key and press the HOLD key.

The following measurements are also possible.
When combined with the interval timer, the results of analysis at the end of each interval can be displayed.

NOTE

- The hold function applies to the whole 3194 product.
  Refer to the following sections in the instruction manual of the 3194.
  Section 6.1, "Hold Function", and 7.2, "Setting the Control Time."
- Averaging is not supported.
- Peak Hold function is not supported.
- If using the sort function, output is in maximum sort order but the hamonic order are not output.

Chapter 6
Output to Floppy Disk/Printer

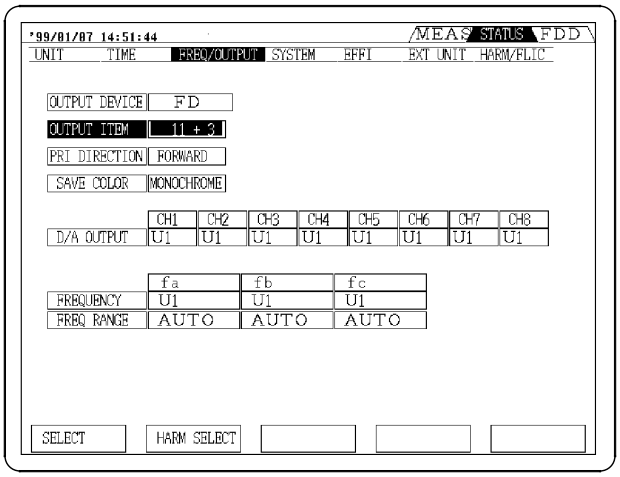
This product can be used with internal thermal printer as option. The measured data and setting data can be easily printed out.

NOTE

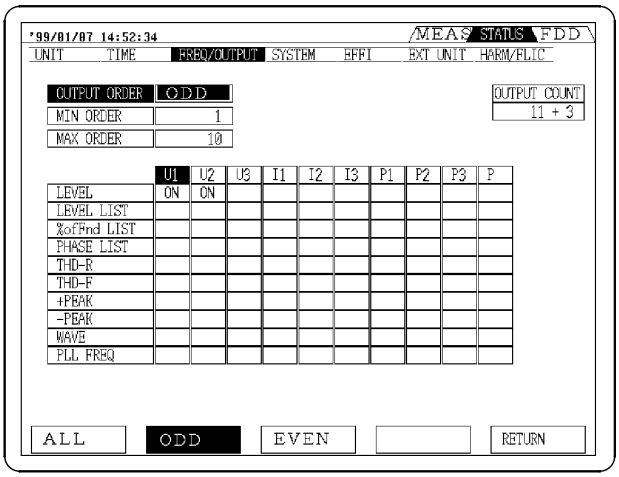
- If output items other than the data measured by the 9605-01 input unit are also specified, they are output at the same time.
- For the basic method of using the floppy disk/printer, and various notes on this, refer to the Instruction Manual for the 3194 product, Chapter 11 "Using the Floppy Disk and Chapter 13 "Using the Printer."
- The total number of output items of the data analyzed by the 9605-01 and other output setting data is displayed. "+3" shows three items (date, time, and interval time) and it is always affixed.
- Waveform data cannot be output to a printer or floppy disk.
- If using the sort function, output is in maximum sort order but the harmonic order are not output.

6.1 Selecting the Output Item to FDD/Printer

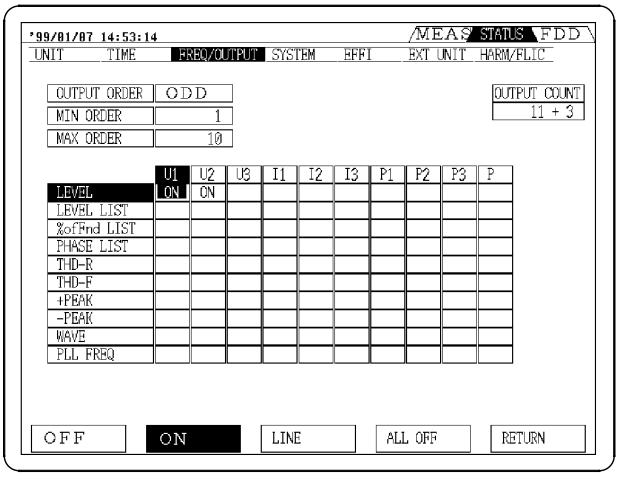
6.1.1 Output Setting in Harmonic Analysis Mode



1. Press the **F2** ″HARM SELECT″ key, to display the screen for output item selection.



2. Move the cursor to ″OUTPUT ORDER″ key.
3. Select the **F1** ″ALL″, **F2** ″ODD″, or **F3** ″EVEN″ key.
4. Move the cursor to ″MIN ORDER″ or ″MAX ORDER″ key.
5. Use the **F1** ″↑″ and **F2** ″↓″ keys to make a selection.



6. Using the **CURSOR** keys, move the cursor to the item to be output.
7. Press the **F2** ″ON″ key to make a setting. To delete the item which has been set, press the **F1** ″OFF″ key.
8. Pressing the **F3** ″LINE″ key sets the items on the specified line to on or off.
9. When the settings are completed, press the **F5** ″RETURN″ key.

NOTE

- For example, when the output item is set to ODD, and "MIN ORDER" is set to 1, and "MAX ORDER" is set to 10, this selects the data items for odd harmonics in the range 1 to 10.
  Even if the waveform output is set to ON, the data is not output on a printer.
- When sorting is enabled, the data is output in the displayed order.

6.2 Timer Control of Output

6.2.1 Harmonic Analysis

You can set control times to output automatically at those times.

1. Set the control time.
2. Select the output items.
3. Press the START/STOP key to start operation.

NOTE

- For the basic method of using the timer control, refer to the Instruction Manual for the 3194 product. Section 7.2, "Setting the Control Time"
- The minimum interval which can be specified is varied automatically, depending on the number of output items.

6.2.2 Relationship Between the Number of Output Items and Interval Time

The maximum number of items to be output and corresponding minimum interval times for output to floppy diskette or printer are determined automatically as follows.

	Number of setting items	Minimum interval time
FDD only	1 to 70, 71 to 400 400 or more	10 s 20 s (20 s + 10 s)/370 items
Printer only	1 to 60 lines every 60 lines	10 s +10 s
FDD+Printer	1 to 60 every 60	Total value of FDD only and printer only

NOTE

- For integration data, one data value is regarded as two values.
- Waveform data cannot be output to a printer or floppy disk.

Specifications of the floppy disk data for the 9605-01(Harmonic Analysis)

Harmonic data is output appended to the end of a line of ordinary measurement data. The output sequence is as shown in the table on the following page. The data for each of the harmonics in the list is output consecutively. If the time averaging or peak hold functions are active, the corresponding values (the same as on the screen) are output.

NOTE

- The suffixes (n) are output as two digit values (xx), with a leading space in the case of a single-digit value.
  Example "U1(3),I2(23)"
  The channel numbers, such as 1, 2, and 3 in "U1," "U2," and "U3" change, for example to "U4," "U5," and "U6," depending on the analysis channel settings.
- The suffixes (n) output by the sort function indicate the sequence. The harmonic order is not output.

	Headers	Meaning	Units
Fundamental frequency	HFREQ	Fundamental frequency of PLL source	Hz
Amplitude value	HU1 HU2 HU3	Voltage (U1) rms value Voltage (U2) rms value Voltage (U3) rms value	V
	HI1 HI2 HI3	Current (I1) rms value Current (I2) rms value Current (I3) rms value	A
	HP1 HP2 HP3 HP123	Active power (P1) Active power (P2) Active power (P3) Active power (Σ P)	W
Peak value	U1+PEAK U2+PEAK U3+PEAK	Voltage (U1) positive peak value Voltage (U2) positive peak value Voltage (U3) positive peak value	V
	I1+PEAK I2+PEAK I3+PEAK	Current (I1) positive peak value Current (I2) positive peak value Current (I3) positive peak value	A
	U1−PEAK U2−PEAK U3−PEAK	Voltage (U1) negative peak value Voltage (U2) negative peak value Voltage (U3) negative peak value	V
	I1−PEAK I2−PEAK I3−PEAK	Current (U1) negative peak value Current (U2) negative peak value Current (U3) negative peak value	A
THD−R	THDR U1 THDR U2 THDR U3	Voltage (U1) total harmonic distortion ratio (THD−R) Voltage (U2) total harmonic distortion ratio (THD−R) Voltage (U3) total harmonic distortion ratio (THD−R)	%
	THDR I1 THDR I2 THDR I3	Current (I1) total harmonic distortion ratio (THD−R) Current (I2) total harmonic distortion ratio (THD−R) Current (I3) total harmonic distortion ratio (THD−R)	%
THD−F	THDF U1 THDF U2 THDF U3	Voltage (U1) total harmonic distortion ratio (THD−F) Voltage (U2) total harmonic distortion ratio (THD−F) Voltage (U3) total harmonic distortion ratio (THD−F)	%
	THDF I1 THDF I2 THDF I3	Current (I1) total harmonic distortion ratio (THD−F) Current (I2) total harmonic distortion ratio (THD−F) Current (I3) total harmonic distortion ratio (THD−F)	%
Harmonic level	U1 (n) U2 (n) U3 (n)	The n−th harmonic voltage (U1) rms value The n−th harmonic voltage (U2) rms value The n−th harmonic voltage (U3) rms value	V
	I1 (n) I2 (n) I3 (n)	The n−th harmonic current (I1) rms value The n−th harmonic current (I2) rms value The n−th harmonic current (I3) rms value	A
	P1 (n) P2 (n) P3 (n) P123 (n)	The n−th harmonic power value (P1) The n−th harmonic power value (P2) The n−th harmonic power value (P3) The n−th harmonic power value (Σ P)	W
Harmonic contents	U1%Fnd(n) U2%Fnd(n) U3%Fnd(n)	The n−th harmonic voltage (U1) contents The n−th harmonic voltage (U2) contents The n−th harmonic voltage (U3) contents	%
	I1%Fnd(n) I2%Fnd(n) I3%Fnd(n)	The n−th harmonic current (I1) contents The n−th harmonic current (I2) contents The n−th harmonic current (I3) contents	%
	P1%Fnd(n) P2%Fnd(n) P3%Fnd(n) P123%Fnd(n)	The n−th harmonic power value (P1) contents The n−th harmonic power value (P2) contents The n−th harmonic power value (P3) contents The n−th harmonic power value (Σ P) contents	%
Harmonic phase angle	U1deg(n) U2deg(n) U3deg(n)	The n−th harmonic voltage (U1) contents The n−th harmonic voltage (U2) contents The n−th harmonic voltage (U3) contents	°

	Headers	Meaning	Units
	I1deg(n) I2deg(n) I3deg(n)	The n-th harmonic current (I1) contents The n-th harmonic current (I2) contents The n-th harmonic current (I3) contents	°
	P1deg(n) P2deg(n) P3deg(n) P123deg(n)	The n-th harmonic power value (P1) contents The n-th harmonic power value (P2) contents The n-th harmonic power value (P3) contents The n-th harmonic power value (Σ P) contents	°

Chapter 7
External Control

DANGER

The measurement input terminal and chassis of the 3194 are not isolated from each other. Do not exceed the maximum rated working voltage. Doing so can damage the product or cause a serious accident.

With a connection to the external output connector on the rear panel of the 3194 product, various external control functions are available. The following controls apply to the 9605-01.

Pin number	Terminal
24	FDD/PRINTER. START
25	EXT.HOLD
48	EXT.CLOCK
49	TRIGGER.IN
50	TRIGGER.OUT

NOTE

- Be sure to observe the items under the WARNING, CAUTION, and NOTE headings in Chapter 9, "External Output/External Control Terminals" in the Instruction Manual supplied with the 3194 product.
- The FDD/PRINTER.START and EXT.HOLD controls are common to overall 3194 operation.

7.1 EXT.CLOCK

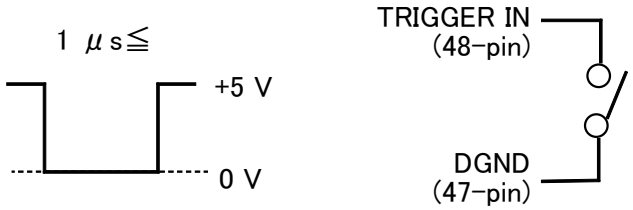
The PLL sync signal is set to a multiple of the external clock for analyzing voltage, current and power.

NOTE

- Set the PLL source to [Ext(Con)].
- Set the [Ext Divide] to match the fundamental voltage frequency to the clock frequency.
- Synchronization is not possible with distorted waveforms.
- Refer to Section 4.6, "Measurement using an External Sync Signal."

7.2 TRIGGER.IN

When an external control signal is input, a single measurement is made and displayed. This operation is repeated each time the control signal is input. This is controlled by triggering at the edge of the input waveform, or shorting between 48-pin and 47-pin.



NOTE To use this control, the external trigger setting must be set to "ON."

7.3 TRIGGER.OUT

This outputs a clock signal with the same frequency as the signal waveform selected as the PLL source. For example, when a 50 Hz sine wave is input, this outputs a 50 Hz clock signal.

NOTE
- If the PLL circuit is not functioning correctly, normally no wave-shaped clock signal is output.
- The duty factor of the clock signal is not specified.
- The point at which the signal waveform crosses the zero value is not synchronized to the rising edge of the clock signal.

Chapter 8
GP-IB/RS-232C Interface

8.1 Overview

⚠ WARNING

In order to avoid the possibility of an electric shock, unplug the power meter's power cord and disconnect the other wiring before connecting the GP-IB or RS-232 cable to the interface connector.

⚠ CAUTION

- Turn the power off when connecting the personal computer to the power meter. Connecting or disconnecting cables while the power is on could damage the equipment.
- After connecting the GP-IB or RS-232C cable, always be sure to secure the connection with the screws on the connector.

The 3194 MOTOR/HARMONIC HiTESTER is fitted as standard with a GP-IB/RS-232C interface. Using this interface, all of the functions of the product can be controlled from a personal computer by remote control, for the acquisition of harmonic measurement data.
This section lists the extra commands added for harmonic measurement.

This section explains only commands added for the 9605-01.
For details on operation of the GP-IB or RS-232C interface, first refer to Chapter 12, "GP-IB/RS-232C Interface" in the instruction manual of the 3194.

NOTE

It is not possible to use simultaneously both GP-IB and RS-232C interfaces.

8.2 Event Registers

This section explains only event registers added for the 9605-01.
For the event status registers ESR2, ESR21 to ESR26, refer to Section 12.3.13, "Event Registers" (7) and (8) in the instruction manual of the 3194.

Event status register 0 (ESR0)

This register is used principally to monitor start and stop processing events.
The bit0 is added for the 9605-01.
For details, refer to ":HARMonic:RTC" command.

The following commands are used for reading the event status register 0, and for setting the event status enable register 0 and for reading it.

Reading event status register 0	*ESR0?
Setting event status enable register 0	*ESE0
Reading event status enable register 0	*ESE0?

Event status register 0 (ESR0)

Bit 7 SE	Sampling End Sampling ended after the end of the sampling count set by the ":RTC:COUNT" command.
Bit 6 ST	Start Time Start time is reached.
Bit 5 PE	Printer Error A printer paper end, head up, or temperature out-of-range status was issued.
Bit 4 FE	Floppy Error A floppy disk write error, read error, or disk full status occurred.
Bit 3 ST	Stop Time Timer and real time processing finished.
Bit 2 IE	Interval End Interval finished.
Bit 1 CE	Clamp Error The clamp was disconnected or connected, or an operation failure occurred.
Bit 0 UE	Harmonic sampling processing end Sampling ended after the end of the sampling count set by the ″:HARMonic:RTC″ command.

8.3 Command Reference

8.3.1 Command Reference Explanation

This section explains each command in the harmonic analysis mode.

The 9605-01 is only capable of simultaneous analysis on three channels. Therefore, when channel are specified in a command, regardless of the channels on which the 9605-01 is operating, these are specified as channels 1, 2, and 3.
For example, if channels 3, 4, and 5 of the 3194 product are used for analysis by the 9605-01, then the specifications to get measurement values are "HU1", "HTFI3", and so forth.

:Command

■ Indicates functions of message reference

Syntax : Indicates the command syntax.

< > : (Data portion)
Indicates the data format for a command that includes data.
<NR1>= integer data

Response syntax : Indicated only for commands for which a response message is returned.

Example : Shows a simple example illustrating the usage of the command. All transmissions are indicated in "short form."

Function : Describes the function of the command.

Note : Describes points that require special attention when using the command.

Error : Indicates the what kinds of errors might occur.

NOTE
"( )", "< >" marks should not be input.

8.3.2 Specific Commands for Harmonic Analysis Function

:DATAout:ITEM:HARMonic:ALLClear

■ Clears all output items for harmonic default.

Syntax :DATAout:ITEM:HARMonic:ALLClear

Example ":DATAout:ITEM:HARMonic:ALLClear"

Function Clears all output items set by the ":DATAout:ITEM:HARMonic" command.

:DATAout:ITEM:HARMonic:ORDer

■ Sets the output item for the harmonic order.

Syntax :DATAout:ITEM:HARMonic:ORDer <NR1>,<NR1>,<ODD/EVEN/ALL>

first <NR1> = 0 to 50 (lower limit order)

second <NR1> = 0 to 50 (upper limit order)

Example ":DATAout:ITEM:HARMonic:ORDer 1,15,ODD"

Sets the output harmonic order to 1st to 15th odd-order.

Function Sets the output item for the harmonic order (level, percentage, and phase angle) to FDD or printer.

:DATAout:ITEM:HARMonic:ORDer?

■ Queries the output order of the harmonic data.

Syntax :DATAout:ITEM:HARMonic:ORDer?

Response syntax ":DATAOUT:ITEM:HARMONIC:ORDER <0-50>,<0-50>,<ODD/EVEN/ALL>"

Example

Transmission ":DATAout:ITEM:HARMonic:ORDer?"

Response ":DATAOUT:ITEM:HARMONIC:ORDER 1,15,ODD"

Function Queries the output item for the harmonic order (level, percentage, and phase angle) to FDD or printer.

:DATAout:ITEM:HARMonic:LIST

■ Setting the output item for the harmonic list.

Syntax :DATAout:ITEM:HARMonic:LIST <NR1>,...(up to 6 items)
<NR1>= 0 to 63

Example ":DATAout:ITEM:HARMonic:LIST 1,1,1,1,1,1"
As the default output items to the floppy disk drive or printer for the normal measurement, the level, percentage, and phase angle for U1 and P1 are specified.

Function Sets the output item for the harmonic list (level, percentage, phase angle) to FDD or printer.
The item is set as shown below by setting bits, to specify a single numerical value.
For the harmonics to be output, it is necessary beforehand to issue a ":DATAout:ITEM:HARMonic:ORDer" command.

Note If the setting value is out of range, an execution error occurs.

		128 bit 7	64 bit 6	32 bit 5	16 bit 4	8 bit 3	4 bit 2	2 bit 1	1 bit 0
Level	data1	–	–	HI3	HI2	HI1	HU3	HU2	HU1
	data2	–	–	–	–	HPSUM	HP3	HP2	HP1
Percentage	data3	–	–	HI3	HI2	HI1	HU3	HU2	HU1
	data4	–	–	–	–	HPSUM	HP3	HP2	HP1
Phase angle	data5	–	–	HI3	HI2	HI1	HU3	HU2	HU1
	data6	–	–	–	–	–	HP3	HP2	HP1

:DATAout:ITEM:HARMonic:LIST?

■ Queries the output item for the harmonic list.

Syntax :DATAout:ITEM:HARMonic:LIST?

Response syntax ":DATAOUT:ITEM:HARMONIC:LIST <0 - 63>,...(up to 6 items)"

Example
Transmission ":DATAout:ITEM:HARMonic:LIST?"
Response ":DATAOUT:ITEM:HARMONIC:LIST 1,1,1,1,1,1"

Function Queries the item set by the ":DATAout:ITEM:HARMonic:LIST" command.

:DATAout:ITEM:HARMonic:NORMal

Sets the output item for the harmonic measurement value.

Syntax :DATAout:ITEM:HARMonic:NORMal
<NR1>,..(up to 5 items)
<NR1>= 0 to 63

Example ":DATAout:ITEM:HARMonic:NORMal
9,1,9,9,0"
As the default output items to the floppy disk drive or printer for the normal measurement, U1,I1,P1,THDRU1,THDRI1,THDFU1, THDFI1 are specified.

Function Sets the output item for the harmonic measurement value (rms value, active power, and total harmonic distortion ratio) to FDD or printer.

Note If the setting value is out of range, an execution error occurs.

The item is set as shown below by setting bits, to specify a single numerical value.

		128 bit 7	64 bit 6	32 bit 5	16 bit 4	8 bit 3	4 bit 2	2 bit 1	1 bit 0
RMS value	data1	–	–	HI3	HI2	HI1	HU3	HU2	HU1
Power	data2	–	–	–	–	HPSUM	HP3	HP2	HP1
THD-R	data3	–	–	HTRI3	HTRI2	HTRI1	HTRU3	HTRU2	HTRU1
THD-F	data4	–	–	HTFI3	HTFI2	HTFI1	HTFU3	HTFU2	HTFU1
Frequency	data5	–	–	–	–	–	–	–	HF

:DATAout:ITEM:HARMonic:NORMal?

Queries the output item for the harmonic measurement value.

Syntax :DATAout:ITEM:HARMonic:NORMal?

Response syntax ":DATAOUT:ITEM:HARMONIC:NORMAL
<0 - 63>,..(up to 5 items)"

Example
Transmission ":DATAout:ITEM:HARMonic:NORMal?"
Response ":DATAOUT:ITEM:HARMONIC:NORMAL
9,1,9,9,0"

Function Queries the item set by the ":DATAout:ITEM:HARMonic:NORMal" command.

:DATAout:ITEM:HARMonic:WAVE

■ Sets the output item for the harmonic peak data.

Syntax :DATAout:ITEM:HARMonic:WAVE <NR1>, . . (up to 2 items)
<NR1> = 0 to 63

Example ":DATAout:ITEM:HARMonic:WAVE 1,1"
As the default output items to the floppy disk drive or printer for the normal measurement, the waveforms of +Upeak and -Upeak are specified.

Function Sets the output item for the harmonic waveform data to FDD or printer.
Sets the waveform data.

Note If the setting value is out of range, an execution error occurs.
The item is set as shown below by setting bits, to specify a single numerical value.

		128 bit 7	64 bit 6	32 bit 5	16 bit 4	8 bit 3	4 bit 2	2 bit 1	1 bit 0
+Peak	data1	–	–	HPIP3	HPIP2	HPIP1	HPUP3	HPUP2	HPUP1
−Peak	data2	–	–	HMIP3	HMIP2	HMIP1	HMUP3	HMUP2	HMUP1

:DATAout:ITEM:HARMonic:WAVE?

■ Queries the output item for the harmonic peak data.

Syntax :DATAout:ITEM:HARMonic:WAVE?

Response syntax ":DATAOUT:ITEM:HARMONIC:WAVE <0-63>,<0-63>,<0-63>"

Example
Transmission ":DATAout:ITEM:HARMonic:WAVE?"
Response ":DATAOUT:ITEM:HARMONIC:WAVE 1,1,1"

Function Queries the item set by the ":DATAout:ITEM:HARMonic:WAVE" command.

:DISPlay:HARMonic:GRAPh

■ Sets the items to be displayed on the harmonic graph screen.

Syntax :DISPlay:HARMonic:GRAPh <NR1>
<NR1> = 1, 2, 3
1: 1 item display
2: each items (3 graphs)
3: each mode (3 graphs)
(non): changing the screen

Example ":DISPlay:HARMonic:GRAPh 2"
Displays 3 graphs for each items.

Function Sets the items to be displayed on the harmonic graph screen.

Note Depending on wiring mode and unit, the number of the graph to be displayed varies.

:DISPlay:HARMonic:GRAPh?

■ Queries the display item on the harmonic graph screen.

Syntax :DISPlay:HARMonic:GRAPh?

Function Queries the display item on the harmonic graph screen.

Response syntax ":DISPLAY:HARMONIC:GRAPH <1/2/3>"

Example
Transmission :DISPlay:HARMonic:GRAPh?"
Response ":DISPLAY:HARMONIC:GRAPH 2"

:DISPlay:HARMonic:LIST

■ Sets the display item on the harmonic list screen.

Syntax :DISPlay:HARMonic:LIST <NR1>

Function Sets the display item on the harmonic list screen.

<NR1> =1, 2
1: 1 item display
2: 2 items display
(non): changing the screen

Example ":DISPlay:HARMonic:LIST 1"
Displays the list for one item.

:DISPlay:HARMonic:LIST?

■ Queries the display item on the harmonic list screen.

Syntax :DISPlay:HARMonic:LIST?

Function Queries the display item on the harmonic list screen.

Response syntax ":DISPLAY:HARMONIC:LIST <1/2>"

Example
Transmission :DISPlay:HARMonic:LIST?"
Response ":DISPLAY:HARMONIC:LIST 2"

:DISPlay:HARMonic:VECTor

■ Displays the harmonic vector screen.

Syntax :DISPlay:HARMonic:VECTor

Function Displays the harmonic vector screen.

Example ":DISPlay:HARMonic:VECTor"

:DISPlay:HARMonic:WAVE

■ Sets the display item on the harmonic waveform screen.

Syntax :DISPlay:HARMonic:WAVE <NR1>

<NR1> = 1, 2, 3, 4, 5
1: 1 cycle waveform
2: 1 cycle waveform and peak value
3: 2 waveforms
4:
5: FFT display
If no data is specified, the previous screen is displayed.

Example ":DISPlay:HARMonic:WAVE 1"
Displays 1 cycle waveform.

Function Sets the display item on the harmonic waveform screen.

Note The number of graphs displayed may vary, depending on the number of input units and the wiring mode.

:DISPlay:HARMonic:WAVE?

■ Queries the display item on the harmonic waveform screen.

Syntax :DISPlay:HARMonic:WAVE?

Response syntax ":DISPLAY:HARMONIC:WAVE <1/2/3>"

Example
Transmission ":DISPlay:HARMonic:WAVE?"
Response ":DISPLAY:HARMONIC:WAVE 1"

Function Queries the display item on the harmonic waveform screen.

:DISPlay?

■ Queries the screen displays.

Syntax :DISPlay?

Response syntax ":DISPLAY <character>"
<character>
H_GRAPH
H_LIST
H_VECTOR
H_WAVE

Example
Transmission ":DISPlay?"
Response ":DISPLAY H_GRAPH"

Function Queries the current screen displayed.

Note The harmonic screen is added to the existing ":DISPLAY" command. There is no change in the response messages for the screen.

:HARMonic:CHANnel

■ Sets the harmonic analysis channel.

Syntax :HARMonic:CHANnel <NR1>

<NR1>= 1 to 5

Example ":HARMonic:CHANnel 1"
Harmonic analysis for channel 1, 2, and 3 is carried out.

Function Specifies the first channel for which harmonic analysis is to be carried out.

Note Some channel numbers cannot be specified as the first channel, depending on the input unit configuration and wiring mode of the 3194. In this case, an execution error occurs.

:HARMonic:CHANnel?

■ Queries the harmonic analysis channel.

Syntax :HARMonic:CHANnel?

Response syntax ":HARMonic:CHANNEL <1-5>"

Example
Transmission ":HARMonic:CHANnel?"
Response ":HARMONIC:CHANNEL 4"
Harmonic analysis for channel 4, 5, and 6 is carried out.

Function Queries the current setting of the first channel number for harmonic analysis.

:HARMonic:DELTa

■ Selects On/Off of wiring conversion.

Syntax :HARMonic:DELTa <ON/OFF>

Example ":HARMonic:DELTa ON"

Function Apply Δ-Y conversion when the wiring mode is 3V3A, and apply Y-Δ conversion when the wiring mode is 3P4W.

:HARMonic:DELTa?

■ Queries the wiring conversion.

Syntax :HARMonic:DELTa?

Response syntax :HARMONIC:DELTA <ON/OFF>

Example
Transmission ":HARMonic:DELTa?"
Response ":HARMONIC:DELTA ON"

Function Obtains the on/off state of the Δ-Y conversion function.

:HARMonic:DIVider

■ Sets the frequency dividing ratio of the external sync signal.

Syntax :HARMonic:DIVider <NR1>
<NR1>= 1 to 255

Example ":HARMonic:DIVider 10"
Sets the frequency dividing ratio to ten.

Function The frequency dividing ratio is set when an external sync signal is selected.

:HARMonic:DIVider?

■ Queries the external sync signal frequency dividing ratio.

Syntax :HARMonic:DIVider?

Function Obtains the frequency dividing ratio of the external sync signal.

Response syntax :HARMONIC:DIVIDER <1-255>

Example
Transmission ":HARMonic:DIVider?"
Response ":HARMONIC:DIVIDER 10"

:HARMonic:LPF

■ Averaging setting

Syntax :HARMonic:LPF <NR1>
<NR1>= 0,1,2
0: None (no averaging)
1: Amplitude (Harmonicrms value)
2: Phase angle (Harmonic phase angle)

Function According to the harmonic waveform analysis results, selects an object to be averaged.

Example "HARMonic:LPF 1"
Amplitude is selected to be averaged.

:HARMonic:LPF?

■ Queries the average setting.

Syntax :HARMonic:LPF?

Function Obtains the object selected to be averaged.

Response syntax :HARMONIC:LPF <0/1/2>

Example
Transmission ":HARMonic:LPF?"
Response ":HARMONIC:LPF 1"
Amplitude has been selected as the object to be averaged.

:HARMonic:PHASezero

■ Phase angle zero adjust of external sync signal

Syntax :HARMonic:PHASezero

Function When measuring with an external sync signal, the phase angle of U1 is normalized to zero degrees. Other measurement values are adjusted relative to the amount of U1 normalization.

Example ":HARMonic:PHASezero"

Note Power phase difference is not adjusted.

:HARMonic:PLL

■ Sets the PLL source of the harmonic analysis.

Syntax :HARMonic:PLL <character>
<character> = HU1, HU2, HU3, HI1, HI2, HI3, CLK, EXT6, EXTC
EXT: external clock (see Section 3.3)

Example ":HARMonic:PLL HU1"
Sets the PLL source to HU1.

Function Selects the PLL source of the harmonic analysis. This selects the PLL source for harmonic analysis. Analysis is based on the PLL source selected by this command.

Note Some channel numbers cannot be specified as the first channel, depending on the input unit configuration and wiring mode of the 3194. In this case, an execution error occurs.

:HARMonic:PLL?

■ Queries the PLL source of the harmonic analysis.

Syntax :HARMonic:PLL?

Response syntax ":HARMONIC:PLL? <HU1, HU2, HU3, HI1, HI2, HI3>"

Example
Transmission ":HARMonic:PLL?"
Response ":HARMONIC:PLL HU1"

Function Queries the current selecting channel as PLL source.

:HARMonic:RTC

■ Sets the harmonic RTC counter.

Syntax :HARMonic:RTC <NR1>
<NR1> = 0 to 10000

Example ":HARMonic:RTC 50"
Sets the harmonic RTC counter to 50.

Function The harmonic display update timing is counted the specified number of times, and is indicated in UE bit (bit 0) of ESR0. When set to 0, this is off.

Note If the setting value is other than 0 to 10000, an execution error occurs.

:HARMonic:RTC?

■ Queries the harmonic RTC counter.

Syntax :HARMonic:RTC?

Response syntax ":HARMONIC:RTC <0-10000>"

Example
Transmission ":HARMonic:RTC?"
Response ":HARMONIC:RTC 50"

Function Queries the counter value set by the harmonic RTC counter.

:HARMonic:SORT

■ Selects the sort basis for harmonic analysis.

Syntax :HARMonic:SORT <OFF,ALL,U,I, HU1,HI1,HU2,HI2,HU3,HI3>

Function Select the basis for sorting harmonic wave analysis results.

Example ":HARMonic:SORT HU1"
HU1 data is sorted and other parameters are output for the respective degree.

:HARMonic:SORT?

■ Query the sorting basis for harmonic analysis.

Syntax :HARMonic:SORT?

Function Obtains the sorting basis for the specified harmonic analysis data.

Response syntax :HARMonic:SORT <data>

Example
Transmission ":HARMonic:SORT?"
Response ":HARMonic:SORT HU1"

:HARMonic:TRIGger

■ Enables or disables the trigger mode.

Syntax :HARMonic:TRIGger <ON/OFF>

Function Selects whether or not to switch to the trigger pending state. When this is ON, the trigger pending state is entered. When OFF, the trigger pending state is left, and the system switches to normal harmonic analysis.
For details, refer to Chapter 7, "TRIGGER IN."

Example ":HARMonic:TRIGger ON"

:HARMonic:TRIGger?

■ Queries the trigger mode.

Syntax :HARMonic:TRIGger?

Function Queries whether the current state is the trigger pending state. When this is ON, it indicates the trigger pending state. When it is OFF, it indicates not the trigger pending state.

Response syntax :HARMONIC:TRIGGER <ON/OFF>

Example
Transmission ":HARMonic:TRIGger?"
Response ":HARMONIC:TRIGGER ON"

:MEASure:HARMonic?

■ Queries the harmonic analysis data.

Syntax

Default mode:
:MEASure:HARMonic?

Data specification mode:
:MEASure:HARMonic?
<character>,..

Response syntax

Headers: ON
<character> <NR3>;<character>
<NR3>;<character> <NR3>,...

Headers: OFF
<NR3>;<NR3>;<NR3>,...

Example

Transmission
:MEASure:HARMonic?
HU1,HPUP1,HTFU1"

Response
"HU1 +110.44E+00;HPUP1
+151.72E+00;HTFU1 +050.33E+00"

Data portion: Numerical data in NR3 format
±□□□□□□E±□□
Mantissa : 6 digits with a decimal point
Exponent : 2 digits

Error: Display blank +6666.6E+99
Calculation impossible +7777.7E+99
Input over +9999.9E+99

Function

① Default mode
If no parameters are specified in the data section, then this mode is used. Default item data specified by the ":MEASure:ITEM:HARMonic" command is created. In this case the data order is fixed.

② Data (parameter) specification mode
If one or more parameters are specified in the data section, then this mode is used. Measurement item data specified by <data> is created.
If data is specified which cannot be selected, because of the number of input units or the channels being used for harmonic analysis, an execution error results.
The order of arranging the data (parameters) is freely selectable, and data is created in the specified order.

Note

- Up to 70 items can be responded, however, in the data section specification mode, the harmonic level, harmonic proportion, and harmonic phase angle cannot be obtained. Select the output items with the ":MEASure:ITEM:HARMonic:..." command, and get the measurement values in the default mode.
- To change the NR3 numerical data format, see the ":TRANsmit:COLumn" command.

Character

HU1, HU2, HU3	Voltage rms value
HI1, HI2, HI3	Current rms value
HP1, HP2, HP3, HPSUM	Active power
HPUP1, HPUP2, HPUP3	Voltage (+) peak value
HMUP1, HMUP2, HMUP3	Voltage (-) peak value
HPIP1, HPIP2, HPIP3	Current (+) peak value
HMIP1, HMIP2, HMIP3	Current (-) peak value
HTRU1, HTRU2, HTRU3	Voltage total harmonic distortion ratio (rms reference)
HTFU1, HTFU2, HTFU3	Voltage total harmonic distortion ratio (fundamental waveform reference)
HTRI1, HTRI2, HTRI3	Current total harmonic distortion ratio (rms reference)
HTFI1, HTFI2, HTFI3	Current total harmonic distortion ratio (fundamental waveform reference)
HF	Frequency

Headers for harmonic level, harmonic percentage, harmonic phase angle are shown below. When headers are ON, headers are affixed to all harmonic measurement value. The value of the last two digits of characters are shown harmonic order.

Level	Voltage Current Power	HU1L00 to HU1L50, HU2L00 to HU2L50, HU3L00 to HU3L50 HI1L00 to HI1L50, HI2L00 to HI2L50, HI3L00 to HI3L50 HP1L00 to HP1L50, HP2L00 to HP2L50, HP3L00 to HP3L50, HPSUML00 to HPSUML50
Percentage	Voltage Current Power	HU1D00 to HU1D50, HU2D00 to HU2D50, HU3D00 to HU3D50 HI1D00 to HI1D50, HI2D00 to HI2D50, HI3D00 to HI3D50 HP1D00 to HP1D50, HP2D00 to HP2D50, HP3D00 to HP3D50, HPSUMD00 to HPSUMD50
Phase angle/ difference	Voltage Current Power	HU1P00 to HU1P50, HU2P00 to HU2P50, HU3P00 to HU3P50 HI1P00 to HI1P50, HI2P00 to HI2P50, HI3P00 to HI3P50 HP1P00 to HP1P50, HP2P00 to HP2P50, HP3P00 to HP3P50

:MEASure:HARMonic:SORT?

Queries the harmonic during sorting.

Syntax :MEASure:HARMonic:SORT?

Response syntax
Headers: ON
<header1> <data1 degree>;<data1>;
<header2> <data2 degree>;<data2>; ;
Headers: OFF
<NR3>;<NR3>;<NR3>,...

Example
Transmission ":MEASure:HARMonic:SORT?"
Response ":HU1L01S 80;1.50E+02"

Character	
HU1L	ch1 voltage level
01S	First sort position
80	80 degrees
1.50E+02	150 V

Function Queries the harmonicdata.
Creates data in the default order specified by "MEASure:ITEM:HARMonic:SORT" and "MEASure:ITEM:HARMonic:LIST" commands.

Note
- Up to 70 items can be responded.
- Refer to "MEASure:HARMonic?" for data beside the sort.
- Select the output items with the ":MEASure:ITEM:HARMonic:SORT...." or ":MEASure:ITEM:HARMonic:LIST" command.
- To change the NR3 numerical data format, see the ":TRANsmit:COLumn" command.
- When sorting is disabled, the data is invalid.

Headers for harmonic level, harmonic percentage, harmonic phase angle are shown below. When headers are ON, headers are affixed to all harmonic measurement value. The two numeric digits before the last character of the string (nnS) indicate the sort order. Up to fifty items can be sorted, so the last three characters range from 01S to 50S.

Level	Voltage Current Power	HU1L01S to HU1L50S, HU2L01S to HU2L50S, HU3L01S to HU3L50S HI1L01S to HI1L50S, HI2L01S to HI2L50S, HI3L01S to HI3L50S HP1L01S to HP1L50S, HP2L01S to HP2L50S, HP3L01S to HP3L50S, HPSUML01S to HPSUML50S
Percentage	Voltage Current Power	HU1D01S to HU1D50S, HU2D01S to HU2D50S, HU3D01S to HU3D50S HI1D01S to HI1D50S, HI2D01S to HI2D50S, HI3D01S to HI3D50S HP1D01S to HP1D50S, HP2D01S to HP2D50S, HP3D01S to HP3D50S, HPSUMD01S to HPSUMD50S
Phase angle/ difference	Voltage Current Power	HU1P01S to HU1P50S, HU2P01S to HU2P50S, HU3P01S to HU3P50S HI1P01S to HI1P50S, HI2P01S to HI2P50S, HI3P01S to HI3P50S HP1P01S to HP1P50S, HP2P01S to HP2P50S, HP3P01S to HP3P50S

:MEASure:ITEM:HARMonic:ALLClear

■ Clears all harmonic default output item.

Syntax :MEASure:ITEM:HARMonic:ALLClear

Example ":MEASure:ITEM:HARMonic:ALLClear"

Function Clears all output items set by the ":MEASure:ITEM" command.

:MEASure:ITEM:HARMonic:ORDer

■ Sets the output order of the harmonic data.

Syntax :MEASure:ITEM:HARMonic:ORDer <NR1>,<NR1>,<ODD/EVEN/ALL>

first <NR1> = 0 to 50 (lower limit order)
second <NR1> = 0 to 50 (upper limit order)

Example ":MEASure:ITEM:HARMonic:ORDer 1,15,ODD"

Sets the default output item to odd data up to the 15th.

Function Sets the default items (harmonic output order for the level, percentage, and phase angle) to be transferred in the response message to the ":MEASure:HARMonic?" query in the default mode.

Note Some harmonics cannot be specified, depending on the measurement frequency.

In this case an execution error occurs.

:MEASure:ITEM:HARMonic:ORDer?

■ Queries the output order of the harmonic data.

Syntax :MEASure:ITEM:HARMonic:ORDer?

Response syntax ":MEASURE:ITEM:HARMONIC:ORDER <0-50>,<0-50>,<ODD/EVEN/ALL>"

Example
Transmission ":MEASure:ITEM:HARMonic:ORDer?"
Response ":MEASURE:ITEM:HARMONIC:ORDER 1,15,ODD"

Function Queries the default items (harmonic output order for the level, percentage, and phase angle) to be transferred in the response message to the ":MEASure?" query in the default mode.

:MEASure:ITEM:HARMonic:LIST

Sets the output item for the harmonic list.

Syntax :MEASure:ITEM:HARMonic:LIST <NR1>,..(up to 6 items)
<NR1> = 0 to 63

Example ":MEASure:ITEM:HARMonic:LIST 1,1,1,1,1,1"
As the default output items for the normal measurement, the level, percentage, and phase angle for U1 and P1 are specified.

Function Sets the default items (harmonic list for the level, percentage, and phase angle) to be transferred in the response message to the ":MEASure:HARMonic?" query in the default mode.
The item is set as shown below by setting bits, to specify a single numerical value.
For the harmonics to be output, it is necessary beforehand to issue a ":MEASure:ITEM:HARMonic:ORDer" command.

Note If the setting value is out of range, an execution error occurs.

		128 bit 7	64 bit 6	32 bit 5	16 bit 4	8 bit 3	4 bit 2	2 bit 1	1 bit 0
Level	data1	–	–	HI3	HI2	HI1	HU3	HU2	HU1
	data2	–	–	–	–	HPSUM	HP3	HP2	HP1
Percentage	data3	–	–	HI3	HI2	HI1	HU3	HU2	HU1
	data4	–	–	–	–	HPSUM	HP3	HP2	HP1
Phase angle	data5	–	–	HI3	HI2	HI1	HU3	HU2	HU1
	data6	–	–	–	–	–	HP3	HP2	HP1

:MEASure:ITEM:HARMonic:LIST?

Queries the output item for the harmonic list.

Syntax :MEASure:ITEM:HARMonic:LIST?

Response syntax ":MEASURE:ITEM:HARMONIC:LIST<0-63>,..(up to 6 items)"

Example
Transmission :MEASure:ITEM:HARMonic:LIST?"
Response ":MEASURE:ITEM:HARMONIC:LIST 1,1,1,1,1,1"

Function Queries the setting items specified by the ":MEASure:ITEM:HARMonic:LIST" command.

:MEASure:ITEM:HARMonic:NORMal

■ Sets the output item for the harmonic measurement value.

Syntax :MEASure:ITEM:HARMonic:NORMal <NR1>,..(up to 5 items)
<NR1> = 0 to 63

Example ":MEASure:ITEM:HARMonic:NORMal 9,1,9,9,0"
As the default output items for the normal measurement, HU1, HI1, HP1, HTRU1, HTRI1, HTFU1, HTFI1 are specified.

Function Sets the default items (rms value, active power, total harmonic distortion ratio) to be transferred in the response message to the ":MEASure:HARMonic?" query in the default mode.
The item is set as shown below by setting bits, to specify a single numerical value.

Note If the setting value is out of range, an execution error occurs.

		128 bit 7	64 bit 6	32 bit 5	16 bit 4	8 bit 3	4 bit 2	2 bit 1	1 bit 0
RMS value	data1	–	–	HI3	HI2	HI1	HU3	HU2	HU1
Power	data2	–	–	–	–	HPSUM	HP3	HP2	HP1
THD-R	data3	–	–	HTRI3	HTRI2	HTRI1	HTRU3	HTRU2	HTRU1
THD-F	data4	–	–	HTFI3	HTFI2	HTFI1	HTFU3	HTFU2	HTFU1
Frequency	data5	–	–	–	–	–	–	–	HF

:MEASure:ITEM:HARMonic:NORMal?

■ Queries the output item for the harmonic measurement value.

Syntax MEASure:ITEM:HARMonic:NORMal?

Response syntax ":MEASURE:ITEM:HARMONIC:NORMAL <0-63>,..(up to 5 items)"

Example
Transmission :MEASure:ITEM:HARMonic:NORMal?"
Response ":MEASURE:ITEM:HARMONIC:NORMAL 9,1,9,9,0"

Function Queries the setting items specified by the ":MEASure:ITEM:HARMonic:NORMal" command.

:MEASure:ITEM:HARMonic:SORT

■ Specifies the (highest) harmonic order of analysis during sorting.

Syntax :MEASure:ITEM:HARMonic:SORT <NR1>

<NR1> = 0 to 50

Example ":MEASure:ITEM:HARMonic:SORT 5"

Specify sorted results for the 1st through 5th harmonics.

Function Specifies the highest harmonic order for returning data in response to "MEASure:HARMonic:SORT?". Items to be output are according to "MEASure:HARMonic:LIST?".

Note

- An execution error results if the numeric value specified is out of range.
- Sorting is by level, and the content and phase angle are output as degree data for the respective level.
- All harmonic orders from the 1st to the specified order will be output. Intermediate orders cannot be skipped.
- The outputs items are always as indicated by the "MEASure:HARMonic:LIST?" command.

:MEASure:ITEM:HARMonic:SORT?

■ Query the (highest) harmonic order of analysis when sorted.

Syntax :MEASure:ITEM:HARMonic:SORT?

Response syntax ":MEASure:ITEM:HARMonic:SORT <data1>" <0-50>"

Example

Transmission ":MEASure:ITEM:HARMonic:SORT?"

Response ":MEASure:ITEM:HARMonic:SORT 5"

Function Obtains the harmonic orders specified by the "MEASure:ITEM:HARMonic:SORT" command.

MEASure:ITEM:HARMonic:WAVE

■ Sets the output item for the harmonic waveform data.

Syntax :MEASure:ITEM:HARMonic:WAVE <NR1>,<NR1>

<NR1> = 0 to 63

Example ":MEASure:ITEM:HARMonic:WAVE 1,1"

As the default output items for the normal measurement, +Upeak and -Upeak are specified.

Function Sets the default items (waveform data) to be transferred in the response message to the ":MEASure:HARMonic?" query in the default mode.

The item is set as shown below by setting bits, to specify a single numerical value.

Note If the setting value is out of range, an execution error occurs.

		128 bit 7	64 bit 6	32 bit 5	16 bit 4	8 bit 3	4 bit 2	2 bit 1	1 bit 0
+Peak	data1	–	–	HPIP3	HPIP2	HPIP1	HPUP3	HPUP2	HPUP1
−Peak	data2	–	–	HMIP3	HMIP2	HMIP1	HMUP3	HMUP2	HMUP1

:MEASure:ITEM:HARMonic:WAVE?

■ Queries the output item for the harmonic waveform data.

Syntax :MEASure:ITEM:HARMonic:WAVE?

Response syntax ":MEASURE:ITEM:HARMONIC:WAVE <0-63>,<0-63>"

Example
Transmission :MEASure:ITEM:HARMonic:WAVE?"
Response ":MEASURE:ITEM:HARMONIC:WAVE 1,1"

Function Queries the setting items specified by the ":MEASure:ITEM:HARMonic :WAVE" command.

:ZEROadjust:HARMonic

■ Carries out the zero adjustment of the 9605-01.

Syntax :ZEROadjust:HARMonic

Example ":ZEROadjust:HARMonic"

Function This carries out zero adjustment of the analog section of the 9605-01.
If there is no specification, zero adjustment is carried out for all channels.

8.4 Specific Commands Reference

Specific commands reference for harmonic analysis

Command	Data format	Explanation
:DATAout:ITEM:HARMonic:ALLClear		Clears all default output item.
:DATAout:ITEM:HARMonic:ORDer	NR1 numerical data (2)/ Character data (1)	Sets the harmonic output order.
:DATAout:ITEM:HARMonic:ORDer?		Queries the harmonic output order.
:DATAout:ITEM:HARMonic:LIST	NR1 numerical data (6)	Sets the output item for the harmonic list.
:DATAout:ITEM:HARMonic:LIST?		Queries the output item for the harmonic list.
:DATAout:ITEM:HARMonic:NORMal	NR1 numerical data (5)	Sets the output item for the harmonic measurement.
:DATAout:ITEM:HARMonic:NORMal?		Queries the output item for the harmonic measurement.
:DATAout:ITEM:HARMonic:WAVE	NR1 numerical data (2)	Sets the output item for the harmonic peak data.
:DATAout:ITEM:HARMonic:WAVE?		Queries the output item for the harmonic peak data.
:DISPlay:HARMonic:GRAPh	NR1 numerical data (1)	Sets the displays for the harmonic graph screen.
:DISPlay:HARMonic:GRAPh?		Queries the displays for the harmonic graph screen.
:DISPlay:HARMonic:LIST	NR1 numerical data (1)	Sets the displays for the harmonic list screen.
:DISPlay:HARMonic:LIST?		Queries the displays for the harmonic list screen.
:DISPlay:HARMonic:VECTor		Sets the displays for the harmonic vector screen.
:DISPlay:HARMonic:WAVE	NR1 numerical data (1)	Sets the displays for the harmonic waveform screen.
:DISPlay:HARMonic:WAVE?		Queries the displays for the harmonic waveform screen.
:DISPlay?		Queries the current display setting.
:HARMonic:CHANnel	NR1 numerical data (1)	Sets the harmonic analysis screen.
:HARMonic:CHANnel?		Queries the harmonic analysis screen.
:HARMonic:DELTa	ON/OFF (1)	Selects On/Off of wiring conversion.
:HARMonic:DELTa?		Queries the wiring conversion.
:HARMonic:DIVider	NR1 numerical data (1)	Sets the frequency dividing ratio of the external sync signal.
:HARMonic:DIVider?		Queries the external sync signal frequency dividing ratio.
:HARMonic:LPF	NR1 numerical data (1)	Averaging setting
:HARMonic:LPF?		Queries the average setting.

Command	Data format	Explanation
:HARMonic:PHASezero		Phase angle zero adjust of external sync signal
:HARMonic:PLL	Character data (1)	Sets the harmonic analysis PLL source.
:HARMonic:PLL?		Queries the harmonic analysis PLL source.
:HARMonic:RTC	NR1 numerical data (1)	Sets the harmonic RTC counter.
:HARMonic:RTC?		Queries the setting of the harmonic RTC counter.
:HARMonic:SORT	Character data (1)	Selects the sort basis for harmonic analysis.
:HARMonic:SORT?		Query the sorting basis for harmonic analysis.
:HARMonic:TRIGger	ON/OFF (1)	Enables or disables the trigger mode.
:HARMonic:TRIGger?		Queries the trigger mode setting.
:MEASure:HARMonic?	Character data (70)	Queries the harmonic analysis data.
:MEASure:HARMonic:SORT?		Queries the harmonic during sorting.
:MEASure:ITEM:HARMonic:ALLClear		Clears the output item for the harmonic default.
:MEASure:ITEM:HARMonic:ORDer	NR1 numerical data (2)/ character data (1)	Sets the output order of the harmonic data.
:MEASure:ITEM:HARMonic:ORDer?		Queries the setting of the output order of the harmonic data.
:MEASure:ITEM:HARMonic:LIST	NR1 numerical data (6)	Sets the output item of the harmonic list.
:MEASure:ITEM:HARMonic:LIST?		Queries the output item of the harmonic list.
:MEASure:ITEM:HARMonic:NORMal	NR1 numerical data (5)	Sets the output item of the harmonic measurement.
:MEASure:ITEM:HARMonic:NORMal?		Queries the output item of the harmonic measurement.
:MEASure:ITEM:HARMonic:SORT	NR1 numerical data (1)	Specifies the (highest) harmonic order of analysis during sorting.
:MEASure:ITEM:HARMonic:SORT?		Query the (highest) harmonic order of analysis when sorted.
:MEASure:ITEM:HARMonic:WAVE	NR1 numerical data (1)	Sets the displays for the harmonic waveform screen.
:MEASure:ITEM:HARMonic:WAVE?		Queries the setting of the displays for the harmonic waveform screen.
:ZEROadjust:HARMonic		Carries out the zero adjustment.

8.5 Valid Commands for Each Status

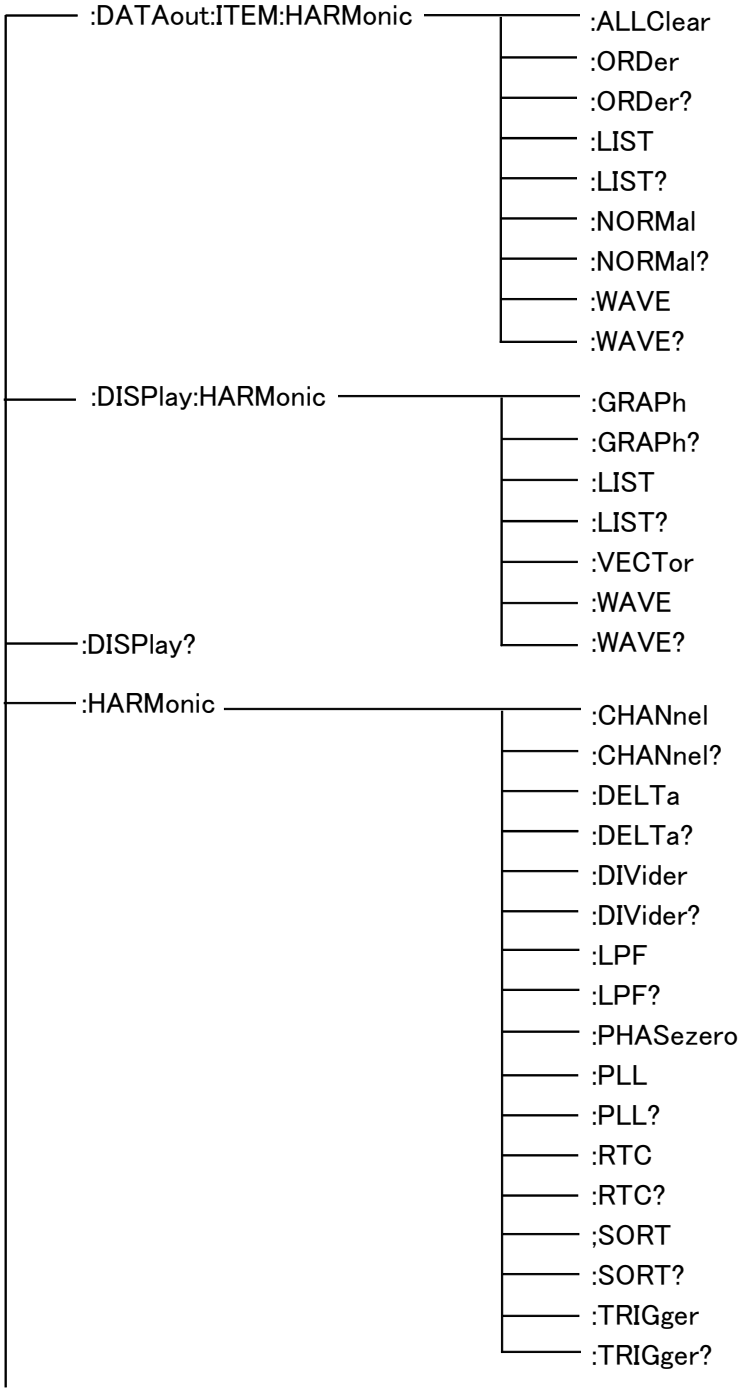
Harmonic analysis

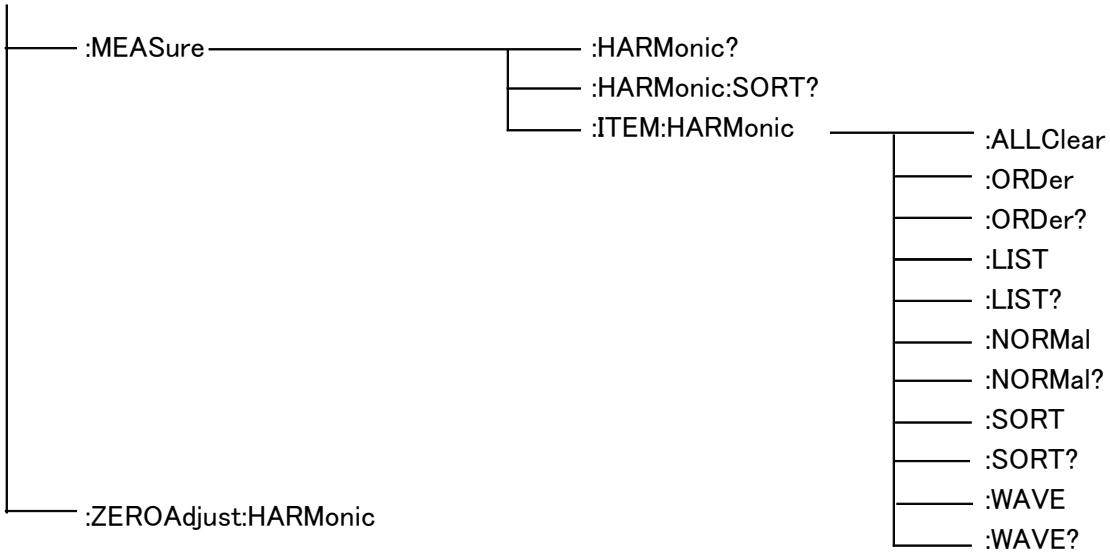
Command \ Integration condition	Reset			Start			Stop		
	HOLD		PEAK	HOLD		PEAK	HOLD		PEAK
	OFF	ON	ON	OFF	ON	ON	OFF	ON	ON
:DATAout:ITEM:HARMonic:ALLClear	●	–	–	–	–	–	–	–	–
:DATAout:ITEM:HARMonic:ORDer	●	–	–	–	–	–	–	–	–
:DATAout:ITEM:HARMonic:ORDer?	●	●	●	●	●	●	●	●	●
:DATAout:ITEM:HARMonic:LIST	●	–	–	–	–	–	–	–	–
:DATAout:ITEM:HARMonic:LIST?	●	●	●	●	●	●	●	●	●
:DATAout:ITEM:HARMonic:NORMal	●	–	–	–	–	–	–	–	–
:DATAout:ITEM:HARMonic:NORMal?	●	●	●	●	●	●	●	●	●
:DATAout:ITEM:HARMonic:WAVE	●	–	–	–	–	–	–	–	–
:DATAout:ITEM:HARMonic:WAVE?	●	●	●	●	●	●	●	●	●
:DISPlay:HARMonic:GRAPh	●	●	●	●	●	●	●	●	●
:DISPlay:HARMonic:GRAPh?	●	●	●	●	●	●	●	●	●
:DISPlay:HARMonic:LIST	●	●	●	●	●	●	●	●	●
:DISPlay:HARMonic:LIST?	●	●	●	●	●	●	●	●	●
:DISPlay:HARMonic:VECTor	●	●	●	●	●	●	●	●	●
:DISPlay:HARMonic:WAVE	●	●	●	●	●	●	●	●	●
:DISPlay:HARMonic:WAVE?	●	●	●	●	●	●	●	●	●
:DISPlay?	●	●	●	●	●	●	●	●	●
:HARMonic:CHANnel	●	–	–	–	–	–	–	–	–
:HARMonic:CHANnel?	●	●	●	●	●	●	●	●	●
:HARMonic:DELTa	●	–	–	–	–	–	–	–	–
:HARMonic:DELTa?	●	●	●	●	●	●	●	●	●
:HARMonic:DIVider	●	–	–	–	–	–	–	–	–
:HARMonic:DIVider?	●	●	●	●	●	●	●	●	●
:HARMonic:LPF	●	–	–	–	–	–	–	–	–
:HARMonic:LPF?	●	●	●	●	●	●	●	●	●
:HARMonic:PHASezero	●	–	–	–	–	–	–	–	–
:HARMonic:PLL	●	–	–	–	–	–	–	–	–
:HARMonic:PLL?	●	●	●	●	●	●	●	●	●
:HARMonic:RTC	●	–	–	–	–	–	–	–	–
:HARMonic:RTC?	●	●	●	●	●	●	●	●	●
:HARMonic:SORT	●	–	–	–	–	–	–	–	–
:HARMonic:SORT?	●	●	●	●	●	●	●	●	●
:HARMonic:TRIGger	●	–	–	–	–	–	–	–	–
:HARMonic:TRIGger?	●	●	●	●	●	●	●	●	●
:MEASure:HARMonic?	●	●	●	●	●	●	●	●	●
:MEASure:HARMonic:SORT?	●	–	–	–	–	–	–	–	–

Command \ Integration condition	Reset			Start			Stop		
	HOLD		PEAK	HOLD		PEAK	HOLD		PEAK
	OFF	ON	ON	OFF	ON	ON	OFF	ON	ON
:MEASure:ITEM:HARMonic:ALLClear	●	—	—	—	—	—	—	—	—
:MEASure:ITEM:HARMonic:ORDer	●	—	—	—	—	—	—	—	—
:MEASure:ITEM:HARMonic:ORDer?	●	●	●	●	●	●	●	●	●
:MEASure:ITEM:HARMonic:LIST	●	—	—	—	—	—	—	—	—
:MEASure:ITEM:HARMonic:LIST?	●	●	●	●	●	●	●	●	●
:MEASure:ITEM:HARMonic:NORMal	●	—	—	—	—	—	—	—	—
:MEASure:ITEM:HARMonic:NORMal?	●	●	●	●	●	●	●	●	●
:MEASure:ITEM:HARMonic:SORT	●	—	—	—	—	—	—	—	—
:MEASure:ITEM:HARMonic:SORT?	●	●	●	●	●	●	●	●	●
:MEASure:ITEM:HARMonic:WAVE	●	—	—	—	—	—	—	—	—
:MEASure:ITEM:HARMonic:WAVE?	●	●	●	●	●	●	●	●	●
:ZEROAdjust:HARMonic	●	—	—	—	—	—	—	—	—

8.6 Specific Command Tree

Harmonic analysis




:MEASure
:HARMonic?
:HARMonic:SORT?
:ITEM:HARMonic
:ALLClear
:ORDer
:ORDer?
:LIST
:LIST?
:NORMal
:NORMal?
:SORT
:SORT?
:WAVE
:WAVE?
:ZEROAdjust:HARMonic

8.7 The Output Item Bits

(1) Harmonic analysis

The data specified by :MEAS:ITEM:HARMonic is output in the following order.

:NORMAL		bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0	Item No.
RMS value	data1	–	–	HI3	HI2	HI1	HU3	HU2	HU1	1
Active power	data2	–	–	–	–	HPSUM	HP3	HP2	HP1	2
THD-R	data3	–	–	HTRI3	HTRI2	HTRI1	HTRU3	HTRU2	HTRU1	3
THD-F	data4	–	–	HTFI3	HTFI2	HTFI1	HTFU3	HTFU2	HTFU1	4
Frequency	data5	–	–	–	–	–	–	–	HF	5

:LIST		bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0	Item No.
Level	data1	–	–	HI3	HI2	HI1	HU3	HU2	HU1	6
	data2	–	–	–	–	HPSUM	HP3	HP2	HP1	7
Percentage	data3	–	–	HI3	HI2	HI1	HU3	HU2	HU1	8
	data4	–	–	–	–	HPSUM	HP3	HP2	HP1	9
Phase angle	data5	–	–	HI3	HI2	HI1	HU3	HU2	HU1	10
	data6	–	–	–	–	–	HP3	HP2	HP1	11

:WAVE		bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0	Item No.
+Peak	data1	–	–	HPIP3	HPIP2	HPIP1	HPUP3	HPUP2	HPUP1	12
-Peak	data2	–	–	HMIP3	HMIP2	HMIP1	HMUP3	HMUP2	HMUP1	13
Waveform	data3	–	–	HWI3	HWI2	HWI2	HWU3	HWU2	HWU1	14*

*:DATAout only

The bits set by :MEAS:ITEM:HARMonic are scanned according to the following rules, and returned in this order in a response message.

The output data sequence is as follows.

① For item number 1, bits 0 to 5 are scanned in order, and when a bit is set to 1 the calculation value for the corresponding item is returned.

② For item number 2, bits 0 to 3 are scanned in order, and when a bit is set to 1 the calculation value for the corresponding item is returned.

③ For item number 3, bits 0 to 5 are scanned in order, and when a bit is set to 1 the calculation value for the corresponding item is returned.

And so on, repeating up to item number 14.

NOTE A bit is ignored if it is set for a calculation value which cannot be obtained in the power measurement configuration being used.

Chapter 9
Specifications

(1) General Specifications

Application	Fitted in a 3194 product (factory-fitted option)
Measurement lines	Single-phase,two-wire (1P2W)/ Single-phase,three-wire (1P3W)/ Three-phase,three-wire (3V3A, 3P3W)/ Three-phase,four-wire (3P4W)
Number of channels	Maximum of 3 channels selectable from channels 1 to 6, depending on 3194 product wiring mode

	1ch	2ch	3ch	4ch	5ch	6ch	Using channels
①	1P2W	1P2W	1P2W	1P2W	1P2W	1P2W	1+2+3, 2+3+4, 3+4+5, 4+5+6
②	1P3W/3P3W		1P2W	1P2W	1P2W	1P2W	12+3, 3+4+5, 4+5+6
③	1P3W/3P3W		1P3W/3P3W		1P2W	1P2W	12+3, 34+5, 4+5+6
④	1P3W/3P3W		1P3W/3P3W		1P3W/3P3W		12+3, 34+5, 56
⑤	3V3A/3P4W			1P2W	1P2W	1P2W	123, 4+5+6
⑥	3V3A/3P4W			1P3W/3P3W		1P2W	123, 45+6
⑦	3V3A/3P4W			3V3A/3P4W			123, 456

Measurement range	Basic frequency 10 Hz to 4.5 kHz
Measurement system	PLL synchronization/fixed clock
Analysis method	FFT
Type of window	Rectangular (gaps in window)
Display update rate	Every 1 window (excluding when FD/printer output and communication)
A/D	12 bits
Computational accuracy	32 bits (floating-point calculations)
PLL source	Selectable from the following sources: U of the selected combination of channels for measurement I of the selected combination of channels for measurement Derived from an external sync signal
External Sync Signal	Possible to synchronize with external synchronization signals input from the 3194 main product's analog connector for U/I/P analysis. Input level (for sine wave, 1 to 10 Vrms, 100 kHz or less) Frequency splitting function included (1/1 to 1/255)
Crest factor	2.5 max. (current, voltage)
Output function	FD, printer, GP-IB, RS-232C

Sampling rate

	Basic frequency (Hz)	Sampling rate (Hz)	Window width	Analysis harmonic order	Waveform display
PLL-synchronized range	10 to 17.5	f X 8192	1 cycle	3000 th (10 kHz or less)	1 cycle
	17.5 to 35	f X 8192	1 cycle	3000 th (10 kHz or less)	
	35 to 70	f X 8192	1 cycle	3000 th (100 kHz or less)	
	70 to 140	f X 4096	2 cycles	1500 th (100 kHz or less)	
	140 to 280	f X 2048	4 cycles	800 th (100 kHz or less)	
	280 to 560	f X 1024	8 cycles	400 th (100 kHz or less)	
	560 to 1120	f X 512	16 cycles	200 th (100 kHz or less)	
	1120 to 2240	f X 256	32 cycles	100 th (100 kHz or less)	2 cycles
	2240 to 4500	f X 128	64 cycles	50 th (100 kHz or less)	4 cycles
Fixed clock	————	50 X 8192 Fixation	2 cycles	3000 th (100 kHz or less)	1 cycles (50 Hz input)

- Accuracy requirement of analysis count is limited by the frequency indicated in the parentheses.
- The waveform number displayed on the screen is different depending on the frequency.
- If the fixed clock approach is used, the basic frequency is set to 50 Hz.

(2) Measurement items

Basic items: Voltage rms value, current rms value, active power value, frequency, ±Upeak, ±Ipeak

Harmonic measurement items

Measurement items	Voltage	Current	Active power
Harmonic level	Harmonic voltage	Harmonic current	Harmonic power
Harmonic percentage	Harmonic voltage percentage	Harmonic current percentage	Harmonic power percentage
Harmonic phase angle	Harmonic voltage phase angle	Harmonic current phase angle	Harmonic power phase angle
Total harmonic distortion ratio *1 (THD-F and THD-R)	Total harmonic voltage distortion ratio	Total harmonic current distortion ratio	

*1 THD-F: total harmonic distortion as proportion of the fundamental
THD-R: total harmonic distortion as proportion of the effective value

(3) Screen Displays

Display screen	Display items
List display	Voltage rms value, current rms value, active power value, harmonic level, harmonic percentage, harmonic phase angle, total harmonic distortion ratio
Graph display	Harmonic level, harmonic percentage, harmonic phase angle
Vector display	Harmonic level, harmonic phase angle
Waveform display	Voltage waveform, current waveform, voltage rms value, current rms value, voltage peak value, current peak value, FFT display, Waveform zoom display

(4) Analysis accuracy

(23℃±5℃, 80%RHmax.warming-up 1 hour or more)

Frequency		Amplitude accuracy (Voltage/current/active power)	Phase difference
Basic wave	10～35 Hz	±0.5%rdg.±0.05%f.s.	± 1 deg
Harmonic wave	10～100 Hz	±0.5%rdg.±0.05%f.s.	± 1 deg
	100 Hz～1 kHz	±1.0%rdg.±0.1%f.s.	± 2 deg
	1～5 kHz	±5.0%rdg.±1.0%f.s.	± 5 deg
	5～10 kHz	±15%rdg.±1.0%f.s.	———
Basic wave	35～500 Hz	±0.5%rdg.±0.05%f.s.	± 1 deg
	500 Hz～4.5 kHz	±1.0%rdg.±0.1%f.s.	± 2 deg
Harmonic wave	35～100 Hz	±0.5%rdg.±0.05%f.s.	± 1 deg
	100 Hz～10 kHz	±2.0%rdg.±0.1%f.s.	± 2 deg
	10～50 kHz	±5.0%rdg.±1.0%f.s.	± 5 deg
	50～100 kHz	±15%rdg.±1.0%f.s.	———

* The valid input range is from 5% to 110%.
* The voltage or current level selected for the PLL source is at least 10% of range.
* Accuracy requirement is set to below 10 kHz if the PLL synchronization range is from 10 Hz to 17.5 Hz or from 17.5 Hz to 35 Hz, or below 100 kHz if the synchronization range is 35 Hz or higher.
* Accuracy requirement is not set if the basic frequency synchronized with PLL is not integer multiples of frequency composition.
* If the fixed clock is used, frequency composition other than integer multiples of 50 Hz does not have accuracy requirement set up.
* In actual use, the rdg accuracy of the combined input unit is added to the above analysis accuracy. Also, when it is used together with a clamp (9270, 9271, 9272, 9277, 9278, or 9279), the accuracy of the clamp and the frequency characteristics add to the analysis accuracy.
* If LPF of the input unit is used, the accuracy requirement is set to below 1/10 of LPF.
* While the phase angle is expressed using the PLL source's basic wave as the base standard, the accuracy requirement for the phase angle of the high frequency composition for the basic wave composition is not set.
* The phase for external synchronization signals is defined as variance amount with sine wave (0.1 to 10 Vrms) input to the external synchronization signals and Ext frequency ratio (1/1) setting conditions. Accuracy requirement for other waveforms is not set.
* In combination with the 9601, the phase accuracy above 5 kHz is not specified.

(5) Basic Calculation Formulas

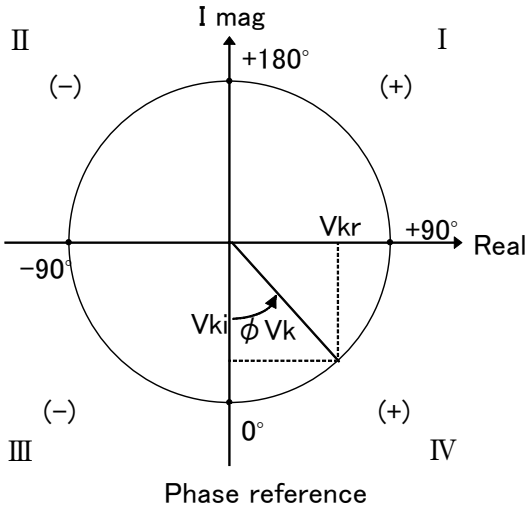
Item \ Mode	1P2W	1P3W	3P3W	3V3A	3P4W
Voltage rms value $U_{(i)} = \sqrt{\frac{1}{M}\sum_{s=0}^{M-1}\{U_{(i)s}\}^2}$	*U* (i) *U* (i+1) *U* (i+2)	*U* (i) *U* (i+1)	*U* (i) *U* (i+1)	*U* (i) *U* (i+1) *U* (i+2)	*U* (i) *U* (i+1) *U* (i+2)
Current rms value $I_{(i)} = \sqrt{\frac{1}{M}\sum_{s=0}^{M-1}\{I_{(i)s}\}^2}$	*I* (i) *I* (i+1) *I* (i+2)	*I* (i) *I* (i+1)	*I* (i) *I* (i+1)	*I* (i) *I* (i+1) *I* (i+2)	*I* (i) *I* (i+1) *I* (i+2)
Active rms value $P_{(i)} = \sqrt{\frac{1}{M}\sum_{s=0}^{M-1}\{U_{(i)s}I_{(i)s}\}^2}$	*P* (i) *P* (i+1) *P* (i+2)	*P* (i) *P* (i+1) *P* (i)+P(i+1)	*P* (i) *P* (i+1) *P* (i+2) *P* (i)+*P*(i+1)	*P* (i) *P* (i+1) *P* (i+2) *P* (i)+*P* (i+1)	*P* (i) *P* (i+1) *P* (i+2) *P* (i)+*P* (i+1)+*P* (i+2)

- (i), (i+1), and (i+2) are the measurement channel numbers.
- M is the number of samples; s is the sample point number.
- The active power of 3P3W and 3V3A channel are displayed but there is no meaning. However, only a sum value (Additional value) has a meaning.

(6) Harmonic Basic Calculation Formulas

Items \ Process		The kth-order harmonic		Total value up to Kth-order harmonic	
Voltage	U [Vrms]	U_k	$\sqrt{\{(U_{kr})^2 + (U_{ki})^2\}}$	U_K	$\sqrt{\sum_{K=2}^{K}(U_k)^2}$
Voltage phase angle	θ U [°]	θU_k	$\tan^{-1}\left(\frac{U_{kr}}{-U_{ki}}\right)$	——	——
Current	I [Arms]	I_k	$\sqrt{\{(I_{kr})^2 + (I_{ki})^2\}}$	I_K	$\sqrt{\sum_{K=2}^{K}(I_k)^2}$
Current phase angle	θ I [°]	θI_k	$\tan^{-1}\left(\frac{I_{kr}}{-I_{ki}}\right)$	——	——
Active power	P [W]	P_k	$U_{kr} \times I_{kr} + U_{ki} \times I_{ki}$	P_K	$\sum_{K=2}^{K} P_k$
Phase difference between voltage and current	θ U_I [°]	θI_k	$\theta_{(i)k} = \theta_{(i)}U_k - \theta_{(i)}U_k$	——	——
Harmonic voltage percentage	HD_U [%]	HDU_k	$\frac{U_k}{U_1} \times 100$	——	——
Harmonic current percentage	HD_I [%]	HDI_k	$\frac{I_k}{I_1} \times 100$		
Harmonic power percentage	HD_P [%]	HD_{Pk}	$\frac{P_k}{P_1} \times 100$		
Total harmonic voltage distortion ratio	THD_{UF} [%]	——	——	THD_{UF}	$\frac{\sqrt{\sum_{k=2}^{k}(U_k)^2}}{U_I} \times 100$
Total harmonic current distortion ratio	THD_{IF} [%]			THD_{IF}	$\frac{\sqrt{\sum_{k=2}^{k}(I_k)^2}}{I_I} \times 100$
Total harmonic voltage distortion ratio	THD_{UR} [%]	——	——	THD_{UR}	$\frac{\sqrt{\sum_{k=2}^{k}(U_k)^2}}{U} \times 100$
Total harmonic current distortion ratio	THD_{IR} [%]			THD_{IR}	$\frac{\sqrt{\sum_{k=2}^{k}(I_k)^2}}{I} \times 100$

Note 1: (i), (i+1), and (i+2) are the measurement channel numbers.
Note 2: The subscript "k" on U, I, and P indicates the harmonic number, so for example "U_1" is the fundamental component of voltage. A "K" indicates the total harmonic analyzed.
Note 3: The subscripts "r" and "i" on Uk and Ik indicate the real and imaginary components of the results of FFT analysis.
Note 4: The harmonic voltage phase angle and harmonic current phase angle are corrected and displayed taking the PLL source forming the phase reference as 0°. A positive sign indicates the phase leading, and a negative sign the phase lagging. (Figure 1 on the next page)
Note 5: The harmonic voltage-current phase difference indicates the difference between the harmonic voltage phase angle and the harmonic current phase angle for the same harmonic. (Figure 2 on the next page)



When the harmonic voltage

$$\text{Ⅰ}: \quad \tan^{-1}\left(\frac{U_{kr}}{-U_{ki}}\right)+180^\circ$$

$$\text{Ⅱ, Ⅲ}: \quad \tan^{-1}\left(\frac{U_{kr}}{-U_{ki}}\right)$$

$$\text{Ⅳ}: \quad \tan^{-1}\left(\frac{U_{kr}}{-U_{ki}}\right)-180^\circ$$

$U_{ki}=0,\ U_{kr}<0$: $+90^\circ$
$U_{ki}=0,\ U_{kr}>0$: -90°
$U_{ki}<0,\ U_{kr}=0$: $+180^\circ$
$U_{ki}=0,\ U_{kr}=0$: 0°

Figure 1

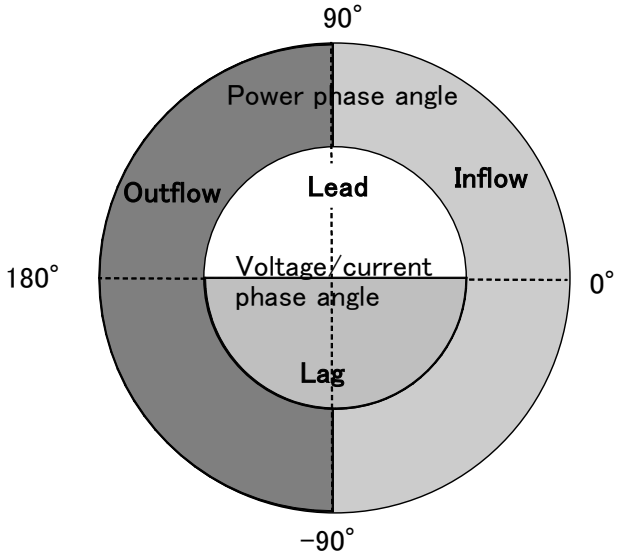


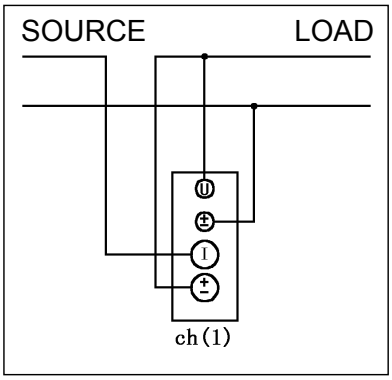
Figure 2

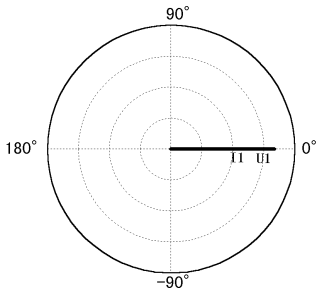
(7) Harmonic calculations for each wiring mode

Item \ Mode	1P2W	1P3W	3P3W	3V3A	3P4W
Harmonic voltage	$U_{(i)k}$ $U_{(i+1)k}$ $U_{(i+2)k}$	$U_{(i)k}$ $U_{(i+1)k}$	$U_{(i)k}$ $U_{(i+1)k}$	$U_{(i)k}$ $U_{(i+1)k}$ $U_{(i+2)k}$	$U_{(i)k}$ $U_{(i+1)k}$ $U_{(i+2)k}$
Harmonic current	$I_{(i)k}$ $I_{(i+1)k}$ $I_{(i+2)k}$	$I_{(i)k}$ $I_{(i+1)k}$	$I_{(i)k}$ $I_{(i+1)k}$	$I_{(i)k}$ $I_{(i+1)k}$ $I_{(i+2)k}$	$I_{(i)k}$ $I_{(i+1)k}$ $I_{(i+2)k}$
Harmonic power	$P_{(i)k}$ $P_{(i+1)k}$ $P_{(i+2)k}$	$P_{(i)k}$ $P_{(i+1)k}$ $P_{(i)k+P\ (i+1)k}$	$P_{(i)k}$ $P_{(i+1)k}$ $P_{(i)k+P\ (i+1)k}$	$P_{(i)k}$ $P_{(i+1)k}$ $P_{(i+2)k}$ $P_{(i)k+P\ (i+1)k}$	$P_{(i)k}$ $P_{(i+1)k}$ $P_{(i+2)k}$ $P_{(i)k}+P_{(i+1)k}+P_{(i+2)k}$
Harmonic voltage percentage	$HD_{(i)}U_k$ $HD_{(i+1)}U_k$ $HD_{(i+2)}U_k$	$HD_{(i)Uk}$ $HD_{(i+1)Uk}$	$HD_{(i)Uk}$ $HD_{(i+1)Uk}$	$HD_{(i)Uk}$ $HD_{(i+1)Uk}$ $HD_{(i+2)Uk}$	$HD_{(i)Uk}$ $HD_{(i+1)Uk}$ $HD_{(i+2)Uk}$
Harmonic current percentage	$HD_{(i)Ik}$ $HD_{(i+1)Ik}$ $HD_{(i+2)Ik}$	$HD_{(i)Ik}$ $HD_{(i+1)Ik}$	$HD_{(i)Ik}$ $HD_{(i+1)Ik}$	$HD_{(i)Ik}$ $HD_{(i+1)Ik}$ $HD_{(i+2)Ik}$	$HD_{(i)Ik}$ $HD_{(i+1)Ik}$ $HD_{(i+2)Ik}$
Harmonic power percentage	$HD_{(i)Pk}$ $HD_{(i+1)Pk}$ $HD_{(i+2)Pk}$	$HD_{(i)pk}$ $HD_{(i+1)pk}$ $HD_{(i)pk+}HD_{(i+1)pk}$	$HD_{(i)pk}$ $HD_{(i+1)pk}$ $HD_{(i)pk+}HD_{(i+1)pk}$	$HD_{(i)pk}$ $HD_{(i+1)pk}$ $HD_{(i+2)pk}$ $HD_{(i)pk+}HD_{(i+1)pk+}$ $HD_{(i+2)pk}$	$HD_{(i)pk}$ $HD_{(i+1)pk}$ $HD_{(i+2)pk}$ $HD_{(i)pk+}HD_{(i+1)pk+}$ $HD_{(i+2)pk}$
Harmonic voltage phase angle	$\theta_{(i)}U_k$ $\theta_{(i+1)}U_k$ $\theta_{(i+2)}U_k$	$\theta_{(i)}U_k$ $\theta_{(i+1)}U_k$	$\theta_{(i)}U_k$ $\theta_{(i+1)}U_k$	$\theta_{(i)}U_k$ $\theta_{(i+1)}U_k$ $\theta_{(i+2)}U_k$	$\theta_{(i)}U_k$ $\theta_{(i+1)}U_k$ $\theta_{(i+2)}U_k$
Harmonic current phase angle	$\theta_{(i)}I_k$ $\theta_{(i+1)}I_k$ $\theta_{(i+2)}I_k$	$\theta_{(i)Ik}$ $\theta_{(i+1)Ik}$	$\theta_{(i)Ik}$ $\theta_{(i+1)Ik}$	$\theta_{(i)Ik}$ $\theta_{(i+1)Ik}$ $\theta_{(i+2)Ik}$	$\theta_{(i)Ik}$ $\theta_{(i+1)Ik}$ $\theta_{(i+2)Ik}$
Harmonic phase difference between voltage and current	$\theta_{(i)k}$ $\theta_{(i+1)k}$ $\theta_{(i+2)k}$	$\theta_{(i)k}$ $\theta_{(i+1)k}$	$\theta_{(i)k}$ $\theta_{(i+1)k}$	$\theta_{(i)k}$ $\theta_{(i+1)k}$	$\theta_{(i)k}$ $\theta_{(i+1)k}$ $\theta_{(i+2)k}$
Total harmonic voltage distortion ratio (THD-F)	$THD_{(i)}U_F$ $THD_{(i+1)}U_F$ $THD_{(i+2)}U_F$	$THD_{(i)}U_F$ $THD_{(i+1)}U_F$	$THD_{(i)}U_F$ $THD_{(i+1)}U_F$	$THD_{(i)}U_F$ $THD_{(i+1)}U_F$ $THD_{(i+2)}U_F$	$THD_{(i)}U_F$ $THD_{(i+1)}U_F$ $THD_{(i+2)}U_F$
Total harmonic current distortion ratio (THD-F)	$THD_{(i)}I_F$ $THD_{(i+1)}I_F$ $THD_{(i+2)}I_F$	$THD_{(i)}I_F$ $THD_{(i+1)}I_F$	$THD_{(i)}I_F$ $THD_{(i+1)}I_F$	$THD_{(i)}I_F$ $THD_{(i+1)}I_F$ $THD_{(i+2)}I_F$	$THD_{(i)}I_F$ $THD_{(i+1)}I_F$ $THD_{(i+2)}I_F$
Total harmonic voltage distortion ratio (THD-R)	$THD_{(i)}U_R$ $THD_{(i+1)}U_R$ $THD_{(i+2)}U_R$	$THD_{(i)}U_R$ $THD_{(i+1)}U_R$	$THD_{(i)}U_R$ $THD_{(i+1)}U_R$	$THD_{(i)}U_R$ $THD_{(i+1)}U_R$ $THD_{(i+2)}U_R$	$THD_{(i)}U_R$ $THD_{(i+1)}U_R$ $THD_{(i+2)}U_R$
Total harmonic current distortion ratio (THD-R)	$THD_{(i)}I_R$ $THD_{(i+1)}I_R$ $THD_{(i+2)}I_R$	$THD_{(i)}I_R$ $THD_{(i+1)}I_R$	$THD_{(i)}I_R$ $THD_{(i+1)}I_R$	$THD_{(i)}I_R$ $THD_{(i+1)}I_R$ $THD_{(i+2)}I_R$	$THD_{(i)}I_R$ $THD_{(i+1)}I\ R$ $THD_{(i+2)}I_R$

Appendix

1P2W wiring

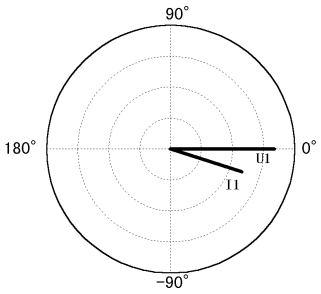




①

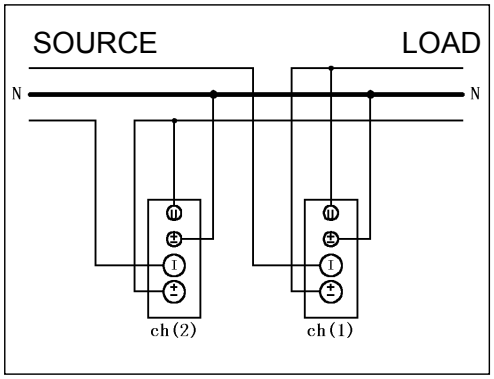
① When the U1 is selected as the PLL source
When the load is purely resistive, the phase difference between voltage and current is 0.

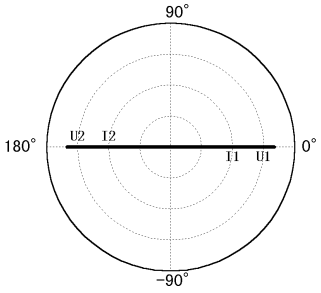
② When the load is capacitive
The current has lagging phase, and when the load is inductive, the current has leading phase.



②

1P3W wiring

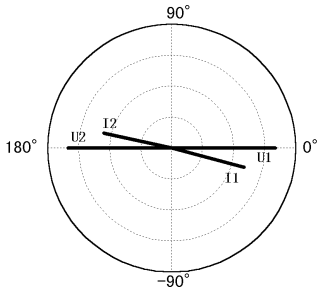




①

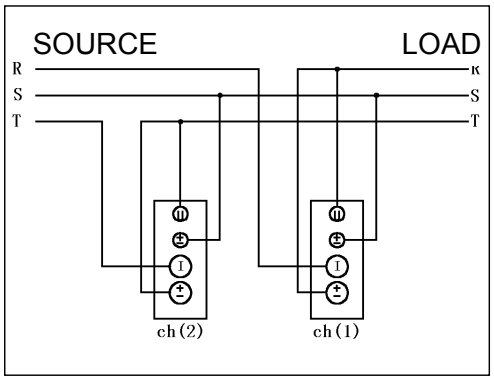
① When the U1 is selected as the PLL source
U2 is reverse phased 180° from U1.

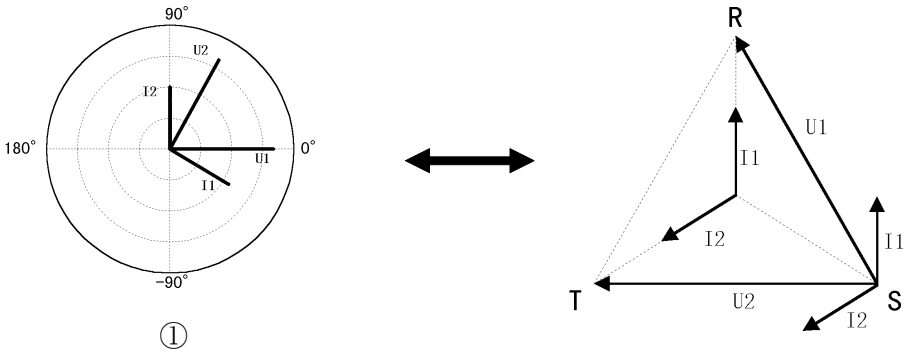
② When the load is purely resistive
The phase difference between U1 and I1 and U2 and I2 is 0, as shown above. When the load is inductive, the current phase lags the voltage.



②

3P3W wiring

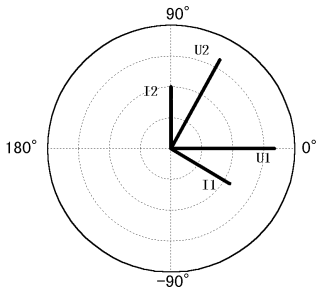




①

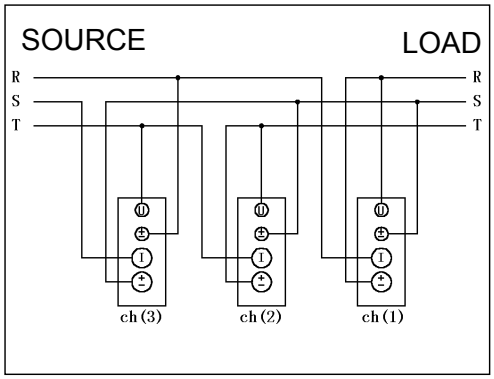
① When the U1 is selected as the PLL source
Voltage is measured between lines and current is measured with phase, so U2 is phased 60° from U1. When the load is purely resistive, I1 lags U1 by 30° , and I2 leads U2 by 30° .

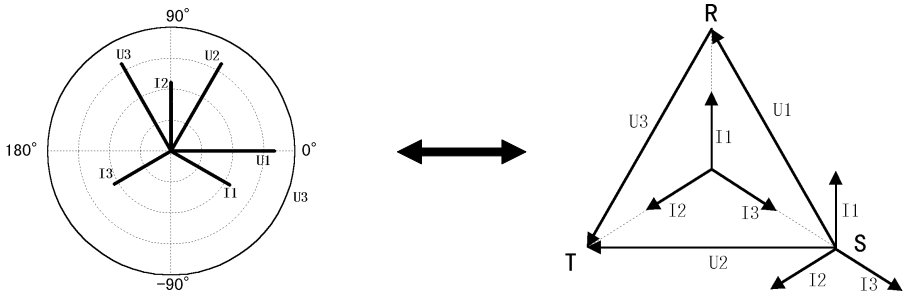
② With an inductive load such as a motor, when the effective power of ch1 is negative, the phase of I1 lags U1 by more than 90° .



②

3V3A wiring

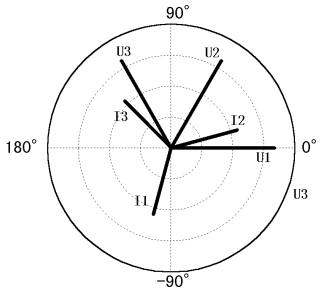




①

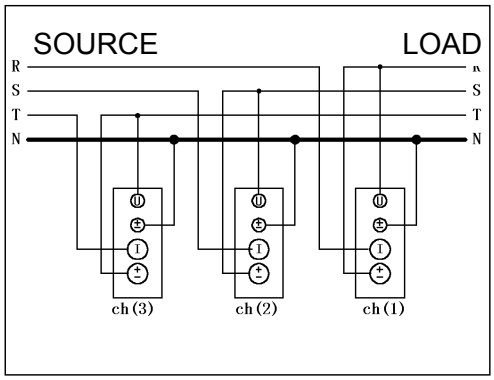
① When the U1 is selected as the PLL source
Based on 3P3W wiring, the three channels of voltage and current are summed. The figures above show the state when the load is purely resistive.

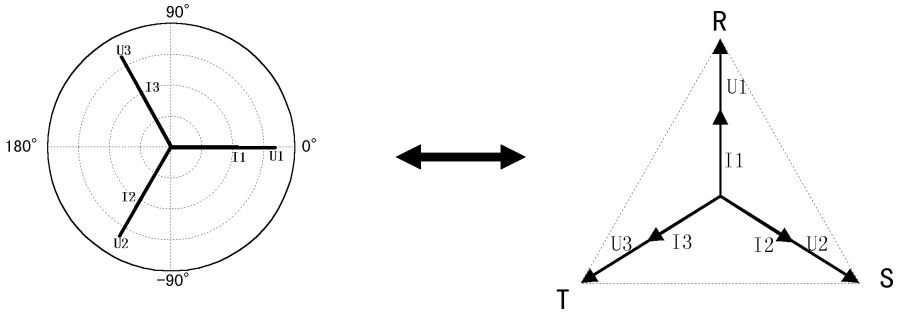
② With an inductive load such as a motor
The effective power of ch1 appears negative because I1 lags U1 by more than 90° . However, the summed data for ch(3) is not related to power measurement, so wiring can be reversed.



②

3P4W wiring

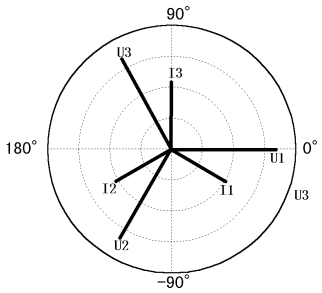




①

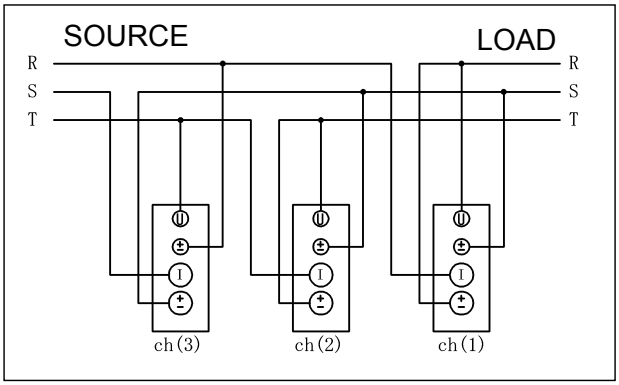
① When the U1 is selected as the PLL source
To measure voltage and current phase, the phase of the voltage of each channel is shifted 120° . When the load is purely resistive, as shown above, the phase difference of the voltage and current of each channel is 0. Compared to 3P3W (3V3A) wiring, ch(2) and ch(3) are switched.

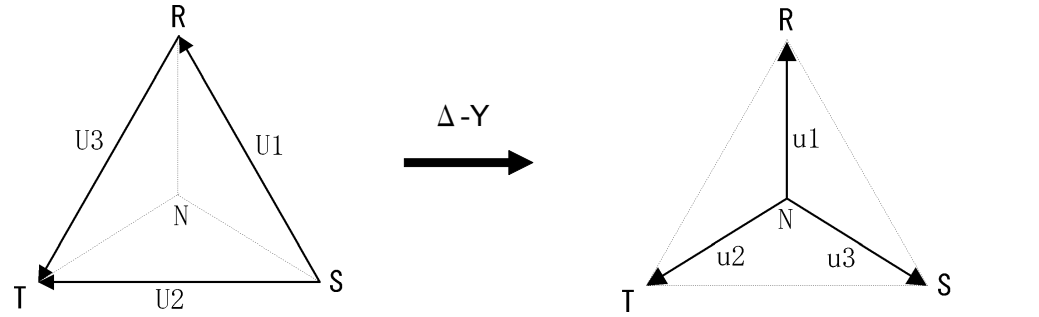
② With an inductive load such as a motor, the phase of the current lags the voltage.



②

3V3A Wiring (Δ-Y conversion)



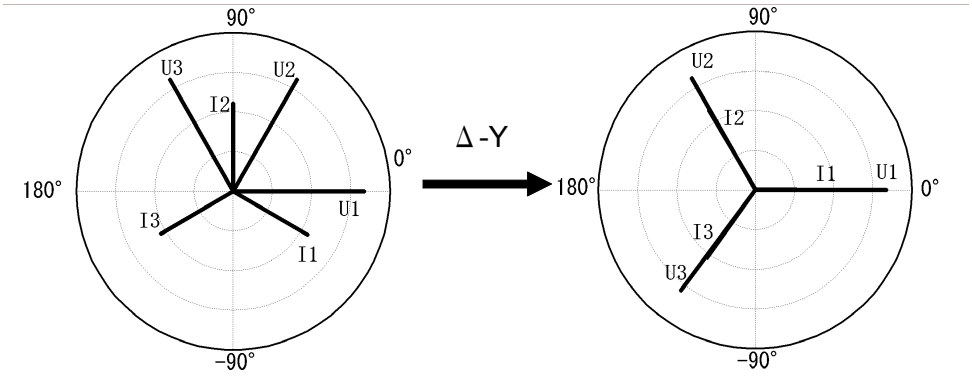


Voltage vector diagram of 3V3A
Psum = P1 + P2

Voltage vector diagram after conversion
Psum = P1 + P2 +P3

■ Conversion Theory

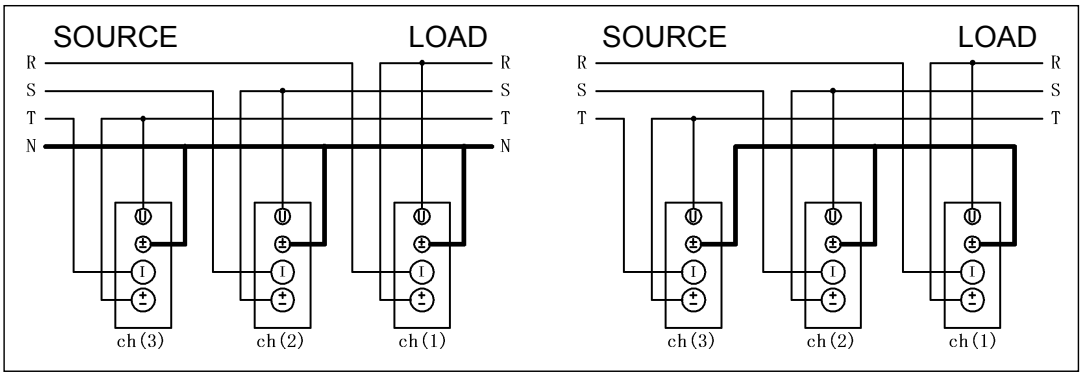
The momentary waveforms of the line voltages (U1, U2, and U3) are converted into momentary waveforms for phase voltages (u1, u2, and u3) using the following operation expressions ("s" refers to value).
u1s = (U1s-U3s)/3, u2s = (U3s+U2s)/3, u3s = (-U2s-U1s)/3

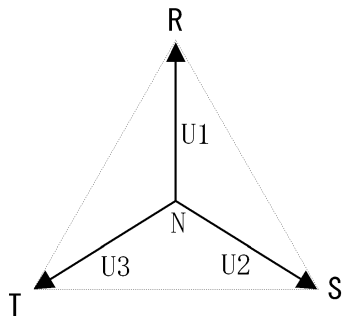


NOTE

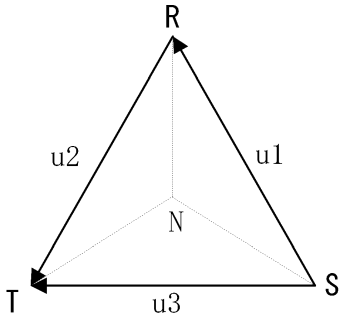
- Since N is a virtual neutral point, phase voltages may differ from actual values.
- Following conversion, the three power meter method is applied.
- Following conversion, the 9605-01 vector screen changes as follows. (Load: resistance)

3P4W Wiring (Y-Δ conversion)





Y-Δ

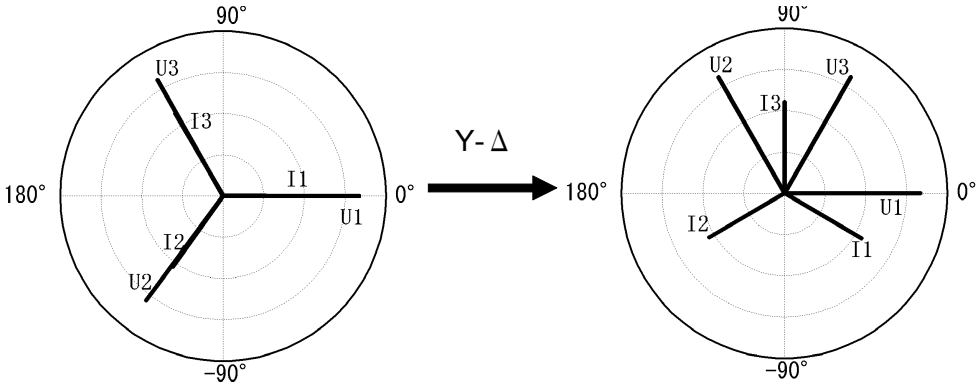


Voltage vector diagram of 3P4W
Psum = P1 + P2 +P3

Voltage vector diagram after conversior
Psum = P1 + P3

■ Conversion Theory

The momentary waveforms for phase voltages (U1, U2, and U3) are converted into momentary waveforms for line voltages (u1, u2, and u3) using the following operation expressions ("s" refers to sampling value).
u1s = (U1s-U2s), u2s = (U3s-U1s) , u3s = (U3s-U2s)



NOTE

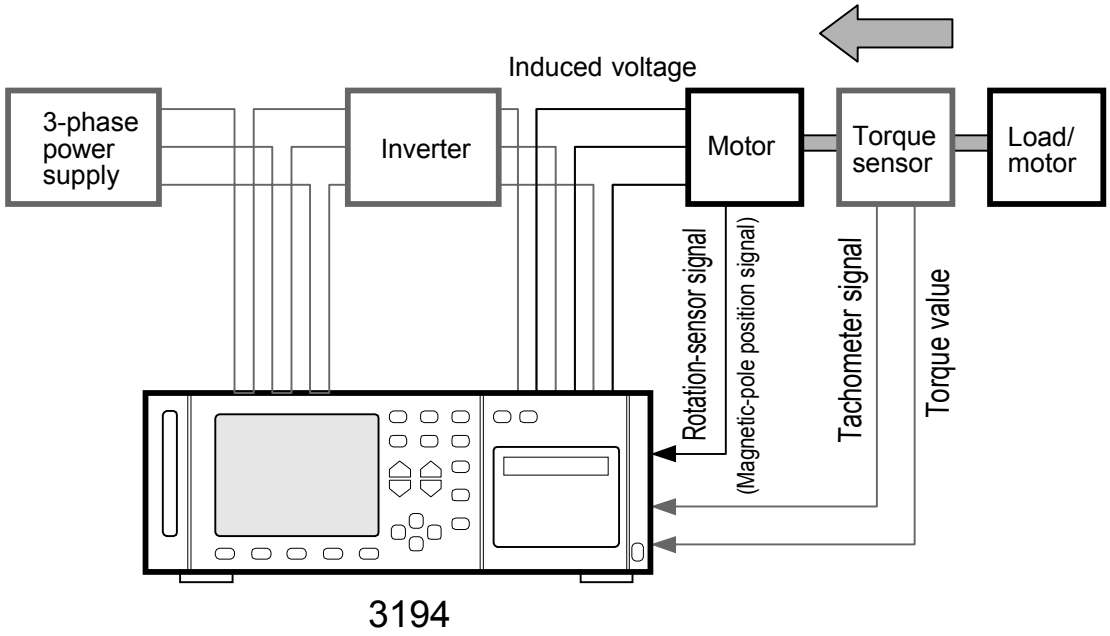
- Following conversion, the two power meter method is applied.
- Following conversion, the 9605-01 vector screen changes as follows. (Load: resistance)

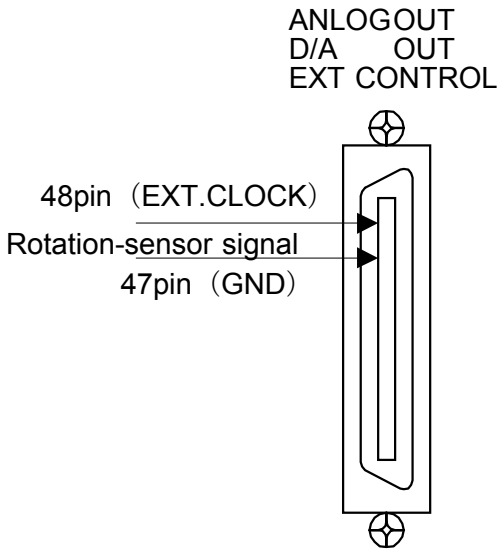
Example of Motor-Induced Voltage Measurement

Run the motor by operating the load (motor), without supplying voltage from the inverter to the motor, and measure the induced voltage generated at the motor terminal.

■ Connection

1. Connect voltage and current lines as shown below, in the same way as when the motor is operated using an inverter.
2. The rotation-sensor signal must be connected to pins 48/47 of the "EXT CONTROL" terminal on the rear panel of the 3194. The required input level is a 1- to 10-Vrms sine wave or a TTL-level rectangular wave. Please note that this input terminal is not insulated from the chassis. In addition, set the PLL source to "EXT (con)."
3. To insulate the rotation-sensor signal, set the PLL source to "EXT (CH6)"; it will be taken in as a CH6 voltage input. In such a case, make sure the rotation-sensor signal level is more than 50% of the voltage range of the unit connected to the CH6.





The 3194 can be used for the following measurement when a rotation-sensor signal (e.g., magnetic-pole position signal) is input.

(1) Zero-correction of phase difference

The 3194 is capable of zero-correction of the phase difference (electrical angle) between the rotation-sensor signal and the induced voltage fundamental wave. If this correction is made, line voltages generated when the motor is driven by an inverter, and the line current vectors can be evaluated by evaluating the rotation-sensor signals instead. Accurate correction will be made even if the induced voltage is distorted, as the 3194 extracts the fundamental wave from the induced voltage using its harmonic analysis function.

NOTE

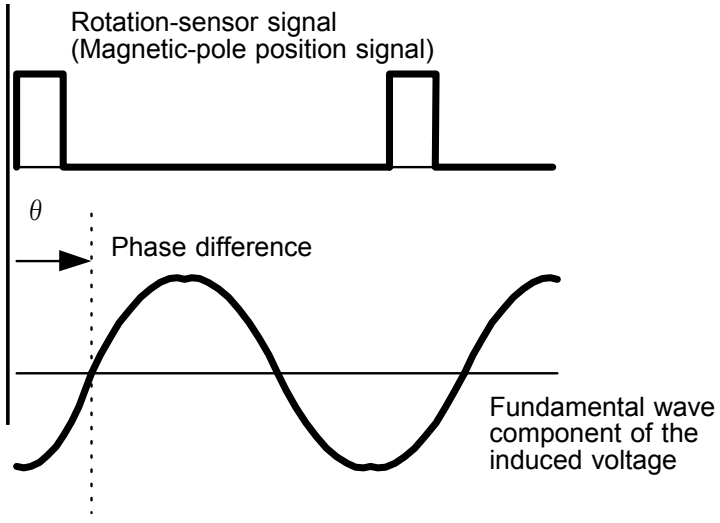
To ensure reproducibility, the motor must have the same rotational pulse count as when the 3194 is used with a dividing setting of 1/1. For example, the pulse count must be 2 pulses/rotation in the case of a 4-pole motor.

(2) Harmonic measurement of induced voltage

The 3194 is capable of harmonic measurement of the induced voltage. Using the harmonic analysis function, the 3194 measures the rms value, fundamental wave component, and harmonic of the induced voltage (line voltage). In addition, using the Δ - Y conversion function, the induced voltage may be converted to a phase voltage.

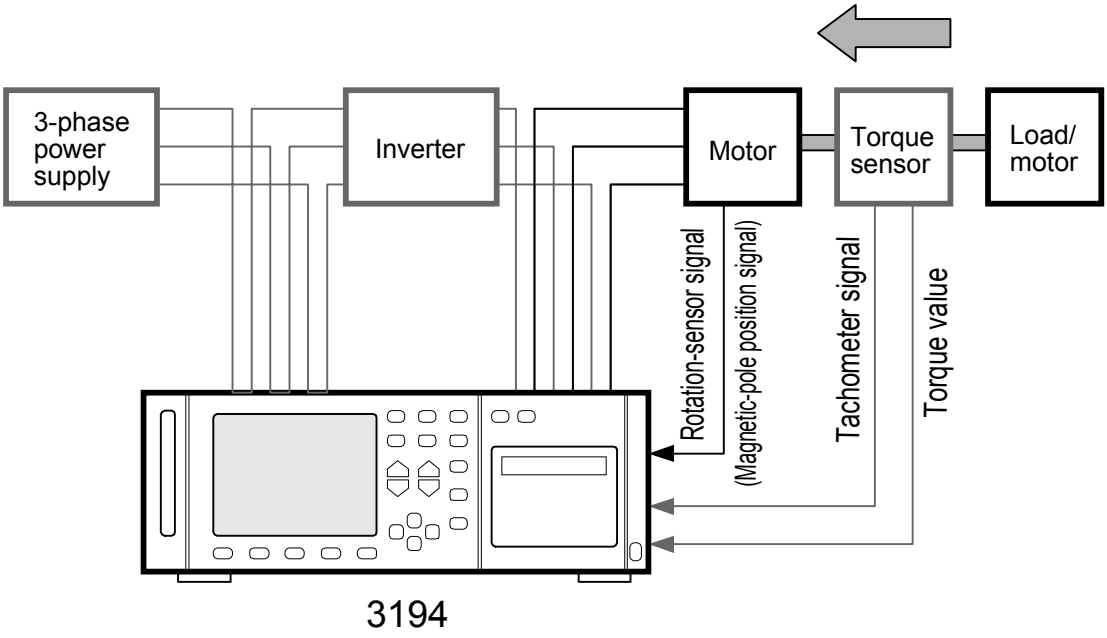
NOTE

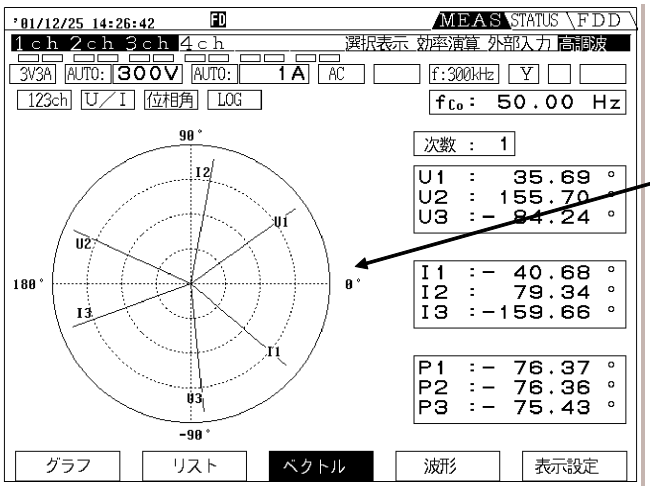
- For the phase difference (θ), the absolute accuracy is not specified. The accuracy will be specified as a deviation, based on a comparison of one cycle of induced voltage with one cycle of the rotation-sensor signal. In addition, the 3194 measures the distance between the rising edge of the rotation-sensor signal and the rising zero-crossing of the induced-voltage fundamental wave.
- The zero-correction setting is valid for a single piece of data only. If the frequency changes, zero-correction must be performed again.
- The zero-correction setting is cleared when power to the 3194 is turned off.



Example of Motor Electrical-Angle Measurement (1)

When a motor is actually run by an inverter, changes in the control of the inverter and the motor can be determined easily, without significant change in the wiring for the induced-voltage measurement.
If zero-correction is performed on the phase difference between the rotation-sensor signal and the induced voltage during the motor induced-voltage measurement, the relationship between the fundamental wave phases (electrical angle) of the line voltages and phase currents can be easily seen on the vector screen, with the induced-voltage phase used as a reference. By checking the screen, therefore, changes in the control of the inverter and the motor as a result of fluctuations in the load can be easily determined. The line voltages may be also expressed as phase voltages (virtual neutral) using the Δ - Y conversion function.





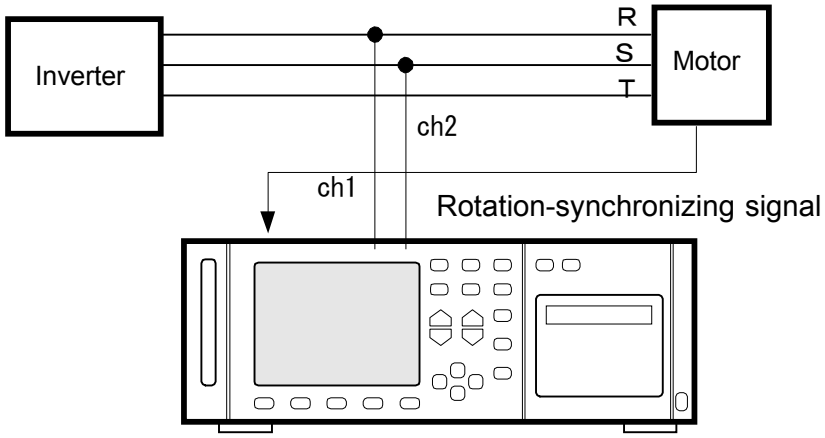
When the rotation-sensor signal is used as a reference, if zero-correction is performed on the rotation-sensor signal phase and the induced-voltage phase, the induced-voltage phase will coincide with the reference.

Example of Motor Electrical-Angle Measurement (2)

If the rotation-synchronizing signal is not a rectangular wave, use the alternative method.

■ Procedure (requiring a 2-channel input unit)

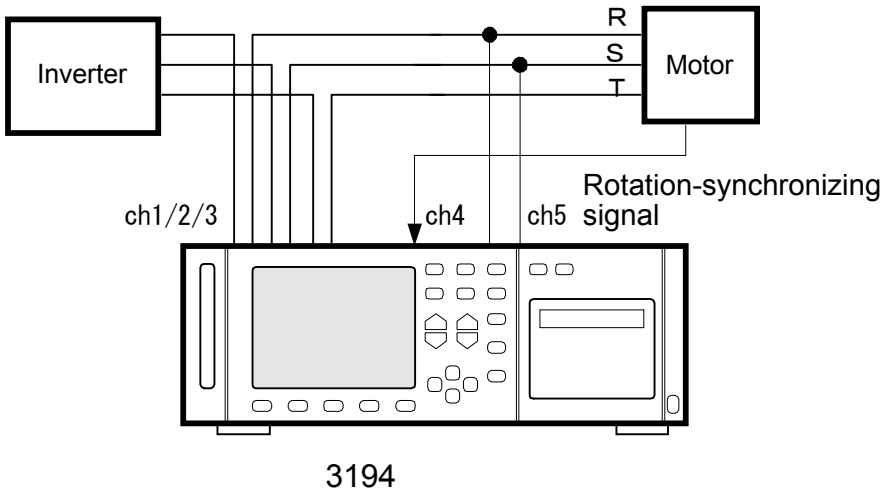
1. Input the rotation-synchronizing signal to channel 1. The rotation-synchronizing signal is a TTL-level signal.
2. Input the line voltage or current to be analyzed to channel 2.
3. Set the PLL source to "U1."



Use the following method to measure the electrical angle while measuring the power of a 3-phase line.

■ Procedure (requiring a 5-channel input unit)

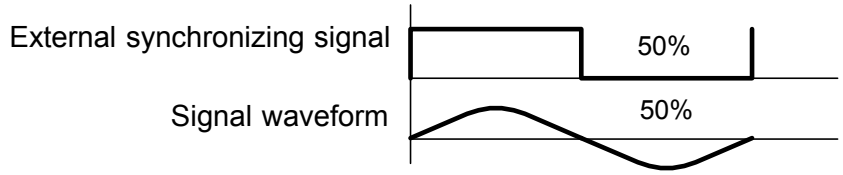
1. Connect the three phases to channels 1, 2, and 3, respectively.
2. Connect the rotation-synchronizing signal to channel 4, and the line to be analyzed to channel 5.
3. Set the harmonic-analysis channels to channels 4 and 5.
4. Set the PLL source to "U4."



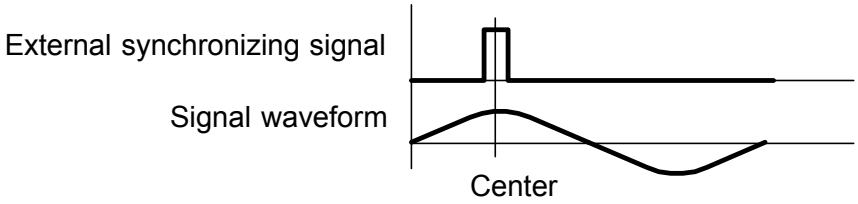
NOTE

Harmonic analysis will not be performed on channels 1, 2, or 3.

With this method, the rotation-synchronizing signal also undergoes FFT analysis. In addition, using the fundamental wave as a reference, the absolute phase of the signal of the line to be analyzed is measured. If the duty ratio of the rotation-synchronizing signal is 50%, when the zero-crossing of the rotation-synchronizing signal coincides with the zero-crossing of the line to be analyzed, the phase difference will be 0 deg. If the duty ratio is other than 50%, even if the phase difference is indicated as 0 deg., the zero-crossing points will not coincide.



Conditions for 0-degree phase difference with a duty ratio of 50%



Conditions for 0-degree phase difference with a duty ratio of 50%

HIOKI 9605-01 HARMONIC MEASUREMENTS UNIT

Instruction Manual

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