User's
Manual

DL850E/DL850EV
ScopeCorder
Real Time Math (/G3)/
Power Math (/G5)

YOKOGAWA
Yokogawa Test & Measurement Corporation

IM DL850E-51EN
7th Edition

Thank you for purchasing the DL850E ScopeCorder or DL850EV ScopeCorder Vehicle Edition (hereinafter, “DL850E/DL850EV” will refer to both of these products).
This User’s Manual explains the real time math and power math features. To ensure correct use, please read this manual thoroughly before beginning operation.
Keep this manual in a safe place for quick reference in the event a question arises.

List of Manuals

The following manuals, including this one, are provided as manuals for the DL850E/DL850EV. Please read all manuals.

Manual Title	Manual No.	Description
DL850E/DL850EV ScopeCorder Features Guide	IM DL850E-01EN	The supplied CD contains the PDF file of this manual. This manual explains all the DL850E/DL850EV features other than the communication interface features.
DL850E/DL850EV ScopeCorder User’s Manual	IM DL850E-02EN	The supplied CD contains the PDF file of this manual. The manual explains how to operate the DL850E/DL850EV.
DL850E/DL850EV ScopeCorder Getting Started Guide	IM DL850E-03EN	This guide explains the handling precautions and basic operations of the DL850E/DL850EV.
DL850E/DL850EV ScopeCorder Communication Interface User’s Manual	IM DL850E-17EN	The supplied CD contains the PDF file of this manual. This manual explains the DL850E/DL850EV communication interface features and how to use them.
DL850E/DL850EV ScopeCorder Real Time Math/Power Math User’s Manual	IM DL850E-51EN	This manual. The supplied CD contains the PDF file of this manual. This manual explains the features of the DL850E/DL850EV Real Time Math/Power Math option and how to use them.
DL850E/DL850EV ScopeCorder Acquisition Software User’s Manual	IM DL850E-61EN	The supplied CD contains the PDF file of this manual. This manual explains all the features of the acquisition software, which records and displays data measured with the DL850E/DL850EV on a PC.
Precautions Concerning the Modules	IM 701250-04E	The manual explains the precautions concerning the modules. This manual is included if you ordered modules.
Model DL850E ScopeCorder, Model DL850EV ScopeCorder Vehicle Edition, User’s Manual	IM DL850E-92Z1	Document for China

The “EN”, “E”, “Z1” and “Z2” in the manual numbers are the language codes.

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

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

Regarding the Conventional DL850 and DL850V

The DL850E/DL850EV manuals also cover how to use the conventional DL850/DL850V (firmware version 3.0 and later).
In the explanations, the model is indicated as DL850E/DL850EV, but if you are using the DL850/DL850V, read “DL850E” as “DL850” and “DL850EV” as “DL850V.” The following options are available only for the DL850E/DL850EV. They cannot be used with the DL850 or DL850V.

- Power math (/G5 option)
- GPS interface (/C30 option)

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Notes

- The contents of this manual are subject to change without prior notice as a result of continuing improvements to the instrument's performance and functionality. The figures given in this manual may differ from those that actually appear on your screen.
- Every effort has been made in the preparation of this manual to ensure the accuracy of its contents. However, should you have any questions or find any errors, please contact your nearest YOKOGAWA dealer.
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Revisions

- 1st Edition: December 2013
- 2nd Edition: July 2014
- 3rd Edition: March 2015
- 4th Edition: October 2015
- 5th Edition: July 2017
- 6th Edition: November 2017
- 7th Edition: April 2018

Conventions Used in This Manual

Notes and Cautions

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

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

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

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

French

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

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

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

Unit

k	Denotes 1000. Example: 100 kS/s (sample rate)
K	Denotes 1024. Example: 720 KB (file size)

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5 Commands

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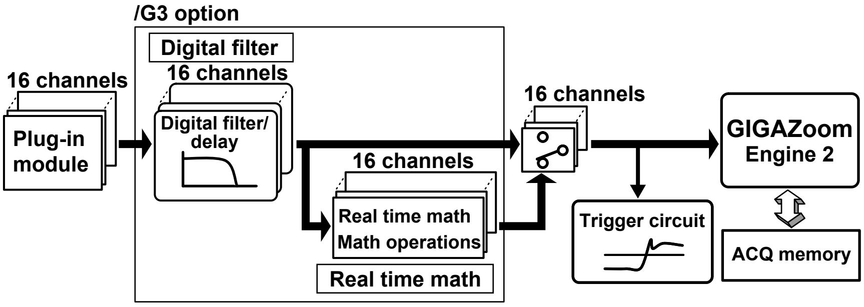
1 Features

The digital filter, delay, and real time math features can be used on DL850E/DL850EVs with the /G3 option. The /G5 option expands the real time math feature to include power math and harmonic analysis.

- You can set a digital filter or delay on input channel waveforms (A/D converted data). You can also perform real time math operations in which the waveforms of input channels or the results of other real time math operations are used as the math source waveforms.
- The results of filtering and math operations are acquired in acquisition memory—the same place that input channel waveforms are acquired.
- You can perform filtering and math operations on up to 16 channels at the same time.
- By setting the waveform that results from filtering or math operations as a trigger source, you can trigger the DL850E/DL850EV on the results.



Digital Filter and Delay (Filter/Delay Setup)

You can set digital filters and delays on input channel waveforms (A/D converted data). This is one of the features of the /G3 and /G5 option.

- Configure the settings for each channel. You can perform filtering on up to 16 channels at the same time.
- Even during waveform acquisition, you can set the filter type, filter band, and cutoff frequency.
- The digital filter/delay setup menu is displayed when the real time math menu is turned off.
- To enable the digital filter/delay feature and the real time math feature at the same time, you have to first configure the digital filter/delay settings, and then turn the real time math menu on.
- You cannot set digital filters or delays on the bits or input channels of a logic, 16-CH voltage input, 16-CH temperature/voltage input, CAN bus monitor, CAN & LIN bus monitor, CAN/CAN FD monitor, SENT monitor, or 4-CH module.
- By setting the waveform that results from filtering as a trigger source, you can trigger the DL850E/DL850EV on the results.
- For details on the digital filter characteristics, delay, and settings, see the appendix.

Bandwidth (Bandwidth)

When you set a filtering feature, it takes effect immediately.

- Digital (Digital): Select this item to display a menu for configuring the optional digital filter.
- LPF: Select this item to display a menu for configuring the standard filter.
  For details on the standard filter feature, see the *Features Guide*, IM DL850E-01EN.

Filter Type (Filter Type)

The following digital filter types are available: Gauss, Sharp, IIR, Mean and IIR-Lowpass. The features of each filter are listed below.

Filter Type	Features	Operation Type
Gauss	• Frequency characteristics with a smooth attenuation slope • Linear phase and constant group delay • No ripples present in the passband • No overshoot in the step response • Low order and short delay	FIR
Sharp	• Frequency characteristics with a sharp attenuation slope (–40 dB at 1 oct) • Linear phase and constant group delay • Ripples present in the passband • Comb-shaped stopband	FIR
IIR	• Attenuation slope steepness between those of the SHARP and GAUSS filters • Non-linear phase and non-constant group delay • No ripples present in the passband and stopband • Characteristics similar to those of analog filters • Compared to Sharp and Gauss filters, lower cutoff frequency possible	IIR
Mean	• Comb-shaped frequency characteristics • Linear phase and constant group delay • No overshoot in the step response	FIR
IIR-Lowpass	• Computes at 10 MS/s regardless of the setting.	IIR

Filter Band (Filter Band)

When the filter type is set to Gauss, Sharp, or IIR, you can select the filter band. The type of filter band that you can select depends on the filter type.

Filter Type	Filter Band
Gauss	Low-Pass
Sharp	Low-Pass, High-Pass, Band-Pass
IIR	Low-Pass, High-Pass, Band-Pass

Cutoff Frequency (CutOff)

When the filter type is set to Sharp, Gauss, or IIR and the filter band is set to Low-Pass or High-Pass, you can set the cutoff frequency. The ranges and resolutions are indicated below.

Filter Type	Filter Band	Range	Resolution
Gauss	Low-Pass	0.002 kHz to 300 kHz Default value: 300 kHz	0.0002 kHz (0.002 kHz to 0.0298 kHz range) 0.002 kHz (0.03 kHz to 0.298 kHz range) 0.02 kHz (0.30 kHz to 2.98 kHz range) 0.2 kHz (3.0 kHz to 29.8 kHz range) 2 kHz (30 kHz to 300 kHz range)
Sharp	Low-Pass	0.002 kHz to 300 kHz Default value: 300 kHz	0.0002 kHz (0.002 kHz to 0.0298 kHz range) 0.002 kHz (0.03 kHz to 0.298 kHz range) 0.02 kHz (0.30 kHz to 2.98 kHz range) 0.2 kHz (3.0 kHz to 29.8 kHz range) 2 kHz (30 kHz to 300 kHz range)
	High-Pass	0.20 kHz to 300 kHz Default value: 300 kHz	0.02 kHz (0.20 kHz to 2.98 kHz range) 0.2 kHz (3.0 kHz to 29.8 kHz range) 2 kHz (30 kHz to 300 kHz range)
IIR	Low-Pass	0.002 kHz to 300 kHz Default value: 300 kHz	0.002 kHz (0.002 kHz to 0.298 kHz range) 0.02 kHz (0.30 kHz to 2.98 kHz range) 0.2 kHz (3.0 kHz to 29.8 kHz range) 2 kHz (30 kHz to 300 kHz range)
	High-Pass	0.02 kHz to 300 kHz Default value: 300 kHz	0.02 kHz (0.02 kHz to 2.98 kHz range) 0.2 kHz (3.0 kHz to 29.8 kHz range) 2 kHz (30 kHz to 300 kHz range)

Filter Type	Filter Band	Range	Resolution
IIR-Lowpass	Low-Pass	128 kHz, 64 kHz, 32 kHz, 16 kHz, 8 kHz, 4 kHz, 2 kHz, 1 kHz, 500 Hz, 250 Hz, 125 Hz, 62.5 Hz Default value: 128 kHz	–

Center Frequency (Center Frequency)

When the filter type is set to Sharp or IIR and the filter band is set to Band-Pass, set the center frequency. The ranges and resolutions are indicated below.

Filter Type	Range	Resolution
Sharp	0.30 kHz to 300 kHz Default value: 300 Hz	0.02 kHz (0.30 kHz to 2.98 kHz range)
		0.2 kHz (3 kHz to 29.8 kHz range)
		2 kHz (30 kHz to 300 kHz range)
IIR	0.06 kHz to 300 kHz Default value: 300 Hz	0.02 kHz (60 Hz to 1.18 kHz range)
		0.2 kHz (1.2 kHz to 11.8 kHz range)
		2 kHz (12 kHz to 300 kHz range)

Bandwidth (Pass Band)

When the filter type is set to Sharp or IIR and the filter band is set to Band-Pass, set the bandwidth. The bandwidth options vary depending on the center frequency that you have set. For details about these options, see the appendix.

Tap (Tap)

When the filter type is set to Mean, select the number of taps (number of levels) from the following options. The larger the number of taps, the sharper the filter characteristics become.
2, 4, 8, 16, 32, 64, 128

Mean Sample Rate (Mean Sample)

When the filter type is set to Mean, select the sample rate from the following options. The specified sample rate is used to sample waveforms and to filter them.
1 M, 100 k, 10 k, 1 k (unit: S/s)

Interpolation On and Off (Interpolate)

Select whether to perform data interpolation when the filter type is Gauss, Sharp, IIR, or Mean (moving average). Select whether to perform data interpolation. Up to 10 M samples of data can be interpolated from the data of waveforms that pass through the digital filter. The interpolation method is linear interpolation.

- ON: Data is interpolated.
- OFF: Data is not interpolated.

Delay (Delay)

You can set a delay on waveforms that pass through the digital filter.
The sampling data is decimated in a simple manner to produce the data delay. Consequently, if you set a large delay, data updating automatically becomes slower. The default value is 0.0 μs.

Range	Resolution	Data Update Frequency
0.0 μs to 100 μs	0.1 μs	10 MHz
101 μs to 1.00 ms	1 μs	1 MHz
1.01 ms to 10.00 ms	0.01 ms	100 kHz

Note

The delay is valid even if you are not using the digital filter. However, if you set a delay, the sampling data automatically passes through the digital filter circuit. Therefore, the actual delay when you are not using the digital filter is 1.4 μs (the minimum math delay) + the set delay.

Real Time Math (RealTime Math)

Turning Real Time Math On and Off

Select whether to use real time math.

- ON: Select this item to display a menu for configuring real time math. At the same time, real time math execution begins.
- OFF: Select this item to display a menu for configuring the standard model. Real time math is not executed.
  For details on the features of the standard model, see the *Features Guide*, IM DL850E-01EN.

You can perform real time math operations in which the waveforms of input channels or the results of other real time math operations are used as the math source waveforms. This is one of the features of the /G3 option.

- Configure the settings for each channel. You can perform math operations on up to 16 channels at the same time.
- When you turn real time math on, the real time math results are output to the real time math channels (the channels that you have turned math on for). The waveforms of input channels whose math is turned on are not used for displaying, saving, triggering, or analyzing (cursor measurement, automated measurement of waveform parameters, math computation, FFT, GO/NO-GO, search, history, power math of the /G5 option, etc.). For example, if you turn real time math on for input channel CH2, CH2 becomes the RMath2 real time math channel, and the math results are displayed on the screen. The data that is saved is that of the math result. If you want to display, save, trigger on, or analyze the waveform of the input channel, set the real time math to a channel that has no input.
- Waveforms of real time math channels (real time math results) are used for displaying, saving, triggering, and analyzing (except for power math).
- Other real time math channels can be used as source waveforms of real time math. If you set the real time math channel to RMathX, you can select the RMath waveforms on channels up to RMathX–1. If the real time math channel is RMath1, you cannot use any other RMath waveforms as math source waveforms.
- You cannot set the channel that the real time math result is output on to an input channel of a 16-CH voltage input, 16-CH temperature/voltage input, CAN bus monitor, CAN & LIN bus monitor, or SENT monitor module (there is no menu for turning real time math on).
- The input channel of a 16-CH voltage input, 16-CH temperature/voltage input, CAN bus monitor, CAN & LIN bus monitor, CAN/CAN FD monitor, SENT monitor, or 4CH* module can be used as a source waveform of real time math.
  * 4-CH module input channels have sub channels 1 and 2. If real time math is turned off, both sub channels 1 and 2 can be selected. If real time math of a 4-CH module is turned on, either sub channel 1 or 2 of that module becomes the output destination of the real time math results. For example, if sub channel 1 is set to CH3_1 and sub channel 2 to CH3_2 and real time math is turned on, the channel becomes a single real time math channel named RMath3, and only CH3_1 is displayed for the source waveform option.
- Of the power math of the /G5 option, CH13 and CH14 if power analysis is in use and CH15 and CH16 if harmonic analysis is in use cannot be used as real time math channels or sources.
- For details on the modules whose channels you can set as real time math sources,see “Notes Regarding Using the Digital Filter and Real Time Math” on page 1-41.
- Even during waveform acquisition, you can set various math conditions, such as the operator or function (the operation definition), the source waveforms, and the coefficients. However, if you change the conditions, the measurement count (waveform acquisition count) is reset. The measurement count is displayed in the lower left of the screen. In roll mode during waveform acquisition, real time math cannot be turned on and off.
- For details on the math expressions, delay, and settings, see the appendix.

Labels (Label)

This is the same as the feature on the standard model. For details, see the *Features Guide*, IM DL850E-01EN.

Real Time Math Setup (RealTime Math Setup)

Select an operator or function (operation definition), and then set its corresponding items.

Operators and Functions (Operation)

- S1+S2: Adds the waveforms assigned to Source1 and Source2
- S1–S2: Subtracts the waveform assigned to Source2 from the waveform assigned to Source1
- S1*S2: Multiplies the waveforms assigned to Source1 and Source2
- S1/S2: Divides the waveform assigned to Source1 by the waveform assigned to Source2
- A(S1)+B(S2)+C: Performs addition with coefficients on the waveforms assigned to Source1 and Source2
- A(S1)–B(S2)+C: Performs subtraction with coefficients on the waveforms assigned to Source1 and Source2
- A(S1)*B(S2)+C: Performs multiplication with coefficients on the waveforms assigned to Source1 and Source2
- A(S1)/B(S2)+C: Performs division with coefficients on the waveforms assigned to Source1 and Source2
- Diff(S1): Performs differentiation on the waveform assigned to Source using a fifth order Lagrange interpolation formula
- Integ1(S1): Performs integration on the positive component of the waveform assigned to Source
- Integ2(S1): Performs integration on the positive and negative components of the waveform assigned to Source
- Rotary Angle: Uses the waveforms or logic signals that have been assigned to phases A, B, and Z to calculate the angle of rotation. This can be used to calculate the angle of rotation or the displacement of an encoder.
- DA: Converts the logic signals that have been assigned to Source1 (the least significant digits) and Source2 (the most significant digits) into an analog waveform and scales the results
- Polynomial: Performs a quartic polynomial calculation on the waveform that has been assigned to Source
- RMS: Calculates the RMS value of the waveform that has been assigned to Source
- Power: Calculates the effective power of the waveforms that have been assigned to Source1 and Source2
- Power Integ: Integrates the effective power of the waveforms that have been assigned to Source1 and Source2.
- Log1: Calculates the common logarithm of the waveforms that have been assigned to Source1 and Source2 (the calculation is performed on “Source1/Source2”)
- Log2: Calculates the common logarithm of the waveform that has been assigned to Source
- Sqrt1: Calculates the square root of the sum (or difference) of the squares of the waveforms that have been assigned to Source1 and Source2. This can be used to analyze displacement and tolerance.
- Sqrt2: Calculates the square root of the waveform that has been assigned to Source
- Cos: Uses the waveforms or logic signals that have been assigned to phases A, B, and Z to determine the angle, and then calculates the cosine of this angle. You can use this to convert the angle to displacement.
- Sin: Uses the waveforms or logic signals that have been assigned to phases A, B, and Z to determine the angle, and then calculates the sine of this angle. You can use this to convert the angle to displacement.
- Atan: Calculates the arc tangent of the waveforms that have been assigned to Source1 and Source2 (the calculation is performed on “Source1/Source2”). You can use this to convert the displacement to an angle.
- Electrical Angle: Calculates the phase difference between (1) the angle that was determined from the logic signals that were specified for phases A, B, and Z, and (2) the fundamental component that was determined from the discrete Fourier transform of the waveform that was specified as the target. You can calculate the phase difference (electrical angle) between the motor’s angle of rotation and the motor drive current.
- Knock Filter (can only be set on the DL850EV): When the signal level of the waveform that has been set to Source is less than or equal to the elimination level, the signal of this waveform is set to 0. You can select whether to perform differentiation. You can use this to extract knocking.

- Poly-Add-Sub: Performs addition or subtraction or both on the waveforms that have been set to Source1, Source2, Source3, and Source4. You can add or subtract the result of the power calculation, to calculate the multi-phase power.
- Frequency: Calculates the frequency of the waveform that has been assigned to Source
- Period: Calculates the period of the waveform that has been assigned to Source
- Edge Count: Counts the number of slope edges of the waveform that has been assigned to Source. You can use this to count the number of events in consecutive tests.
- Resolver: Calculates the angle of rotation from the sine signal and cosine signal that are generated from the detection coils of the resolver depending on the angle of the rotor.
- IIR Filter: This can be used to filter the waveform that has been set to Source with the same characteristics of the IIR filter of the digital filter. You can set the frequency to values over a wider range than is available with the IIR filter of a digital filter.
- PWM: Integrates a pulse width modulation signal and demodulates it to an analog signal.
- Reactive Power(Q): Calculates the reactive power from apparent power and effective power.
- CAN ID: Detects the frame of the CAN bus signal with the specified ID.
- Torque: Measures the frequency of the pulse frequency output torque sensor and calculates the torque using the specified coefficient.
- S1–S2(Angle): Determines the angle difference by subtracting the Source 2 angle from the Source 1 angle.
- 3 Phase Resolver: Calculates the angle of rotation from the two sine signals that are generated from the detection coil of the 3 phase resolver depending on the angle of the rotor.

Turning the Mean On and Off (Mean)

Select whether to perform the mean. This mean is the same feature as the one in the digital filter. However, the number of taps is fixed to 32. The sampling frequency is the same as the DL850E/DL850EV sample rate. The maximum sampling frequency is 10 MHz.

- ON: The mean is performed.
- OFF: The mean is not performed.

Optimizing Value/Div (Optimize Value/Div)

Press the Optimize Value/Div soft key to automatically set the value/div that the DL850E/DL850EV determines is the most appropriate for the math source waveform range and the expression. The selected value is from among the 123 value/div options for vertical axis sensitivity.

- The automatically selected option does not line up with the input values and math results, so you need to use the SCALE knob to change the value/div.
- There are a total of 123 value/div options within the following range: 500.0E+18 to 10.00E–21 (in steps of 1, 2, or 5).

Waveform Vertical Position (Vertical POSITION knob)

This is the same as the feature on the standard model. For details, see the *Features Guide*, IM DL850E-01EN.

Zoom Method (V Scale), Zooming by Setting a Magnification (V Zoom), Zooming by Setting Upper and Lower Display Limits (Upper/Lower)

This is the same as the feature on the standard model. For details, see the *Features Guide*, IM DL850E-01EN.

Offset (Offset)

This is the same as the feature on the standard model. For details, see the *Features Guide*, IM DL850E-01EN.

Trace Settings (Trace Setup)

This is the same as the feature on the standard model. For details, see the *Features Guide*, IM DL850E-01EN.

Unit (Unit)

You can assign a unit of up to four characters in length to the math results. The specified unit is reflected in the scale values.

All Channels Setup Menu

There is a menu (ALL CH) that is used to configure the settings for all channels for real time math. The menu is operated in the same way as the all channels setup menu on the standard model.

- You can configure the real time math settings of all channels while viewing the settings in a list.
- You can turn real time math on and off for all channels at once.
- There are some items that cannot be configured from the ALL CH menu.

Basic Arithmetic (S1+S2, S1–S2, S1*S2, and S1/S2)

Performs addition, subtraction, multiplication, or division on the two waveforms assigned to Source1 and Source2.

Math Source Waveforms (Source1 and Source2)

CH1 to CH16,[1] 16chVOLT,[2] 16chTEMP/VOLT,[2] CAN,[3] LIN,[3] SENT,[3] RMath1 to RMath15[4]

1. You can select input channels of installed modules. On a 4-CH module, select sub channel 1 or 2. You cannot select the input channel of a logic module. However, you cannot select input channels of a logic module.
2. When a 16-CH voltage input module or 16-CH temperature/voltage input module is installed. After you select 16chVOLT or 16chTEMP/VOLT, select a sub channel.
3. On a DL850EV when a CAN bus monitor, CAN & LIN bus, CAN/CAN FD monitor, or SENT monitor module is installed. After you select CAN, LIN, or SENT, select a sub channel. This cannot be selected on a CAN bus monitor, CAN & LIN bus monitor or CAN/CAN FD monitor module if the data type (Value Type) is set to Logic. Even if the data type is not set to Logic, you cannot use data that exceeds 16 bits in length. On a SENT monitor module, S&C and Error Trigger sub channels cannot be selected.
4. You can use other RMath waveforms as math source waveforms. If you set the real time math channel to RMathX, you can select the RMath waveforms on channels up to RMathX–1. If the real time math channel is RMath1, you cannot use any other RMath waveforms as math source waveforms.

Basic Arithmetic with Coefficients (A(S1)+B(S2)+C, A(S1)–B(S2)+C, A(S1)*B(S2)+C, A(S1)/B(S2)+C)

Performs addition, subtraction, multiplication, or division with coefficients on the two waveforms assigned to Source1 and Source2.

Math Source Waveforms (Source1 and Source2)

The options are the same as were described above for basic arithmetic. For details,see “Notes Regarding Using the Digital Filter and Real Time Math” on page 1-41.

Coefficients (A, B, and C)

Set the scaling coefficients (A and B) and the offset (C).
Range: –9.9999E+30 to +9.9999E+30
Default value of A and B: 1.0000
Default value of C: 0.0000

Differentiation (Diff(S1))

Performs differentiation on the waveform assigned to Source using a fifth order Lagrange interpolation formula. For details on the differentiation characteristics, see the appendix.

Math Source Waveform (Source)

The options are the same as were described above for basic arithmetic. For details,see “Notes Regarding Using the Digital Filter and Real Time Math” on page 1-41.

Integration (Integ1(S1) and Integ2(S1))

Integration is performed on the waveform that has been assigned to Source.

- Integ1(S1): Performs integration on the positive component of the waveform assigned to Source
- Integ2(S1): Performs integration on the positive and negative components of the waveform assigned to Source

Math Source Waveform (Source)

The options are the same as were described above for basic arithmetic. For details,see “Notes Regarding Using the Digital Filter and Real Time Math” on page 1-41.

Reset Condition (Reset Condition)

Select the condition for resetting integration from one of the settings below.

- Start (Start): When the waveform acquisition starts
- Overlimit (Overlimit): When “Value/Div” exceeds +10 div or falls below –10 div
- Zero crossing (ZeroCross): When the math source waveform signal crosses zero
  Set the slope direction (positive or negative) and the hysteresis when the signal crosses zero. The hysteresis level is the same as the trigger hysteresis. For details, see the *Features Guide*, IM DL850E-01EN.

Manual Reset (Manual Reset)

To manually reset the integration, select Execute.

Angle of Rotation (Rotary Angle)

Uses the waveforms or logic signals that have been assigned to phases A, B, and Z to calculate the angle of rotation. This can be used to calculate the angle of rotation or the displacement of an encoder.

Type (Type)

You can select the type of the encoding from the following options.

- Incremental ABZ (Incremental ABZ): The angle of rotation is calculated from the A, B, and Z phase signals.
- Incremental AZ (Incremental AZ): The angle of rotation is calculated from the A and Z phase signals.
- Absolute 8 bit (Absolute 8bit): The angle of rotation is calculated from an 8-bit logic signal (binary code).
- Absolute 16 bit (Absolute 8bit): The angle of rotation is calculated from a 16-bit logic signal (binary code).
- Gray code (Gray Code): The angle of rotation is calculated from a logic signal (gray code) consisting of 2 to 16 bits.

Source Conditions (Source Condition)

Set the conditions of the source whose pulses you want to count.

If the type of the encoding is ABZ or AZ

- **Turning the logic source on and off (Logic Source)**
  - ON: You can set the A, B, and Z phase signals to the signals of logic modules.
  - OFF: You can set the A, B, and Z phase signals to the signals of analog waveform modules. The options are the same as were described above for basic arithmetic. However, you cannot select input channels of frequency modules or real time math channels (RMath). For details,see “Notes Regarding Using the Digital Filter and Real Time Math” on page 1-41.

- **When logic sources are turned on**
  - Source (Source): Select an input channel of a logic module.
  - Phase A (Phase A): Select the bit that you want to use for the phase A signal from among the logic signals of the selected input channel.
  - Phase B (Phase B): Select the bit that you want to use for the phase B signal from among the logic signals of the selected input channel.
  - Phase Z (Phase Z): Select the bit that you want to use for the phase Z signal from among the logic signals of the selected input channel. You can also select whether the phase Z input is inverted.
- **When logic sources are turned off**

  Set the input channels for the phase A, B, and Z signals,[1] the signal level of each signal that you will count as a pulse,[2] and the hysteresis of each signal.[3]
  - Phase A (Phase A): Set the input channel, signal level, and hysteresis of the phase A signal.
  - Phase B (Phase B): Set the input channel, signal level, and hysteresis of the phase B signal.
  - Phase Z (Phase Z): Set the input channel, signal level, and hysteresis of the phase Z signal. You can also select whether the phase Z input is inverted.

  To set the timing that pulses are counted and the timing that the pulse count is reset for the signal level that you set here, see "Encoding Conditions" later in this section.

1 The options are the same as were described above for basic arithmetic. However, you cannot select input channels of frequency modules or real time math channels (RMath). For details,see "Notes Regarding Using the Digital Filter and Real Time Math" on page 1-41.
2 The signal level range is the same as the trigger level range. For details, see the *Features Guide*, IM DL850E-01EN.
3 The hysteresis level is the same as the trigger hysteresis. For details, see the *Features Guide*, IM DL850E-01EN.

If the type of the encoding is absolute 8 bit, absolute 16 bit, or gray code

Select the input channel of the logic module. For absolute 16 bit and gray code encoding, set the logic channel for the least significant digits to Source1 and the logic channel for the most significant digits to Source2.

* When the bit length of Gray Code is 8 or less, the Source2 setting is ignored.

Negative Logic ON/OFF (Negative logic)

Select which bit state will be recognized to be logic I.
- ON: Negative logic (low state is logic I)
- OFF: Positive logic (high state is logic I)

Pulses per Rotation (Pulse/Rotate)

Set the number of pulses per rotation.
Range: 1 to 500000. The default value is 180.
However, if the encode type is absolute 8 bit, the maximum number is 256. If the type is absolute 16 bit, the maximum is 65536.

Bit Length (Bit Length)

When the bit length (Bit Length) encoding type is set to Gray Code, set the bit length.
Selectable range: 2 to 16

Scaling (Scaling)

Select the unit that is used on the vertical scale.
- Radian: Radian
- Degree: Degrees
- User-defined (User Define): Set K, the size of the scale.
  Range: –9.9999E+30 to +9.9999E+30. The default value is 1.0000.

Encoding Conditions (Encode Condition)

If the type of the encoding is ABZ or AZ, set the encoder's pulse multiplier and the timing (edge) for counting pulses.

Count Conditions (Count Condition)

You can select the encoder's pulse multiplier from the following options.
×4, ×2, ×1
When the multiplier is ×4, regardless of the timing setting made in the next section, pulses are counted on all the edges of the signal.

Timing1 (Timing1)

Select the edges that are counted as pulses when the multiplier is ×1.

- A ↑: Rising edge of the phase A signal
- A ↓: Falling edge of the phase A signal
- B ↑: Rising edge of the phase B signal
- B ↓: Falling edge of the phase B signal

Rising edge: The point where the signal rises from a low level and passes through the specified signal level
Falling edge: The point where the signal falls from a high level and passes through the specified signal level

If the signal is that of an analog waveform, turn the logic sources off as shown earlier this manual in "Source Conditions," and then set the signal level that is counted as a pulse and the hysteresis.

Timing2 (Timing2)

Select the edges that are counted as pulses when the multiplier is ×2.
The options are the same as were described above for Timing1.
When the multiplier is ×2, if you select the same edges as in Timing1, the pulse count conditions are the same as were explained for multiplier ×1.

Reset Timing (Reset Timing)

Select the timing (edge) at which the pulse count will be reset.

- A ↑: Rising edge of the phase A signal
- A ↓: Falling edge of the phase A signal
- B ↑: Rising edge of the phase B signal
- B ↓: Falling edge of the phase B signal
- Z level (Z Level): When the Z phase signal is at a high level.

Reverse (Reverse)

Set the direction that the angle of rotation increases in.

- ON: The rotation is counter-clockwise.
- OFF: The rotation is clockwise.

Manual Reset (Manual Reset)

To manually reset the angle of rotation, select Execute.

Logic Signal to Analog Waveform Conversion (DA)

Converts the logic signals that have been assigned to Source1 (the least significant digits) and Source2 (the most significant digits) into an analog waveform and scales the results.
You cannot select the input channels of CAN bus monitor, CAN & LIN bus monitor, CAN/CAN FD monitor, or SENT monitor modules.

Math Source Waveforms (Source1 and Source2)

You can select input channels of an installed logic module. Set the logic channel for the least significant digits to Source1 and the logic channel for the most significant digits to Source2.
You cannot select the input channels of CAN bus monitor modules, CAN & LIN bus monitor, or CAN/CAN FD monitor modules.

Type (Type)

Select the type of the logic signal.
- Unsigned: Unsigned integer
- Signed: Signed integer
- Offset Binary: Offset binary

Bit Length (Bit Length)

Set the bit length that will be converted to an analog signal. The length that you specify will be counted from the least significant bit.
Range: 2 to 16. The default value is 16.

Coefficient (K)

Set scaling coefficient K.
Range: –9.9999E+30 to +9.9999E+30. The default value is 1.0000.

Quartic Polynomial (Polynomial)

Performs a quartic polynomial calculation on the waveform that has been assigned to Source.

$As^4+Bs^3+Cs^2+Ds+E$

A, B, C, and D: Scaling coefficients
s: Sampling data
E: Offset

Math Source Waveform (Source)

The options are the same as were described above for basic arithmetic. For details,see “Notes Regarding Using the Digital Filter and Real Time Math” on page 1-41.

Coefficients (A, B, C, D, and E)

Set the scaling coefficients (A, B, C, and D) and the offset (E).
Range: –9.9999E+30 to +9.9999E+30
Default value of A and B: 1.0000
Default value of C, D, and E: 0.0000

RMS Value (RMS)

Calculates the RMS value of the waveform that has been assigned to Source.

$$\sqrt{\frac{1}{N}\sum_{n=1}^{N} s(n)^2}$$

s: Sampling data
N: Number of samples

Math Source Waveform (Source)

The options are the same as were described above for basic arithmetic. However, you cannot select an input channel of a frequency module. For details,see "Notes Regarding Using the Digital Filter and Real Time Math" on page 1-41.

Calculation Period (Calc Period)

Select the method that is used to determine the RMS calculation period.

- Edge: Rising or falling edge of the selected signal or both edges
- Time: Specified time

If the Calculation Period Is Edge

- **Edge detection source (Edge Source)**
  Select the input channel of the signal that is used to determine the calculation period.
  If you want to use the same channel as the math source waveform, select Own. You can also select other channels. For details,see "Notes Regarding Using the Digital Filter and Real Time Math" on page 1-41.

- **Level (Level), Slope (Slope), and Hysteresis (Hysteresis)**
  Set the signal level,[1] the slope (rising or falling), and the hysteresis[2] of the edges that separate the calculation periods.
  1 The signal level range is the same as the trigger level range. For details, see the *Features Guide*, IM DL850E-01EN.
  2 The hysteresis level is the same as the trigger hysteresis. For details, see the *Features Guide*, IM DL850E-01EN.

If the Calculation Period Is Time

Time (Time)

Set the calculation period time.
Range: 1 ms to 500 ms. Default value: 1 ms. Resolution: 1 ms.

Effective Power (Power)

Calculates the effective power of the waveforms that have been assigned to Source1 and Source2.

$$\frac{1}{T}\int_0^T (s1 \cdot s2)dt$$

T: 1 period (calculation period)
s1 and s2: Sampling data
dt: Sampling period

Math Source Waveforms (Source1 and Source2)

Set the voltage and current input channels to use to calculate the effective power to Source1 and Source2. The options are the same as were described above for basic arithmetic. However, you cannot select input channels of a frequency module. For details,see "Notes Regarding Using the Digital Filter and Real Time Math" on page 1-41.

Calculation Period (Calc Period)

Set the calculation period for the effective power calculation.

Edge Detection Source (Edge Source)

Select the input channel of the signal that is used to determine the calculation period.
If you want to use the same channel as the math source waveform, select Source1 or Source2. You can also select other channels. For details,see “Notes Regarding Using the Digital Filter and Real Time Math” on page 1-41.

Level (Level), Slope (Slope), and Hysteresis (Hysteresis)

Set the signal level, the slope, and the hysteresis of the edges that separate the calculation periods. These settings are shared with the RMS operation.

Effective Power Integration (Power Integ)

Integrates the effective power of the waveforms that have been assigned to Source1 and Source2.

$$\int_0^T (s1 \cdot s2)dt$$

T: Integration time
s1 and s2: Sampling data
dt: Sampling period

Math Source Waveforms (Source1 and Source2)

Set the voltage and current input channels to use to integrate the effective power to Source1 and Source2. The options are the same as were described above for basic arithmetic. However, you cannot select input channels of a frequency module. For details,see “Notes Regarding Using the Digital Filter and Real Time Math” on page 1-41.

Reset Condition (Reset Condition)

Select the condition for resetting integration from one of the settings below.

- Start (Start): When the waveform acquisition starts
- Overlimit (Overlimit): When “Value/Div” exceeds +10 div or falls below –10 div

Manual Reset (Manual Reset)

To manually reset the integration, select Execute.

Scaling (Scaling)

Select the unit that is used on the vertical scale.

- Seconds (Second): The unit is seconds.
- Hours (Hour): The unit is hours.

Common Logarithm (Log1 and Log2)

- Log1:Calculates the common logarithm of the waveforms that have been assigned to Source1 and Source2 (the calculation is performed on “Source1/Source2”).
  $K \cdot \log_{10}(s1/s2)$ K: Coefficient. s1 and s2: Sampling data.
- Log2:Calculates the common logarithm of the waveform that has been assigned to Source.
  $K \cdot \log_{10}(s)$ K: Coefficient. s: Sampling data.

Math Source Waveforms (Source1, Source2, and Source)

The options are the same as were described above for basic arithmetic. For details,see “Notes Regarding Using the Digital Filter and Real Time Math” on page 1-41.

Coefficient (K)

Set scaling coefficient K.
Range: –9.9999E+30 to +9.9999E+30. The default value is 1.0000.

Square Root (Sqrt1 and Sqrt2)

- Sqrt1: Calculates the square root of the sum (or difference) of the squares of the waveforms that have been assigned to Source1 and Source2. This can be used to analyze displacement and tolerance.
  $\sqrt{s1^2 \pm s2^2}$ s1 and s2: Sampling data
- Sqrt2: Calculates the square root of the waveform that has been assigned to Source
  $\sqrt{s}$ s: Sampling data

Math Source Waveforms (Source1, Source2, and Source)

The options are the same as were described above for basic arithmetic. For details,see “Notes Regarding Using the Digital Filter and Real Time Math” on page 1-41.

Sign (Sign)

Set the operator between $s1^2$ and $s2^2$ in Sqrt1.

- +: Addition
- –: Subtraction

Cosine (Cos) and Sine (Sin)

Uses the waveforms or logic signals that have been assigned to phases A, B, and Z to determine the angle, and then calculates the cosine or sine of this angle. You can use this to convert the angle to displacement.

Type (Type)

Select the type of the encoding. The settings other than the Resolver Ch setting are shared with the Rotary Angle operation. You can specify the Resolver Ch setting when there is a channel that has been defined with the resolver function of real time math.

- If there are multiple channels that have been defined with the resolver function, select Resolver Ch, and then select the channel.
- If Resolver Ch has been selected, the setup menu explained later is not displayed.

Source Conditions (Source Condition)

Set the conditions of the source whose pulses you want to count. This setting is shared with the Rotary Angle operation. For details,see “Notes Regarding Using the Digital Filter and Real Time Math” on page 1-41.

Pulses per Rotation (Pulse/Rotate) and Bit Length (Bit Length)

Set the number of pulses per rotation. When the encoding type is set to Gray Code, set the bit length. This setting is shared with the Rotary Angle operation.

Encoding Conditions (Encode Condition)

If the type of the encoding is ABZ or AZ, set the encoder’s pulse multiplier and the timing (edge) for counting pulses. This setting is shared with the Rotary Angle operation.

Manual Reset (Manual Reset)

To manually reset the computed value, select Execute.

Arc Tangent (Atan)

Calculates the arc tangent of the waveforms that have been assigned to Source1 and Source2 (the calculation is performed on “Source1/Source2”). You can use this to convert the displacement to an angle.

atan(s1/s2) s1 and s2: Sampling data

Math Source Waveforms (Source1 and Source2)

The options are the same as were described above for basic arithmetic. For details,see “Notes Regarding Using the Digital Filter and Real Time Math” on page 1-41.

Scaling (Scaling)

Select the unit that is used on the vertical scale. This setting is shared with the Rotary Angle operation. However, there are no user-defined settings.

Quadrant Range (Quadrant)

Select the quadrant range to use for converting displacements to angles. This can be used on models with firmware version 2.05 and later.

- Quadrant-2: –90° to +90° (–π/2 to +π/2)
  Even if a calculated result is between –180° and –90° or between +90° and +180°, it is converted to an angle between –90° to +90°.
- Quadrant-4: –180° to +180° (–π to +π)

Electrical Angle (Electrical Angle)

Calculates the phase difference between (1) the angle that was determined from the logic signals that were specified for phases A, B, and Z, and (2) the fundamental component that was determined from the discrete Fourier transform of the waveform that was specified as the target. You can calculate the phase difference (electrical angle) between the motor’s angle of rotation and the motor drive current.

Type (Type)

Select the type of the encoding. The settings other than the Resolver Ch setting are shared with the Rotary Angle operation. You can specify the Resolver Ch setting when there is a channel that has been defined with the resolver function of real time math.

- If there are multiple channels that have been defined with the resolver function, select Resolver Ch, and then select the channel.
- If Resolver Ch has been selected, set the scaling and the target on the setup menus explained later.

Source Conditions (Source Condition)

Set the conditions of the source whose pulses you want to count. This setting is shared with the Rotary Angle operation. However, you can only specify the input channels of logic modules as math source waveforms. For details,see “Notes Regarding Using the Digital Filter and Real Time Math” on page 1-41.

Pulses per Rotation (Pulse/Rotate) and Bit Length (Bit Length)

Set the number of pulses per rotation. When the encoding type is set to Gray Code, set the bit length. This setting is shared with the Rotary Angle operation.

Scaling (Scaling)

Select the unit that is used on the vertical scale. This setting is shared with the Rotary Angle operation. However, there are no user-defined settings.

Encoding Conditions (Encode Condition)

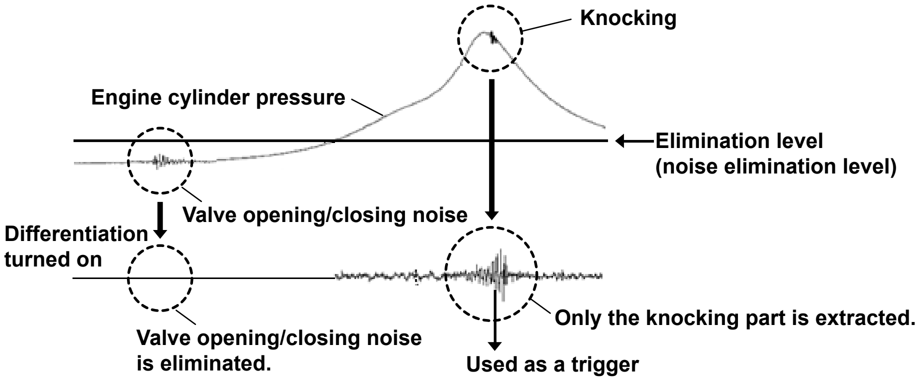
If the type of the encoding is ABZ or AZ, set the encoder’s pulse multiplier and the timing (edge) for counting pulses. This setting is shared with the Rotary Angle operation.

Target (Target)

The fundamental component of the waveform that you specify here is determined through a discrete Fourier transform. If the angle is the motor’s angle of rotation and the target is the motor’s drive current, the electrical angle can be determined.
The options are the same as were described above for basic arithmetic. However, you cannot select an input channel of a frequency module. For details,see “Notes Regarding Using the Digital Filter and Real Time Math” on page 1-41.

Knocking Filter (Knock Filter; only on the DL850EV)

When the signal level of the waveform that has been set to Source is less than or equal to the elimination level, the signal of this waveform is set to 0. You can select whether to perform differentiation. You can use this to extract knocking.



Math Source Waveform (Source)

The options are the same as were described above for basic arithmetic. However, you cannot select an input channel of a frequency module or a real time math channel (RMath). For details,see “Notes Regarding Using the Digital Filter and Real Time Math” on page 1-41.

Elimination Level

Set the elimination level, which is used to set the input signal to 0.
The range of the elimination level is the same as that of the trigger level. For details, see the *Features Guide*, IM DL850E-01EN.

Differential

Select whether to differentiate the waveform after elimination. A fifth order Lagrange interpolation formula is used to perform differentiation. For details on the differentiation characteristics, see the appendix.

- ON: Differentiation is performed.
- OFF: Differentiation is not performed.

Polynomial with a coefficient (Poly-Add-Sub)

Performs addition or subtraction or both on the waveforms that have been set to Source1, Source2, Source3, and Source4. You can add or subtract the result of the power calculation, to calculate the multi-phase power.

K (±s1 ±s2 ±s3 ±s4) K: Coefficient. s1, s2, s3, and s4: Sampling data.

Math Source Waveforms (Source1, Source2, Source3, and Source4)

The options are the same as were described above for basic arithmetic. For details,see “Notes Regarding Using the Digital Filter and Real Time Math” on page 1-41.

Sign

You can set the sign of the sampling data of the math source waveforms to positive or negative.

Coefficient (K)

Set scaling coefficient K.
Range: –9.9999E+30 to +9.9999E+30. The default value is 1.0000.

Frequency (Frequency)

Calculates the frequency of the waveform that has been assigned to Source.

Math Source Waveform (Source)

The options are the same as were described above for basic arithmetic. However, you can select an input channel of a logic module (select the channel, and then select the bit). You cannot select an input channel of a frequency module. For details,see “Notes Regarding Using the Digital Filter and Real Time Math” on page 1-41.

Slope (Slope), Level (Level), Hysteresis (Hysteresis)

Set the signal level,[1] the slope (rising or falling), and the hysteresis[2] of the edges that are used to detect the periods. If the math source is the signal of a logic module, only set the slope.

1 The signal level range is the same as the trigger level range. For details, see the *Features Guide*, IM DL850E-01EN.

2 The hysteresis level is the same as the trigger hysteresis. For details, see the *Features Guide*, IM DL850E-01EN.

Scaling (Scaling)

Select the unit that is used on the vertical scale.

- Hz: The unit is hertz.
- Rpm: The unit is revolutions per minute.

Pulses per Rotation (Pulse/Rotate)

If scaling is set to Rpm, set the number of pulses per rotation.
Selectable range: 1 to 99999. The default setting is 1.

Deceleration Prediction (Deceleration Prediction)

Set whether to compute the decelaration curve from the elapsed time after the pulse input stops.

- ON: Deceleration prediction is performed.
- OFF: Deceleration prediction is not performed. For details, see the *Features Guide*, IM DL850E-01EN.

Stop Prediction (Stop Prediction)

Set the time from the point when the pulse input stops to the point when the DL850E/DL850EV determines that the object has stopped.

- 2, 4, 8, 16: Stop prediction is performed on the basis of the specified number of times the pulse period (T) of the pulse one period before the pulse input stopped.
- OFF: Stop prediction is not performed. For details, see the features guide, IM DL850E-01EN.

Offset (Hz/Rpm) (Offset (Hz/Rpm))

Offset can be added to display only the changes in the frequency at a higher resolution.
Selectable range: −9.9999E+30 to +9.9999E+30.The default value is 0.0000

Period (Period)

Calculates the period of the waveform that has been assigned to Source.

Math Source Waveform (Source)

The options are the same as were described above for basic arithmetic. However, you can select an input channel of a logic module (select the channel, and then select the bit). You cannot select an input channel of a frequency module. For details,see “Notes Regarding Using the Digital Filter and Real Time Math” on page 1-41.

Slope (Slope), Level (Level), Hysteresis (Hysteresis), Deceleration Prediction (Deceleration Prediction), Stop Prediction (Stop Prediction)

Set the slope (rising or falling), signal level, and hysteresis of the edges that are used to detect the periods as well as the deceleration prediction and stop prediction. These settings are shared with the Frequency operation.

Edge Count (Edge Count)

Counts the number of slope edges of the waveform that has been assigned to Source. You can use this to count the number of events in consecutive tests.

Math Source Waveform (Source)

The options are the same as were described above for basic arithmetic. However, you can select the input channel of a logic module (select the bit after selecting the channel) or select the S&C and Error Trigger sub channels of a SENT module. You cannot select an input channel of a frequency module. For details,see “Notes Regarding Using the Digital Filter and Real Time Math” on page 1-41.

Slope (Slope), Level (Level), Hysteresis (Hysteresis)

Set the slope (rising or falling), the signal level, and the hysteresis of the edges that you want to count. These settings are shared with the Frequency operation.

Reset Condition (Reset Condition)

Select the condition for resetting the count from one of the settings below.

- Start (Start): When the waveform acquisition starts
- Overlimit (Overlimit): When “Value/Div” exceeds +10 div or falls below –10 div

Manual Reset (Manual Reset)

To manually reset the count, select Execute.

Resolver (Resolver)

Calculates the angle of rotation from the sine signal and cosine signal that are generated from the detection coils of the resolver depending on the angle of the rotor.

Sine Phase Signal and Cosine Phase Signal (Sin Ch, Cos Ch)

Select the sine signal and the cosine signal that are generated from the detection coil of the resolver. The options are the same as were described above for basic arithmetic. For details,see “Notes Regarding Using the Digital Filter and Real Time Math” on page 1-41.

Excitation Signal (Carrier Ch)

Select the resolver’s excitation signal. The options are the same as were described above for basic arithmetic. For details,see “Notes Regarding Using the Digital Filter and Real Time Math” on page 1-41.

Hysteresis (Hysteresis)

Set the rising edge hysteresis of the excitation, sine, and cosine signals. When the sample point mode in detail settings is set to Auto, this setting is applied to all signals. When the sample point mode is set to Manual, this setting is applied to the excitation signal.

Tracking Filter (Tracking Filter)

If the sine signal and cosine signal data is changing in a staircase pattern, select a filter that will smooth out the data that is used to calculate the angle of rotation.
OFF, 2kHz, 1kHz, 250Hz, 100Hz

Detail Setting (Detail)

Sample Point (Sample Point)

- **Mode (Mode)**
  To enable more accurate calculations of the angle of rotation, set the mode that is used to sample the peak values of sine and cosine signals.
  - Auto: The rising edges of the excitation, sine, and cosine signals are detected, and the peak values of sine signals and cosine signals are sampled automatically.
    - The Auto setting can be applied when the time difference of the sine and cosine signals in reference to the excitation signal is less than ±90°(π/2).
    - Turn the SCALE knob to set the vertical scale (V/div) so that the amplitudes of the excitation, sine, and cosine signals are all ±1.5 div or greater. If the amplitudes are less than ±1.5 div, the Auto function will not operate.
  - Manual: The rising edge of the excitation signal is detected, and sine and cosine signals at the specified time (Time) after this detected rising edge are sampled.
    Time Setting
    Selectable range: 0.1 µs to 1000.0 µs, Default value: 0.1 µs, Resolution: 0.1 µs.

Scaling (Scaling)

Select how the upper and lower limits of the vertical scale are displayed.
–180° to +180°, 0° to 360°, –π to +π, 0 to 2π

Offset (°) (Offset (°))

An offset can be added to set the initial phase of the rotation angle.
Selectable range: −180.00° to +180.00°. The default setting is 0.00°, and the resolution is 0.01°.

Note

- To improve the calculation accuracy, set the vertical axis sensitivity for each signal so that the signal amplitude is as large as possible.
- Set the vertical axis sensitivity to the same value for sine signals and cosine signals. If you specify different values, the DL850E/DL850EV cannot perform calculations correctly.

IIR Filter (IIR Filter)

This can be used to filter the waveform that has been set to Source with the same characteristics of the IIR filter of the digital filter. You can set the frequency to values over a wider range than is available with the IIR filter of the digital filter.

Math Source Waveforms (Source)

The options are the same as were described above for basic arithmetic. For details,see “Notes Regarding Using the Digital Filter and Real Time Math” on page 1-41.

Filter Band (Filter Band)

Select the filter band.
Low-Pass, High-Pass, Band-Pass

Cutoff Frequency (CutOff)

When the filter band is set to Low-Pass or High-Pass, set the cutoff frequency. The ranges and resolutions are indicated below.

Filter Band	Range	Resolution
Low-Pass	0.2 Hz to 3.00 MHz Default value: 0.30 MHz	0.2 Hz (range: 0.2 Hz to 29.8 Hz)
		2 Hz (range: 30 Hz to 298 Hz)
		0.02 kHz (range: 0.30 kHz to 2.98 kHz)
		0.2 kHz (range: 3.0 kHz to 29.8 kHz)
		2 kHz (range: 30 kHz to 298 kHz)
		0.02 MHz (range: 0.30 MHz to 3.00 MHz)
High-Pass	0.02 kHz to 3.00 MHz Default value: 0.30 MHz	0.02 kHz (range: 0.02 kHz to 2.98 kHz)
		0.2 kHz (range: 3.0 kHz to 29.8 kHz)
		2 kHz (range: 30 kHz to 298 kHz)
		0.02 MHz (range: 0.30 MHz to 3.00 MHz)

Center Frequency (Center Frequency)

When the filter band is set to Band-Pass, set the center frequency. The ranges and resolutions are indicated below.

Range	Resolution
0.06 kHz to 3.00 MHz Default value: 0.30kHz	0.02 kHz (range: 0.06 kHz to 1.18 kHz)
	0.2 kHz (range: 1.2 kHz to 11.8 kHz)
	2 kHz (range: 12 kHz to 118 kHz)
	0.02 MHz (range: 0.12 MHz to 3.00 MHz)

Bandwidth (Pass Band)

When the filter band is set to Band-Pass, select the bandwidth. The bandwidth options vary depending on the center frequency that you have set. For details on the options, see the appendix.

Interpolation On and Off (Interpolate)

Select whether to perform data interpolation. Up to 10 M samples of data can be interpolated from the data of waveforms that pass through the real time math IIR filter. The interpolation method is linear interpolation.

- ON: Data is interpolated.
- OFF: Data is not interpolated.

Demodulation of the Pulse Width Modulated Signal (PWM)

Integrates a pulse width modulation signal and demodulates it to an analog signal.

Math Source Waveforms (Source)

The options are the same as were described above for basic arithmetic. For details,see “Notes Regarding Using the Digital Filter and Real Time Math” on page 1-41.

Period of the Pulse Width Modulated Signal (Period)

Set the period of the pulse width modulated signal. The pulse width modulation signal is repeatedly integrated over the set period and demodulated to an analog signal.
Selectable range: 0.1 μs to 5000.0 μs, Default value: 0.1 μs, Resolution: 0.1 μs.

Reactive Power (Reactive Power(Q))

Calculates the reactive power from apparent power and effective power.
To calculate the reactive power, you must use the real time math feature to calculate the apparent power and effective power by following the procedure below.

Apparent Power Calculation

1. Calculate the RMS voltage and current (RMS) that are used to derive the reactive power.
2. Take the product of the RMS voltage and current (S1*S2) that were calculated in step 1. The result is the apparent power.

Effective Power Calculation

Calculate the effective power of the RMS voltage and current (Power) that are used to derive the reactive power.

Apparent Power (Apparent Power(S))

Select the real time math channel (RMath channel) used to calculate the apparent power.

Effective Power (Effective Power(P))

Select the real time math channel (RMath channel) used to calculate the effective power.

Reactive Power Polarity

Determine the reactive power polarity from the phases of the voltage and current used to derive the reactive power.

Voltage (Voltage)

Select the voltage channel used to derive the reactive power.
The options are the same as were described above for basic arithmetic. However, you cannot select input channels of frequency modules. For details,see “Notes Regarding Using the Digital Filter and Real Time Math” on page 1-41.

Hysteresis (Hysteresis)

Select the hysteresis used to detect the zero crossing of the selected voltage.
The hysteresis level is the same as the trigger hysteresis. For details, see the *Features Guide*, IM DL850E-01EN.

Current (Current)

Select the current channel used to derive the reactive power.
The options are the same as were described above for basic arithmetic. However, you cannot select input channels of frequency modules. For details,see “Notes Regarding Using the Digital Filter and Real Time Math” on page 1-41.

CAN ID Detection (CAN ID)

Detect the frame of the CAN bus signal with the specified ID. A pulse waveform whose detection point is at high level is displayed.

Detection Source Waveforms (Source)

CH1 to CH16,[1] RMath1 to RMath[2]

1 You can select an input channel of an installed module. However, you cannot select an input channel of a logic, frequency, 16-CH voltage, 16-CH temperature/voltage, CAN bus monitor, CAN & LIN bus monitor, CAN/CAN FD monitor, or SENT monitor module.

2 You can use other RMath waveforms as math source waveforms. If you set the real time math channel to RMathX, you can select the RMath waveforms on channels up to RMathX–1. If the real time math channel is RMath1, you cannot use any other RMath waveforms as math source waveforms.

Bit Rate (Bit Rate)

Select the transmission speed of the CAN bus signal to detect.
10k, 20k, 33.3k, 50k, 62.5k, 66.7k, 83.3k, 100k, 125k, 200k, 250k, 400k, 500k, 800k, or 1Mbps

Message Format

Select the data frame message format of the CAN bus signal to detect.
STD: Standard format
XTD: Extended format

ID (Hexadecimal (Hex))

Set the data frame message ID of the CAN bus signal to detect.
Standard format (11 bits): 0x000 to 0x7ff
Extended format (29 bits): 0x00000000 to 0x1fffffff

Torque (Torque)

Measures frequency f of the waveform specified as the source and calculate the torque.
A(f+c) f: Measuring frequency A and C: Coefficients

Math Source Waveforms (Source)

The options are the same as were described for basic arithmetic. However, you can select the input channels of logic modules (select the channel, and then select the bit).
You cannot select the input channel of a frequency module. For details,see “Notes Regarding Using the Digital Filter and Real Time Math” on page 1-41.

Slope (Slope), Level (Level), Hysteresis (Hysteresis)

Set the signal level[1], the slope (rising or falling), and the hysteresis[2] of the edges that are used to detect the periods.
If the math source is the signal of a logic module, set only the slope.

1 The signal level range is the same as the trigger level range.

2 The hysteresis level is the same as the trigger hysteresis.

Deceleration Prediction (Deceleration Prediction)

Set whether to compute the deceleration curve from the elapsed time after the pulse input stops.

- ON: Deceleration prediction is performed.
- OFF: Deceleration prediction is not performed.

Stop Prediction (Stop Prediction)

Set the time from the point when the pulse input stops to the point when the DL850E/DL850EV determines that the object has stopped.

- 2, 4, 8, 16: Stop prediction is performed on the basis of the specified number of times the pulse period (four settings) of the pulse one period before the pulse input stopped.
- OFF: Stop prediction is not performed.

For details, see the *Features Guide*, IM DL850E-01EN.

Coefficients (A and C)

Set the scaling coefficient (A) and the frequency reference (C).

Angle Difference (S1–S2(Angle))

Determines the angle difference in the range of –180° to +180° by subtracting the Source2 angle from the Source1 angle.

If the computed value is in the range of –360° to –180° or +180° to +360°, this function calculates its supplement.

Math Source Waveforms (Source1 and Source2)

Select the input channels to assign to Source1 and Source2 for calculating the angle difference. The options are the same as were described for basic arithmetic. However, you cannot select input channels of frequency modules. For details,see “Notes Regarding Using the Digital Filter and Real Time Math” on page 1-41.

Scaling (Scaling)

Select the unit that is used on the vertical scale.

- Radian: Radian
- Degree: Degrees

3 Phase Resolver (3 Phase Resolver)

Calculates the angle of rotation from the two sine signals that are generated from the detection coil of the 3 phase resolver depending on the angle of the rotor.

Sine Signal Phase (Phase)

Select the phases of the two sine signals that are generated from the detection coil of the 3 phase resolver.

0° to 120°, 0° to 240°, 120° to 240

Sine Signal (Sin Ch)

In accordance with the phases selected in the previous section, select the sine signals that are generated from the detection coil of the 3 phase resolver. The options are the same as were described for basic arithmetic. For details,see “Notes Regarding Using the Digital Filter and Real Time Math” on page 1-41.

Excitation Signal (Carrier Ch)

Select the 3 phase resolver’s excitation signal. The options are the same as were described for basic arithmetic. For details,see “Notes Regarding Using the Digital Filter and Real Time Math” on page 1-41.

Hysteresis (Hysteresis)

Set the rising edge hysteresis of the excitation, and sine signals. When the sample point mode in detail settings is set to Auto, this setting is applied to all signals. When the sample point mode is set to Manual, this setting is applied to the excitation signal.

Tracking Filter (Tracking Filter)

If the sine signal and cosine signal data is changing in a staircase pattern, select the cutoff frequency of the tracking filter that will smooth out the data that is used to calculate the angle of rotation.
OFF, 2kHz, 1kHz, 250Hz, 100Hz

Detail Setting (Detail

Sample Point (Sample Point)

- **Mode (Mode)**
  To enable more accurate calculations of the angle of rotation, set the mode that is used to sample the peak values of sine signals.
  - Auto: The rising edges of the excitation and sine signals are detected, and the peak values of sine signals are sampled automatically.
    - The Auto setting can be applied when the time difference of the sine signals in reference to the excitation signal is less than ±90° (π/2).
    - Turn the SCALE knob to set the vertical scale (V/div) so that the amplitudes of the excitation, and sine signals are all ±1.5 div or greater. If the amplitudes are less than ±1.5 div, the Auto function will not operate.
  - Manual: The rising edge of the excitation signal is detected, and sine signals at the specified time (Time) after this detected rising edge are sampled.
    Time Setting
    Selectable range: 0.1 μs to 1000.0 μs. The default setting is 0.1 μs, and the resolution is 0.1 μs.

Scaling (Scaling)

Select how the upper and lower limits of the vertical scale are displayed.
−180° to +180°, 0° to 360°, −π to +π, 0 to 2π

Offset (°) (Offset(°))

An offset can be added to set the initial phase of the rotation angle.
Selectable range: −180.00° to +180.00°. The default setting is 0.00°, and the resolution is 0.01°.

Note

- To improve the calculation accuracy, set the vertical axis sensitivity for each signal so that the signal amplitude is as large as possible.
- Set the vertical axis sensitivity to the same value for sine signals and cosine signals. If you specify different values, the DL850E/DL850EV cannot perform calculations correctly.

Power Math (ANALYSIS)

Digital Monitor Mode (Digital Monitor Mode)

Only the numeric monitor of the selected group is displayed on the screen.

Display Group: Only the numeric monitor of the group selected with Select Display Gr of Display Groups (DISPLAY) is displayed on the screen.

Power: Only the numeric monitor of the power analysis measurement functions is displayed on the screen.

Harmonic: Only the numeric monitor of the harmonic analysis measurement functions is displayed on the screen.

Power Analysis (Power)

The voltage and current measured on separate input channels can be used as math sources to calculate various power parameters for power analysis. This is a feature available on the /G5 option.

- Power analysis can be performed when any of the following modules is installed in a slot other than slot 7.
  701250 (HS10M12), 720250(HS10M12), 701251 (HS1M16), 701255 (NONISO_10M12), 701267 (HV (with RMS)), 720268(HV(AAF, RMS)), 720210 (HS100M12), 720211 (HS100M12), 701261 (UNIVERSAL), 701262 (UNIVERSAL (AAF)), 701265 (TEMP/HPV), 720266(TEMP/HPV), 701275 (ACCL/VOLT), 720254 (4CH 1M16)
- Channels that can be used for power analysis are CH13 and CH14. Power analysis results are output to the subchannels of CH13 and CH14.
  The number of calculations performed in one analysis is equal to the total number of subchannels of CH13 and CH14.
- There can be up to 126 power analysis parameters that can be calculated. The number of parameters varies depending on the number of systems to be analyzed and wiring system. For details, see the appendix.
- Power analysis conditions can be changed even during waveform acquisition. However, if you change the conditions, the measurement count (waveform acquisition count) is reset.
  The measurement count is displayed in the lower left of the screen.
- The analysis result waveform can be used as a trigger source, but it cannot be used as a real time math source.
- Power analysis can be performed on two systems. This allows power efficiency and motor efficiency to be calculated.

Measurement Functions

The various physical quantities such as rms voltage, average current, power, and phase difference that the DL850E/DL850EV measures and displays are called measurement functions. Each physical quantity is displayed with a corresponding symbol.

For example, Urms represents the true rms voltage.

Source Channels

The channels that receive the pair of voltage and current signals to be measured are called source channels.

There are three source channel numbers: 1, 2, and 3. The DL850E/DL850EV displays a source channel number after the measurement function symbol to indicate which source channel corresponds to the displayed numeric data.

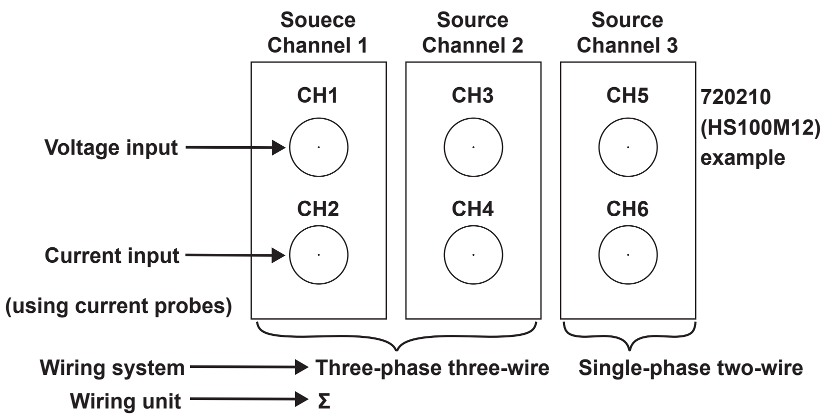
For example, Urms1 represents the true rms voltage of source channel 1.

The channels that can be used as source channels are those of the modules that can perform power analysis (indicated above).

Wiring Unit

Wiring Unit refers to a group of two or three input source channels with the same wiring system used to measure three-phase power.
Wiring unit is represented with the symbol Σ. Measurement functions for wiring units are called Σ functions.
For example, UrmsΣ represents the true rms value of the average of the voltages measured on the input source channels assigned to wiring unit Σ.

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

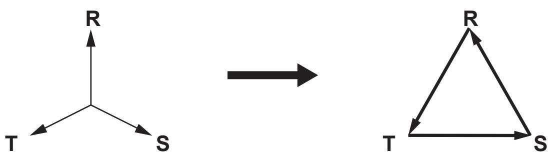


Delta Math

Measurement function ΔU and ΔI can be determined based on the sum and difference of the instantaneous voltage and current (sampling data) of the source channels assigned to the wiring unit set as the delta math source. This calculation is called delta math.

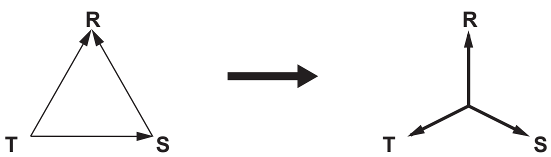
3P4W→3V3A

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



3V3A→3P4W

- Using the data of a three-phase three-wire system (three-voltage, three-current method), star connection data can be calculated from delta connection data (delta-star transformation). This is useful when you want to observe the phase voltage of a measurement source without a neutral line.



Measurement Function Types

- **Source channel measurement functions**

  The following 32 measurement functions are available.
  U (voltage): Urms (rms value),* Umn (rectified mean value calibrated to the rms value),*
  Udc (simple average), Uac (AC component)
  I (current): Irms (rms value),* Imn (rectified mean value calibrated to the rms value),*
  Idc (simple average), Iac (AC component)
  P (active power), S (apparent power), Q (reactive power), λ (power factor), φ (phase difference), fU (voltage frequency), fI (current frequency), U+pk (maximum voltage), U-pk (minimum voltage), I+pk (maximum current), I-pk (minimum current), P+pk (maximum power), P-pk (minimum power), WP (integrated power), WP+ (positive integrated power), WP- (negative integrated power)
  q (integrated ampere-hour), q+ (positive integrated ampere-hour), q- (negative integrated ampere-hour), WS (volt-ampere hours), WQ (var hours),
  Z (impedance), RS (series resistance), XS (series reactance), RP (parallel resistance), XP (parallel reactance)

  * You can select either the rms value or the rectified mean value calibrated to the rms value (but not both). In either case, the value is displayed as rms.

- **Wiring unit Σ measurement functions**

  The following 24 measurement functions are available.
  UΣ (average voltage): UrmsΣ (rms value),* UmnΣ (rectified mean value calibrated to the rms value),*
  UdcΣ (simple average), UacΣ (AC component)
  IΣ (average current): IrmsΣ (rms value),* ImnΣ (rectified mean value calibrated to the rms value),*
  IdcΣ (simple average), IacΣ (AC component)
  PΣ (total active power), SΣ (total apparent power), QΣ (total reactive power), λΣ (average power factor), φΣ (average phase difference)
  WPΣ (total integrated power), WP+Σ (total positive integrated power), WP-Σ (total negative integrated power),
  qΣ (total integrated ampere-hour), q+Σ (positive total integrated ampere-hour), q-Σ (negative total integrated ampere-hour),
  WSΣ (total apparent energy), WQΣ (total reactive energy), ZΣ (average impedance), RSΣ (average series resistance), XSΣ (average series reactance), RPΣ (average parallel resistance), XPΣ (average parallel reactance)

  * You can select either the rms value or the rectified mean value calibrated to the rms value (but not both). In either case, the value is displayed as rms.

- **Delta math measurement functions**

  For details on line voltages and R, S, and T points, see the wiring system figure provided later.

3P3W→3V3A

The following 8 measurement functions are available.
Urs (R-S line voltage): Urms3 (rms value),* Umn3 (rectified mean value calibrated to the rms value),*
Udc3 (simple average), Uac3 (AC component)
It (phase current): Irms3 (rms value),* Imn3 (rectified mean value calibrated to the rms value),*
Idc3 (simple average), Iac3 (AC component)

3V3A→3P4W

The following 13 measurement functions are available.

Ur (R-N voltage): Urms1 (rms value),* Umn1 (rectified mean value calibrated to the rms value),*
Udc1 (simple average), Uac1 (AC component)

Us (S-N voltage): Urms2 (rms value),* Umn2 (rectified mean value calibrated to the rms value),*
Udc2 (simple average), Uac2 (AC component)

Ut (T-N line voltage): Urms3 (rms value),* Umn3 (rectified mean value calibrated to the rms value),*
Udc3 (simple average), Uac3 (AC component)

In (neutral line current)

3P4W→3V3A

The following 13 measurement functions are available.

Urs (R-S voltage): Urms1 (rms value),* Umn1 (rectified mean value calibrated to the rms value),*
Udc1 (simple average), Uac1 (AC component)

Ust (S-T voltage): Urms2 (rms value),* Umn2 (rectified mean value calibrated to the rms value),*
Udc2 (simple average), Uac2 (AC component)

Utr (T-R line voltage): Urms3 (rms value),* Umn3 (rectified mean value calibrated to the rms value),*
Udc3 (simple average), Uac3 (AC component)

In (neutral line current)

* You can select either the rms value or the rectified mean value calibrated to the rms value (but not both). In either case, the value is displayed as rms.

- **Other measurement functions**

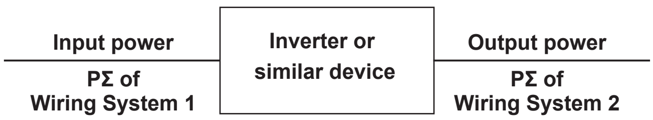
  The following 3 measurement functions are available.
  η (efficiency): Motor efficiency, power efficiency
  Uubf (three-phase voltage unbalance factor)
  Iubf (three-phase current unbalance factor)

Analysis Mode (Analysis Mode)

Select the system to be analyzed.

- 1 Wiring System: One system is analyzed.
- 2 Wiring Systems: Two systems are analyzed. The primary and secondary sides of the system to be analyzed can be measured to derive the efficiency.
- OFF: Power analysis is disabled.

- Device's power factor example



Setting Analysis Conditions (Wiring System)

Set the wiring system, math source waveforms, and analysis method (measurement period, analysis conditions, and efficiency).

Wiring System (Wiring)

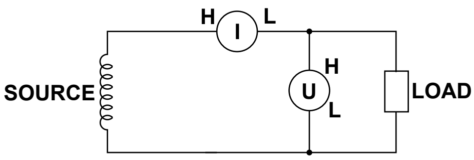
The following eight wiring systems are available on the DL850E/DL850EV.

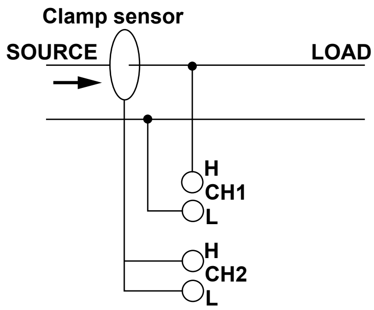
1P2W: Single-phase two-wire
1P3W: Single-phase three-wire
3P3W: Three-phase three-wire
3V3A: Three-voltage three-current measurement method
3P4W: Three-phase four-wire
3P3W→3V3A: Conversion of three-phase three-wire system data to the three-voltage three-current measurement method
3V3A→3P4W: Delta-star transformation using three-phase three-wire system data
3P4W→3V3A: Star-delta transformation using three-phase four-wire system data

To apply voltage, use a passive probe.
For details on how to select the appropriate passive probes and how to connect them (high and low), see section 3.5 in the Getting Started Guide, IM DL850E-03EN.
To apply current, use a current probe.
For details on how to select the appropriate current probes and how to connect them (current direction), see section 3.5 in the Getting Started Guide, IM DL850E-03EN, and the user's manual that came with the current probe.

- **Single-Phase Two-wire (1P2W)**

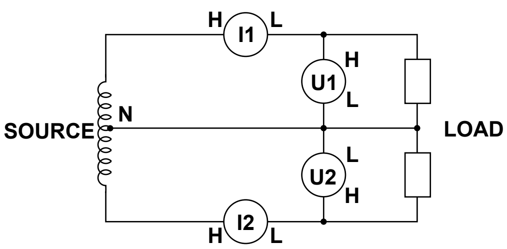
  Two channels that receive one pair of voltage and current signals can be wired.

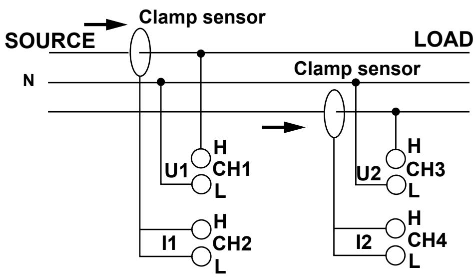




- **Single-Phase Three-Wire (1P3W)**

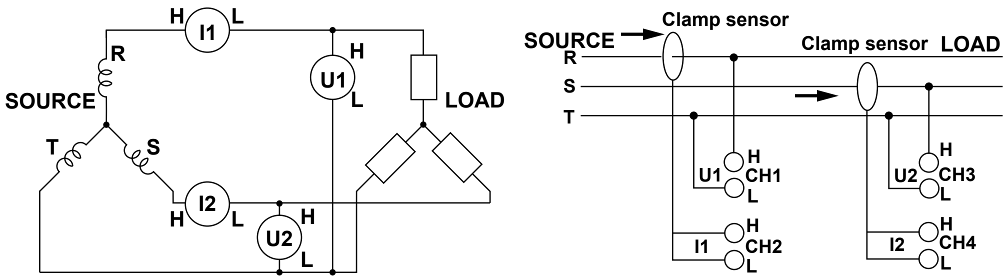
  Four channels that receive two pairs of voltage and current signals can be wired.





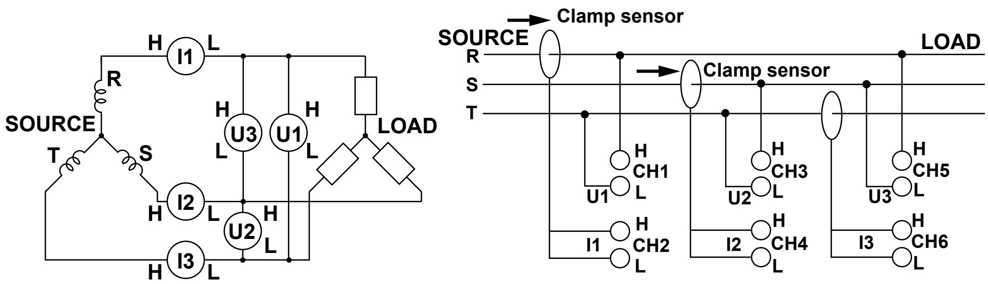
- **Three-Phase Three-Wire (3P3W)**

  Four channels that receive two pairs of voltage and current signals can be wired.



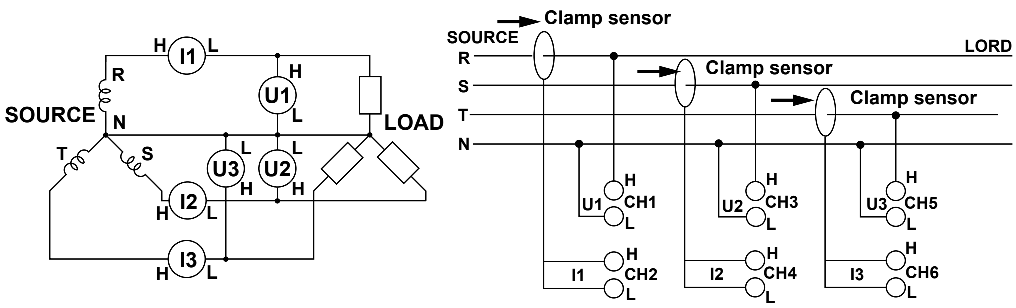
- **Three-Voltage Three-Current Method (3V3A)**

  Six channels that receive three pairs of voltage and current signals can be wired.



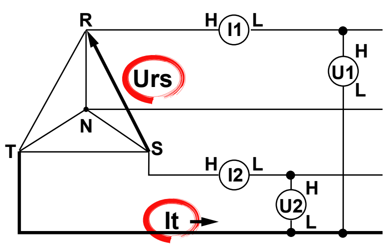
- **Three-Phase Four-Wire (3P4W)**

  Six channels that receive three pairs of voltage and current signals can be wired.

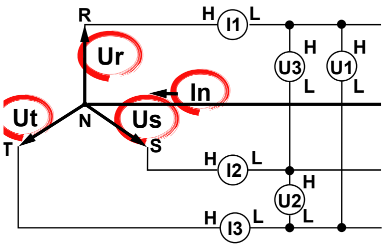


- **Conversion of Three-Phase Three-Wire System Data to the Three-Voltage Three-Current Measurement Method (3P3W→3V3A)**

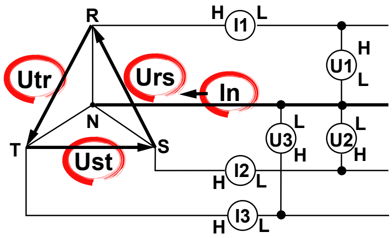
  Four channels that receive two pairs of voltage and current signals can be wired. Urs and It can be determined using delta math.



- **Delta-Star Transformation (3V3A→3P4W)**
  Six channels that receive three pairs of voltage and current signals can be wired. Ur, Us, Ut, and In can be determined using delta math.
  The center of the delta connection is assumed to be the center of the star connection. If the actual centers are not aligned, errors will result in the calculation.



- **Star-Delta Transformation (3P4W→3V3A)**
  Six channels that receive three pairs of voltage and current signals can be wired. Urs, Ust, Utr, and In can be determined using delta math.



Math Source Waveforms (U1 to U3, I1 to I3)

The modules described in “Power analysis can be performed only when one of the following modules is installed in a slot other than slot 7” under “Power Analysis (Power)” are applicable. CH13 or CH14 cannot be selected.

Calculation Period (Calc Period)

Select the method that is used to determine the calculation period of power math values.

- Edge: Power math starts when an edge is detected on the specified channel. The previous data is held until an edge is detected.
- Auto Timer: Calculation is performed at the specified interval, regardless of edge detection.
- AC: Power math starts when an edge is detected on the specified channel. Stop prediction can be specified. The power value is set to 0 after a stop detection. This is useful for analysis in which the power becomes 0 when the rotation of the motor or the like stops.
- AC+DC: After a stop is detected, the mode switches automatically to Auto Timer (calculation at a given interval). This is useful for analysis in which the DC component resides even after a stop.

If the Calculation Period Is Edge

- **Edge Detection Source (Edge Source)**
  Select the input channel of the signal that is used to determine the calculation period.

- **Hysteresis (Hysteresis)**
  The same as the standard feature. For details, see “Trigger Hysteresis” the chapter 4 in the *Features Guide*, IM DL850E-01EN.

- **Edge Source Filter (Edge Source Filter)**
  Select from the following.
  OFF, 128 kHz, 64 kHz, 32 kHz, 16 kHz, 8 kHz, 4 kHz, 2 kHz, 1 kHz, 500 Hz, 250 Hz, 125 Hz, 62.5 Hz

  The DL850E/DL850EV reduces the effects of noise by using hysteresis when it detects zero crossings.
  If the synchronization source is distorted or harmonics and noise are superposed on the signal to a level exceeding this hysteresis, harmonic components will cause zero crossing detection to occur frequently, and the zero crossing of the fundamental frequency will not be detected stably. Consequently, the measured voltage and current may be unstable.
  To stably detect zero crossings, set the edge source filter.

If the Calculation Period Is Auto Timer

Set the calculation period update time.
Range: 100 ns to 500 ms. Resolution: 100 ns.

If the Calculation Period Is AC

- **Edge Detection Source (Edge Source)**
  The options are the same as Edge.

- **Hysteresis (Hysteresis) and Edge Source Filter (Edge Source Filter)**
  The options are the same as Edge.

- **Stop Prediction (Stop Prediction)**
  Set the time from the point when the pulse input stops to the point when the DL850E/DL850EV determines that the object has stopped.
  - 2, 4, 8, 16: Stop prediction is performed on the basis of the specified number of times the pulse period (four settings) of the pulse one period before the pulse input stopped.
    For details, see chapter 2 in the *Features Guide*, IM DL850E-01EN.

If the Calculation Period Is AC+DC

- **Edge Detection Source (Edge Source)**
  The options are the same as Edge.

- **Hysteresis (Hysteresis) and Edge Source Filter (Edge Source Filter)**
  The options are the same as Edge.

- **Stop Prediction (Stop Prediction)**
  The options are the same as Edge.

- **Update Time (Auto Timer)**
  Range: 100 ns to 500 ms. Resolution: 100 ns.

Vertical Scale (Value/Div) Optimization (ALL Output Optimize Value/Div)

This is the same feature as Optimize Value/Div of real time math (RealTime Math).

Analysis Setting (Analysis Setting)

Set how to calculate power math values.

- **RMS Type (RMS Type)**
  Select the rms value from the following.
  True RMS (rms value), Rect. Mean (rectified mean value calibrated to the rms value)

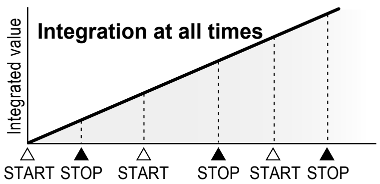
- **φ Scaling (φ Scale)**
  Select how to display phase differences.
  Radian: Radian
  Degree: Degrees

- **Integration Condition (Condition)**
  All times: Integration is performed at all times.
  In Acquisition: Integration is performed only during measurement.

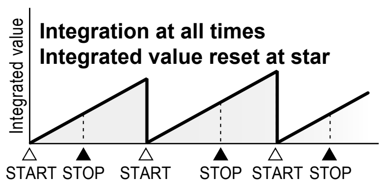
- **Reset on Start (Reset on Start)**
  OFF: Integration continues regardless of the START/STOP key state. To reset the value, reset manually.
  ON: The integrated value is reset to zero whenever waveform acquisition starts as a result of pressing the START/STOP key.

When Integration Condition is set to All times

- **When Reset on Start is OFF**

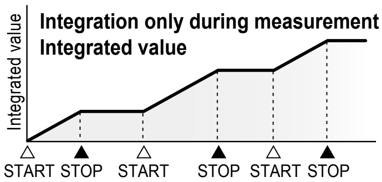


- **When Reset on Start is ON**

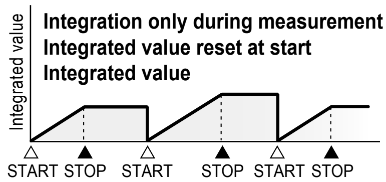


When Integration Condition is set to In Acquisition

- **When Reset on Start is OFF**



- **When Reset on Start is ON**



- **Scaling (Scaling)**
  Select the integral time unit.
  Second: Second
  Hour: Hour

Efficiency Setting (Efficiency Setting)

Select the measurement function efficiency η type from the following.

- Power: The power efficiency is calculated. Available when the analysis mode is 2Wirig System.
- Motor: The motor drive efficiency is calculated.
- OFF: Efficiency is not calculated.

- **Torque (Torque)**
  Select the real time math channel set to math “Torque.”

- **Coefficient (K)**
  Set scaling coefficient K.
  Range: –9.9999E+30 to +9.9999E+30. The default value is 1.0000.

- **Pm Type (Pm Type)**
  Select the type of rotating speed.
  RotationAngle: Rotation angle (rad/s)
  Speed: Rotating speed

  When the Pm Type Is RotationAngle

  - **Rotation Angle (Rotation Angle)**
    Select the real time math channel set to math “Rotary Angle.”

  When the Pm Type Is Speed

  - **Speed**
    Select the input channel of the module measuring the number of rotations.
  - **Scaling (Scaling)**
    Select the unit that is used on the vertical scale.
    rps: The unit is set to revolutions per second.
    rpm: The unit is set to revolutions per minute.

Harmonic Analysis (Harmonics)

Harmonics refer to sine waves whose frequency is an integer multiple (2 and higher) of the fundamental wave except for the fundamental wave itself.
When the fundamental is mixed with harmonics, waveform distortion results.
The DL850E/DL850EV analyzes the harmonics of rms values (voltage and current) and active power.
The DL850E/DL850EV analyzes harmonic orders 1 to 40 for rms values and 1 to 35 for active power.
This is a feature available on the /G5 option.

- Harmonic analysis can be performed when any of the following modules is installed in a slot other than slot 8.
  701250 (HS10M12), 720250(HS10M12), 701251 (HS1M16), 701255 (NONISO_10M12), 701267 (HV (with RMS)), 720268(HV(AAF, RMS)), 720210 (HS100M12), 720211 (HS100M12),701261 (UNIVERSAL), 701262 (UNIVERSAL (AAF)), 701265 (TEMP/HPV), 720266(TEMP/HPV), 701275 (ACCL/VOLT), 720254 (4CH 1M16)
- Channels that can be used for harmonic analysis are CH15 and CH16. Harmonic analysis results are output to the subchannels of CH15 and CH16.
  The number of calculations performed in one analysis is equal to the total number of subchannels of CH15 and CH16.
- The maximum number of harmonic analysis parameters that can be calculated is as follows.
  Harmonic analysis of rms values: 123 parameters
  Harmonic analysis of active power: 121 parameters
- The harmonic analysis result waveform can be used as a trigger source, but it cannot be used as a real time math source.

Measurement Functions and Source Channels

For the terminology definitions, see “Measurement Functions“ and “Source Channels” provided in the Power Analysis section.

Measurement Function Types

The following measurement functions are available.

- **Rms Value Measurement Functions**
  RMS (rms values of the 1st to the 40th harmonic), Rhdf (percentage contents of the 1st to the 40th harmonic), φ (phases of the 1st to the 40th harmonic), RMS (total rms value), THDIEC (distortion factor: IEC), THDCSA (distortion factor: CSA)

- **Active Power Measurement Functions**
  P (active powers of the 1st to the 35th harmonic), Phdf (active power percentage contents of the 1st to the 35th harmonic), φ (active power phases of the 1st to the 35th harmonic), P (all active powers), S (all apparent powers), Q (all reactive powers), λ (power factor),
  U1 (1st harmonic rms voltage), U2 (1st harmonic rms voltage), U3 (1st harmonic rms voltage), I1 (1st harmonic rms current),
  I2 (1st harmonic rms current), I3 (1st harmonic rms current), φU1-U1 (phase angle), φU1-I1 (phase angle), φU1-U2 (phase angle), φU1-I2 (phase angle), φU1-U3 (phase angle), φU1-I3 (phase angle)

Analysis Mode (Analysis Mode)

Select the harmonic analysis item.

- Line RMS: Harmonic analysis is performed on voltage and current.
- Power: Harmonic analysis is performed on active power.
- OFF: Harmonic analysis is disabled.

When the Analysis Mode Is Line RMS

- **Math Source Waveforms (Source)**
  The modules described in "Harmonic analysis can be performed only when one of the following modules is installed in a slot other than slot 8" under "Harmonic Analysis (Harmonic)" are applicable. CH15 or CH16 cannot be selected.

- **Edge Detection Source (Edge Source)**
  The same channel as the math source waveform (cannot be changed).

- **Hysteresis (Hysteresis)**
  The same as the standard feature. For details, see "Trigger Hysteresis" in chapter 4.

- **Edge Source Filter (Edge Source Filter)**
  Select from the following.
  OFF, 128 kHz, 64 kHz, 32 kHz, 16 kHz, 8 kHz, 4 kHz, 2 kHz, 1 kHz, 500 Hz, 250 Hz, 125 Hz, 62.5 Hz
  This is the same as "Edge Source Filter" described under "Power Analysis (Power)."

- **φ Scaling (φ Scale)**
  Select how to display phase differences.
  Radian: Radian
  Degree: Degrees

When the Analysis Mode is Power

- **Wiring System (Wiring)**
  The same as Wiring System under "Power Analysis (Power)."

- **Math Source Waveforms (U1 to U3, I1 to I3)**
  The options are the same as those for Line RMS analysis mode.

- **Edge Detection Source (Edge Source)**
  The same channel as the math source waveform. Select from U1 to U3 and I1 to I3.

- **Hysteresis (Hysteresis)**
  The same as the standard feature. For details, see "Trigger Hysteresis" in chapter 4.

- **Edge Source Filter (Edge Source Filter)**
  Select from the following.
  OFF, 128 kHz, 64 kHz, 32 kHz, 16 kHz, 8 kHz, 4 kHz, 2 kHz, 1 kHz, 500 Hz, 250 Hz, 125 Hz, 62.5 Hz
  This is the same as "Edge Source Filter" described under "Power Analysis (Power)."

- **φ Scaling (φ Scale)**
  Select how to display phase differences.
  Radian: Radian
  Degree: Degrees

All Item (Value/Div) Optimization (ALL Output Optimize Value/Div)

This is the same feature as Optimize Value/Div of real time math (RealTime Math).

Harmonic Analysis Window Setup (Harmonic Window Setup)

Graph Position (Graph Position)

Select the analysis position on the waveform display of the main screen. The analysis results for the cursor position are displayed in the graph window.

Main Screen Ratio (Main Ratio)

Set the percentage of the entire waveform display area that the main screen will occupy.

- 50%: The main screen is displayed in the top half of the entire area.
- 20%: The main screen is displayed in the top 20% of the entire area.
- 0%: The main screen is not displayed.

Window Layout (Window Layout)

Set the display layout of the two graph windows.

- Side: Side by side
- Vertical: Top and bottom

Graph Window (Graph Window)

Select from the following.

- Bar: A bar graph is displayed for the calculated harmonic value of each harmonic up to the 40th harmonic.
- Vector: The relationship of the phase difference and size (rms value) between the fundamental waves U(1) and I(1) of the source channel is displayed with vectors.
- List: A numerical list is displayed for the calculated harmonic value of each harmonic up to the 40th harmonic.

When the Graph Window is Bar

- **Display Item (Display Item)**

  The following parameters can be displayed.
  RMS (rms value), P (active power), hdf (percentage content), φ (phase)

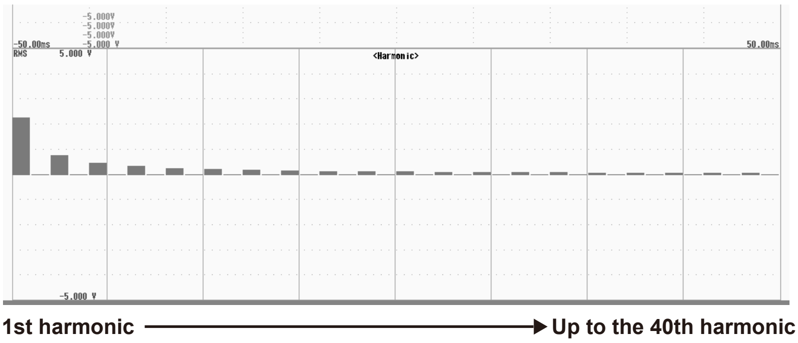
- **Maximum Order to Display (Display Max Order)**

  Set the harmonics to display in the graph window.
  The range is as follows.
  Line RMS mode: 1 to 40
  Power mode: 1 to 35

- **Vertical Scale (V Scale)**

  Set the vertical scale to Linear or Log (logarithmic).
  This setting applies to the scales for RMS (rms value) and P (active power).

Graph display example



When the Graph Window is Vector

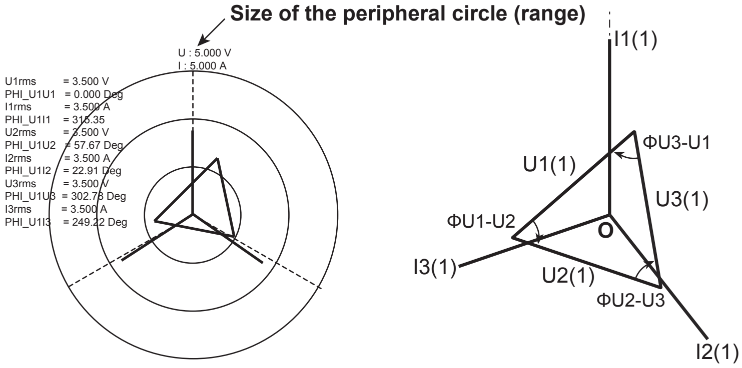
• Numeric Display On/Off

Set whether to display the numeric measured results in the graph window.
ON: The numeric measured results are displayed.
OFF: The numeric measured results are not displayed.

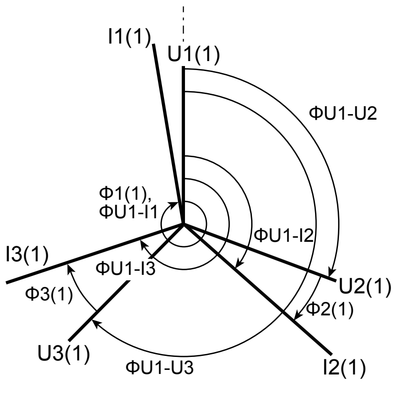
• Zoom (U:Zoom, I:Zoom)

You can change the size of vectors. When you zoom the vectors, the value that indicates the size of the vector display's peripheral circle changes according to the zoom factor.
Range: 0.1 to 100

When the wiring system is 3V3A (three-voltage three-current method),
3P3W→3V3A (conversion of three-phase three-wire system to
the three-voltage three-current measurement method), or
3P4W→3V3A (star-delta transformation)
• U1(1), U2(1), and U3(1) are line voltages.
• I1(1), I2(1), and I3(1) are line currents.



When the wiring system is 1P2W (single-phase two-wire),
1P3W (single-phase three-wire), 3P3W (three-phase four-wire),
3P4W (three-phase four-wire), or 3V3A→3P4W (delta-star transformation)
• U1(1), U2(1), and U3(1) are phase voltages.
• I1(1), I2(1), and I3(1) are line currents.



When the Graph Window is List

- **Display Item (Display Item)**

  The same as with Bar.

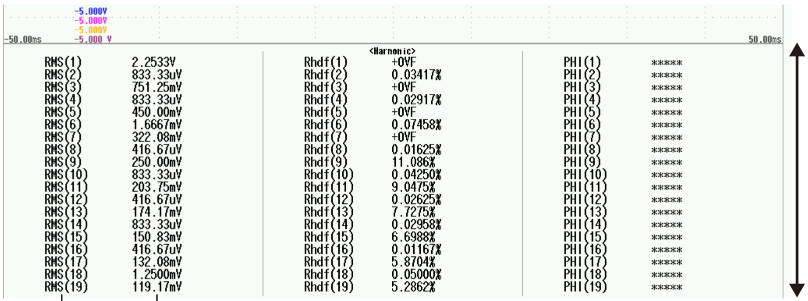
- **Maximum Order to Display (Display Max Order)**

  The same as with Bar.

- **List Start Order (List Start Order)**

  Set the harmonic to display at the top of the list.
  Harmonics less than the specified harmonic are not shown in the list.
  This is used to scroll the list.
  The range is as follows.
  Line RMS mode: 1 to 40
  Power mode: 1 to 35

List display example (rms and percentage content)



Press the List Start Order soft key and turn the jog shuttle to scroll.

Harmonics **Harmonic analysis values**

Labels (Label)

This is the same as the feature on the standard model. For details, see the *Features Guide*, IM DL850E-01EN.

Optimizing Value/Div (Optimize Value/Div)

Press the Optimize Value/Div soft key to automatically set the value/div that the DL850E/DL850EV determines is the most appropriate for the math source waveform range and the expression. The selected value is from among the 123 value/div options for vertical axis sensitivity.

- The automatically selected option does not line up with the input values and math results, so you need to use the SCALE knob to change the value/div.
- There are a total of 123 value/div options within the following range: 500.0E+18 to 10.00E–21 (in steps of 1, 2, or 5).

Waveform Vertical Position (Vertical POSITION knob)

This is the same as the feature on the standard model. For details, see the *Features Guide*, IM DL850E-01EN.

Zoom Method (V Scale), Zooming by Setting a Magnification (V Zoom), Zooming by Setting Upper and Lower Display Limits (Upper/Lower)

This is the same as the feature on the standard model. For details, see the *Features Guide*, IM DL850E-01EN.

Offset (Offset)

This is the same as the feature on the standard model. For details, see the *Features Guide*, IM DL850E-01EN.

Trace Settings (Trace Setup)

This is the same as the feature on the standard model. For details, see the *Features Guide*, IM DL850E-01EN.

Notes Regarding Using the Digital Filter and Real Time Math

Real Time Math Source Modules and Channels

The modules and channels that you can select as real time math source waveforms (source) are shown below.

Operators and Functions	Input Module Model and RMath (Real Time Math Channel) (Yes: Can be selected, No: Cannot be selected)				
	701250, 720250, 701251, 701255, 701267, 720268, 701261, 701262, 701265, 720266, 701270, 701271, 701275, 720210, 720211, 720220,[1] 720221,[1] 720254	701281 720281	720230	720240,[1, 2] 720241,[1, 2] 720242,[1, 2] 720243,[1, 2] (Only usable on the DL850EV)	RMath[3]
S1+S2, S1–S2, S1*S2, S1/S2	Yes	Yes	No	Yes	Yes
A(S1)+B(S2)+C, A(S1)–B(S2)+C, A(S1)*B(S2)+C, A(S1)/B(S2)+C	Yes	Yes	No	Yes	Yes
Diff(S1), Integ1(S1), Integ2(S1)	Yes	Yes	No	Yes	Yes
Rotary Angle	Yes[4]	No	Yes[4]	Yes	No
DA	No	No	Yes	No	No
Polynomial	Yes	Yes	No	Yes	Yes
RMS, Power: Math source	Yes	No	No	Yes	Yes
RMS, Power: Edge source	Yes	No	Yes	Yes[*2]	Yes
Power Integ	Yes	No	No	Yes	Yes
Log1, Log2	Yes	Yes	No	Yes	Yes
Sqrt1, Sqrt2	Yes	Yes	No	Yes	Yes
Cos, Sin	Yes[4]	No	Yes[4]	Yes	No
Atan	Yes	Yes	No	Yes	Yes
Electrical Angle: Math source	No	No	Yes	No	No
Electrical Angle: Target	Yes	No	No	Yes	Yes
Knock Filter (Only settable on the DL850EV)	Yes	No	No	Yes	No
Poly-Add-Sub	Yes	Yes	No	Yes	Yes
Frequency, Period	Yes	No	Yes	Yes	Yes
Edge Count	Yes	No	Yes	Yes[2]	Yes
Resolver	Yes	Yes	No	Yes	Yes
IIR Filter	Yes	Yes	No	Yes	Yes
PWM	Yes	Yes	No	Yes	Yes
Reactive Power(Q)	Yes	No	No	Yes[2]	Yes
CAN ID	Yes[5]	No	Yes	Yes	Yes
Torque	Yes[5]	No	Yes	Yes	Yes
S1–S2 (Angle)	Yes[5]	No	No	Yes	Yes
3 Phase Resolver	Yes	Yes	No	Yes	Yes

For the names of the input modules, see the *Getting Started Guide*, IM DL850E-03EN.

1 To set the input channels of a 720220 16-CH voltage input module or a 720221 temperature/voltage input module as the source waveforms of real time math, you have to set the input coupling (Coupling) to DC or GND. To set the input channels of a 720240 CAN bus monitor module, 720241 CAN & LIN bus monitor module, 720242 CAN/CAN FD monitor or 720243 SENT monitor module as the source waveforms of real time math, you have to turn the input (Input) on.
2 Input channels of a 720240 CAN bus monitor, 720241 CAN & LIN bus monitor or 720242 CAN/CAN FD monitor module cannot be selected if the data type (Value Type) is set to Logic. Even if the data type is not set to Logic, you cannot use data that exceeds 16 bits in length. On a 720243 SENT monitor module, S&C and Error Trigger sub channels cannot be selected. However, if the function is Edge Count, these channels can be selected.
3 If you set the real time math channel to RMathX, you can select the RMath waveforms on channels up to RMathX–1. If the real time math channel is RMath1, you cannot use any other RMath waveforms as math source waveforms.
4 If you have turned logic sources on, select an input channel of a 720230 logic module. If logic sources have been turned off, select an input channel of an analog waveform module.
5 The input channels of a 16-CH voltage input module (720220) or 16-CH temperature/voltage input module (720221) cannot be selected.

Math Delay

The real time math delay is “1.4 μs + the digital filter delay + the math delay.”
The digital filter and math delays vary depending on the type of filter and math operation.

- If you are using the result of a real time math channel as the source waveform for another real time math operation, the math delays accumulate.
- For details, see the appendix.

Internal Processing of Real Time Math

The math source waveforms are 16-bit binary data. If they are only 12 bits long, they are converted to 16 bits. Internally, the waveforms are converted to floating-point numbers and calculated.

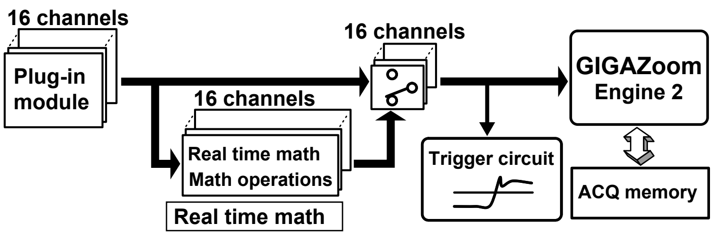
- The math results are converted to 16-bit data in relation to the range (value/div) and are then recorded in acquisition memory.
- The basic display is 2400 LSB/div (the same as the 16-bit analog waveform module).
- For details on the internal math expressions, see the appendix.

Differences between Real Time Math and Standard Math

This section explains the differences between the real time math operations that you configure by pressing CH (/G3 option) and the standard math operations that you configure by pressing MATH.

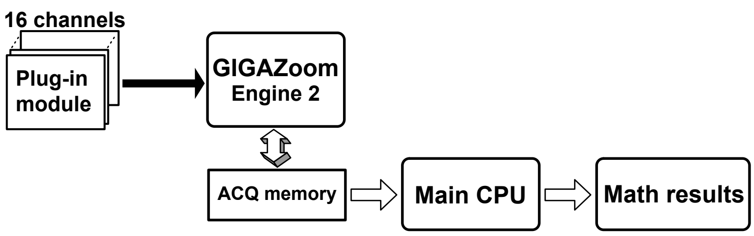
Real Time Math

- Math operations can be performed in real time on waveforms (A/D converted data) that are applied to the input channels of each of the modules.
- Even when the display is in roll mode, you can view the real time math results.
- There are no limits on the record length. Because the data of normal input channels is switched with the real time math results and acquired in acquisition memory, you can specify the same record length as that of the normal input channels.
- You can trigger the DL850E/DL850EV on real time math results.
- Regardless of the DL850E/DL850EV sample rate, math operations are always performed on the data that is output from each module at a maximum math rate of 10 MS/s.
- Real time math can be used in all acquisition modes (including the dual capture mode).



Standard Math

- Because waveforms are processed after they are acquired, the waveform update period is long.
- Math cannot be performed when the display is in roll mode.
- Math is performed on data that was acquired into acquisition memory at the DL850E/DL850EV sample rate.
- Because math results are stored in the main memory of the main CPU, there are limits on the record length (for one channel, the maximum is 1 Mpoint).
- You can not trigger the DL850E/DL850EV on math results.
- Because math is performed by a general-purpose CPU, a wide variety of expressions are available.



2 Configuring Digital Filter Settings

Digital Filter

The digital filter operation menu has the following settings:

- Filter type: You can select from four filter types—Gauss, Sharp, IIR, and Mean.
- Filter band: You can select the type of filter bands.
- Delay: You can add a delay to the updating of data after data passes through a digital filter.

For details on the digital filter, see chapter 1.
For the filter characteristics, see the appendix.

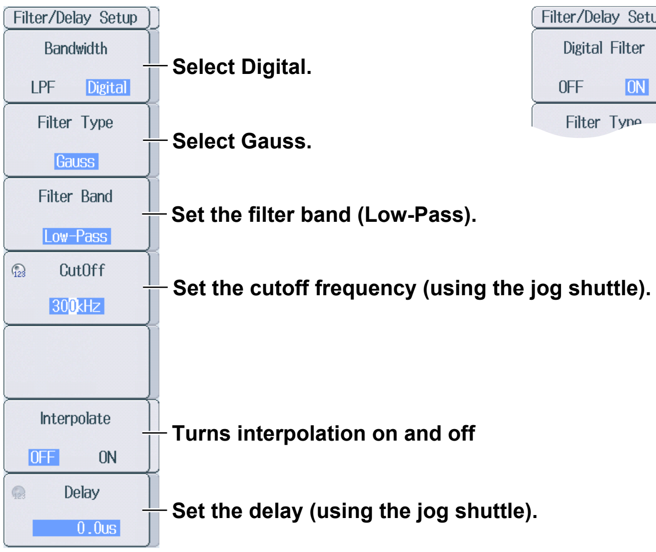
Gauss

This section explains the following settings (which are used when using the Gauss filter):

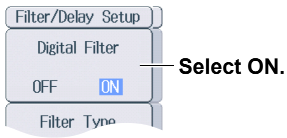
- Filter type
- Filter band
- Cutoff frequency
- Interpolation
- Delay

CH Menu

1. Press a key from **CH1** to **CH16**, and then the **RealTime Math** soft key to select OFF.
2. Press the **Filter/Delay Setup** soft key and then the **Bandwidth** soft key to select Digital.
   The following menu appears.



When you have selected the input channel of a frequency module



Note

- The same delay is used for all filter types of the same channel.
- To display the Filter/Delay Setup soft key on the setup menu that is displayed when you press a key from CH1 to CH16, press the RealTime Math soft key to select OFF.
- If you want to perform real time math at the same time as the digital filter, press the RealTime Math soft key again to select ON.
- For information on other features, how to use these features, and handling precautions, see the following manuals.
  - The *Features Guide*, IM DL850E-01EN
  - The *User's Manual*, IM DL850E-02EN
  - The *Getting Started Guide*, IM DL850E-03EN

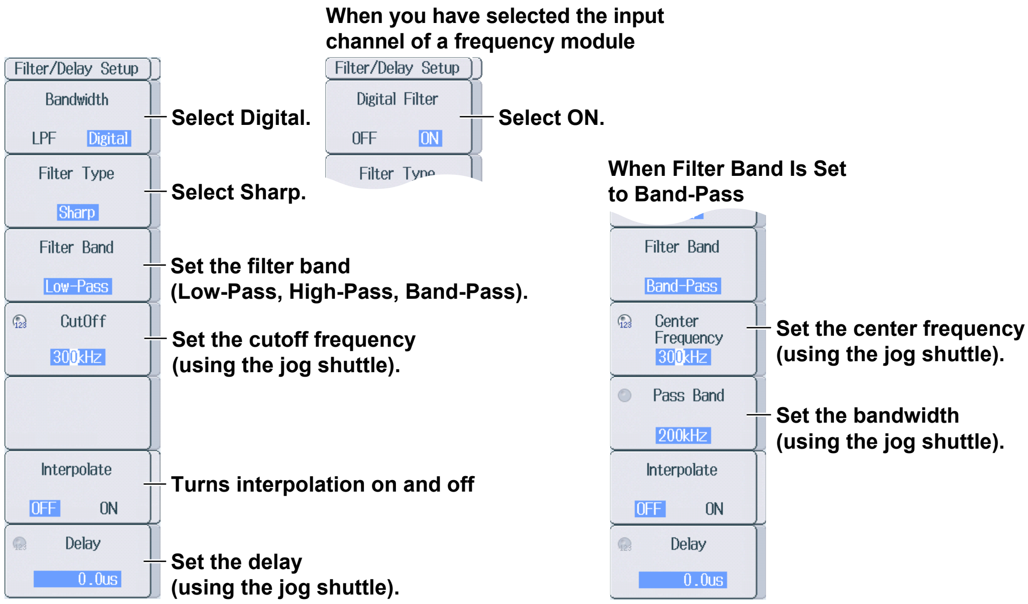
Sharp

This section explains the following settings (which are used when using the Sharp filter):

- Filter type
- Filter band
- Cutoff frequency
- Center frequency
- Bandwidth
- Interpolation
- Delay

CH Menu

1. Press a key from **CH1** to **CH16**, and then the **RealTime Math** soft key to select OFF.
2. Press the **Filter/Delay Setup** soft key and then the **Bandwidth** soft key to select Digital. The following menu appears.



Note

- The same delay is used for all filter types of the same channel.
- To display the Filter/Delay Setup soft key on the setup menu that is displayed when you press a key from CH1 to CH16, press the RealTime Math soft key to select OFF.
- If you want to perform real time math at the same time as the digital filter, press the RealTime Math soft key again to select ON.
- For information on other features, how to use these features, and handling precautions, see the following manuals.
  - The *Features Guide*, IM DL850E-01EN
  - The *User's Manual*, IM DL850E-02EN
  - The *Getting Started Guide*, IM DL850E-03EN

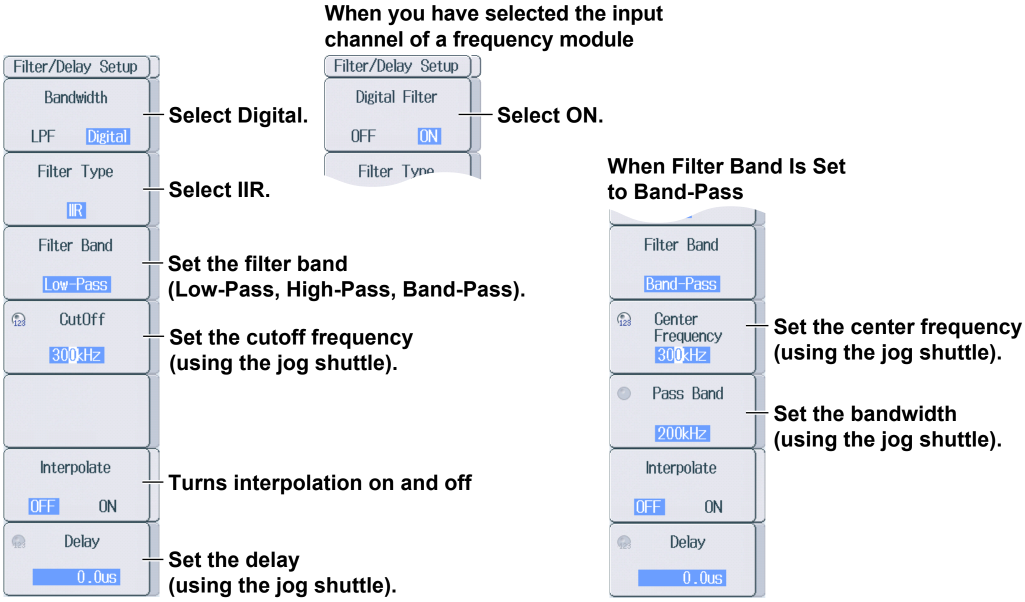
IIR

This section explains the following settings (which are used when using the IIR filter):

- Filter type
- Filter band
- Cutoff frequency
- Center frequency
- Bandwidth
- Interpolation
- Delay

CH Menu

1. Press a key from **CH1** to **CH16**, and then the **RealTime Math** soft key to select OFF.
2. Press the **Filter/Delay Setup** soft key and then the **Bandwidth** soft key to select Digital.
   The following menu appears.



Note

- The same delay is used for all filter types of the same channel.
- To display the Filter/Delay Setup soft key on the setup menu that is displayed when you press a key from CH1 to CH16, press the RealTime Math soft key to select OFF.
- If you want to perform real time math at the same time as the digital filter, press the RealTime Math soft key again to select ON.
- For information on other features, how to use these features, and handling precautions, see the following manuals.
  - The *Features Guide*, IM DL850E-01EN
  - The *User's Manual*, IM DL850E-02EN
  - The *Getting Started Guide*, IM DL850E-03EN

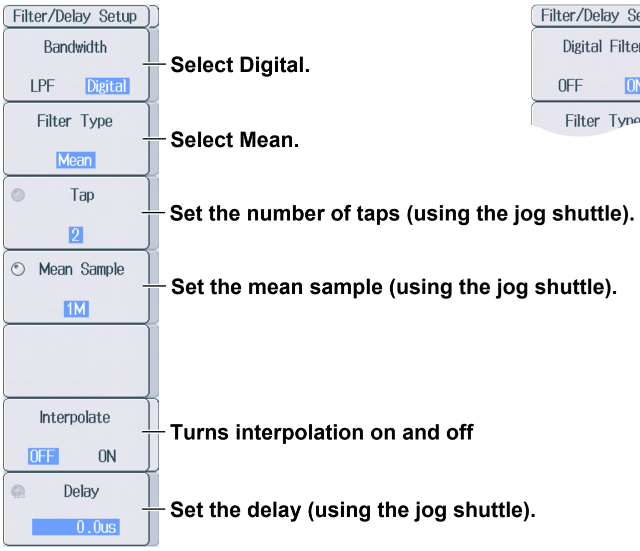
Mean

This section explains the following settings (which are used when using the Mean filter):

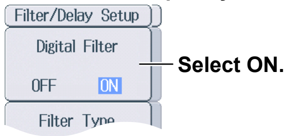
- Filter type
- Number of taps
- Mean sample
- Interpolation
- Delay

CH Menu

1. Press a key from **CH1** to **CH16**, and then the **RealTime Math** soft key to select OFF.
2. Press the **Filter/Delay** Setup soft key and then the **Bandwidth** soft key to select Digital.
   The following menu appears.



When you have selected the input channel of a frequency module



Note

- The same delay is used for all filter types of the same channel.
- To display the Filter/Delay Setup soft key on the setup menu that is displayed when you press a key from CH1 to CH16, press the RealTime Math soft key to select OFF.
- If you want to perform real time math at the same time as the digital filter, press the RealTime Math soft key again to select ON.
- For information on other features, how to use these features, and handling precautions, see the following manuals.
  - The *Features Guide*, IM DL850E-01EN
  - The *User's Manual*, IM DL850E-02EN
  - The *Getting Started Guide*, IM DL850E-03EN

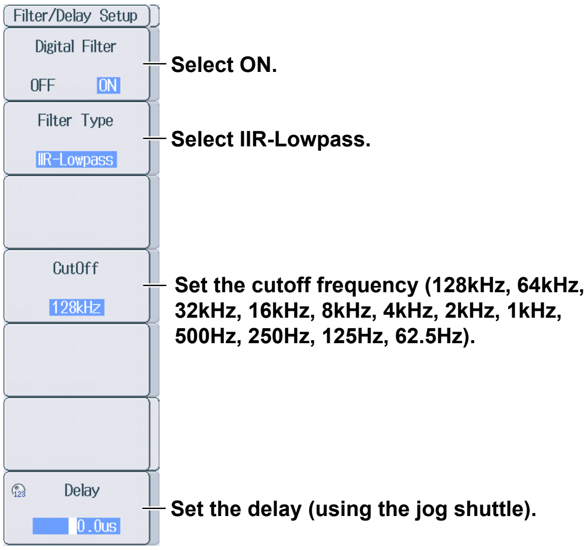
IIR-Lowpass

This section explains the following settings (which are used when using the IIR-Lowpass filter):

- Cutoff frequency
- Delay

CH Menu

1. Press a key from **CH1** to **CH16**, and then the **RealTime Math** soft key to select OFF.
2. Press the **Filter/Delay** Setup soft key and then the **Digital Filter** soft key to select ON.
   The following menu appears.



Note

- The same delay is used for all filter types of the same channel.
- To display the Filter/Delay Setup soft key on the setup menu that is displayed when you press a key from CH1 to CH16, press the RealTime Math soft key to select OFF.
- If you want to perform real time math at the same time as the digital filter, press the RealTime Math soft key again to select ON.
- For information on other features, how to use these features, and handling precautions, see the following manuals.
  - The *Features Guide*, IM DL850E-01EN
  - The *User's Manual*, IM DL850E-02EN
  - The *Getting Started Guide*, IM DL850E-03EN

3 Configuring Real Time Math Settings

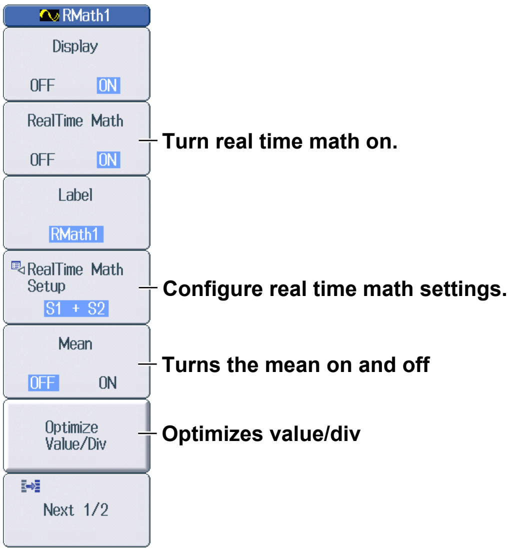
Real Time Math Settings

This section explains the following settings (which are used when performing real time math):

- Real time math on/off
- Real time math settings
- Input settings for all channels

RMath Menu

Press a key from **CH1** to **CH16**, and then the **RealTime Math** soft key to select ON to display the following menu.

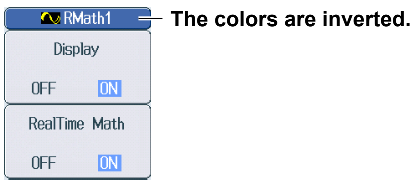


Note

- When you turn real time math on, the colors that are used to display the menu title are inverted.

When OFF Is Selected

When ON Is Selected

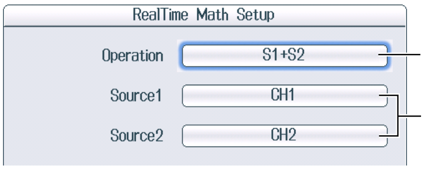


- For information on other features, how to use these features, and handling precautions, see the following manuals.
  - The *Features Guide*, IM DL850E-01EN
  - The *User's Manual*, IM DL850E-02EN
  - The *Getting Started Guide*, IM DL850E-03EN

Configuring Real Time Math Settings (RealTime Math Setup)

Press the **RealTime Math Setup** soft key to display the following screen.

Example when the Operation is S1+S2



Select an operator or function (see the operations and function that are described later in this section).

Select the math source waveforms (CH1 to CH16,[1] RMath1 to RMath15[2]).

1 You can select channels in which input modules that support basic arithmetic are installed.

2 You can select channels whose numbers are smaller than the channel you are operating.

Operations and Functions

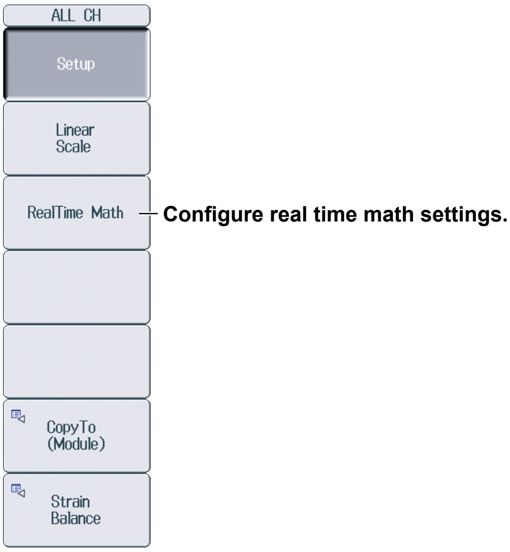
Menu Item	Description	
S1+S2	Basic arithmetic	Addition
S1−S2		Subtraction
S1*S2		Multiplication
S1/S2		Division
A(S1)+B(S2)+C	Basic arithmetic with coefficients	Addition
A(S1)−B(S2)+C		Subtraction
A(S1)*B(S2)+C		Multiplication
A(S1)/B(S2)+C		Division
Diff(S1)	Differentiation	
Integ1(S1)	Integration	Area of the positive amplitude (T-Y waveform)
Integ2(S1)		Area of the positive amplitude minus area of the negative amplitude (T-Y waveform)
Rotary Angle	Angle of rotation	
DA	Logic signal to analog waveform conversion	
Polynomial	Quartic polynomial	
RMS	RMS value	
Power	Effective power	
Power Integ	Effective power integration	
Log1	Common logarithm	Common logarithm of S1/S2
Log2		Common logarithm of S1
Sqrt1	Square root	Square root of "$S1^2 \pm S2^2$"
Sqrt2		Square root of S1
Cos	Cosine	
Sin	Sine	
Atan	Arc tangent	
Electrical Angle	Electrical angle	
Knock Filter	Knocking filter (only on the DL850EV)	
Poly-Add-Sub	Polynomial with a coefficient	
Frequency	Frequency	
Period	Period	
Edge Count	Edge count	
Resolver	Resolver	
IIR Filter	IIR Filter	
PWM	Demodulation of the Pulse Width Modulated Signal	
Reactive Power(Q)	Reactive power	
CAN ID	CAN ID detection	
Torque	Torque	
S1−S2(Angle)	Angle Difference	
3 Phase Resolver	3 Phase Resolver	

Note

For details on the types of modules that support the operations and functions, see "Notes Regarding Using the Digital Filter and Real Time Math," in chapter 1.

ALL CH Menu

Press **ALL CH** to display the following menu.

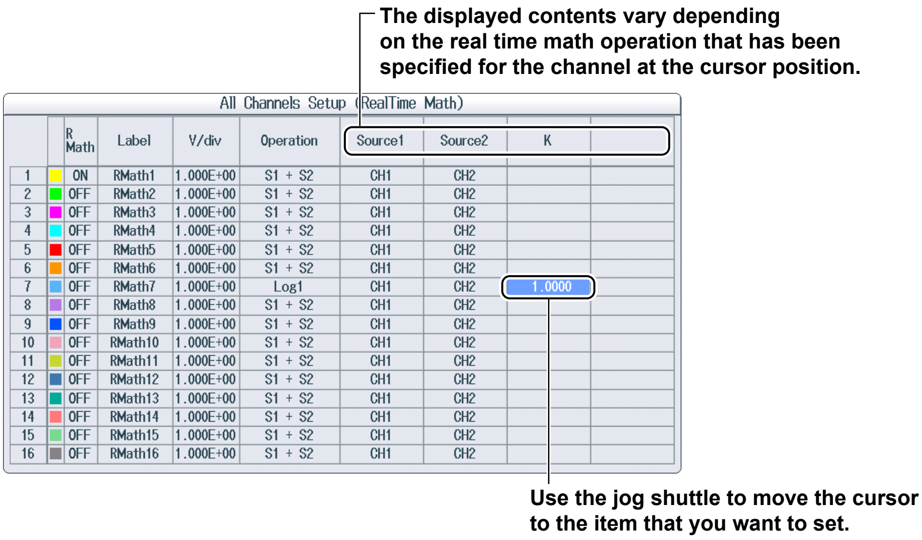


Note

- For information on other features, how to use these features, and handling precautions, see the following manuals.
  - The *Features Guide*, IM DL850E-01EN
  - The *User's Manual*, IM DL850E-02EN
  - The *Getting Started Guide*, IM DL850E-03EN

Configuring Real Time Math Settings for All Channels (RealTime Math)

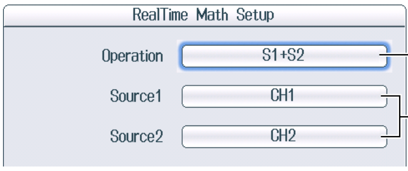
Press the **RealTime Math** soft key to display the following screen.



	R Math	Label	V/div	Operation	Source1	Source2	K
1	ON	RMath1	1.000E+00	S1 + S2	CH1	CH2	
2	OFF	RMath2	1.000E+00	S1 + S2	CH1	CH2	
3	OFF	RMath3	1.000E+00	S1 + S2	CH1	CH2	
4	OFF	RMath4	1.000E+00	S1 + S2	CH1	CH2	
5	OFF	RMath5	1.000E+00	S1 + S2	CH1	CH2	
6	OFF	RMath6	1.000E+00	S1 + S2	CH1	CH2	
7	OFF	RMath7	1.000E+00	Log1	CH1	CH2	1.0000
8	OFF	RMath8	1.000E+00	S1 + S2	CH1	CH2	
9	OFF	RMath9	1.000E+00	S1 + S2	CH1	CH2	
10	OFF	RMath10	1.000E+00	S1 + S2	CH1	CH2	
11	OFF	RMath11	1.000E+00	S1 + S2	CH1	CH2	
12	OFF	RMath12	1.000E+00	S1 + S2	CH1	CH2	
13	OFF	RMath13	1.000E+00	S1 + S2	CH1	CH2	
14	OFF	RMath14	1.000E+00	S1 + S2	CH1	CH2	
15	OFF	RMath15	1.000E+00	S1 + S2	CH1	CH2	
16	OFF	RMath16	1.000E+00	S1 + S2	CH1	CH2	

Basic Arithmetic (S1+S2, S1−S2, S1*S2, and S1/S2)

The following screen appears when you select a basic arithmetic operation.

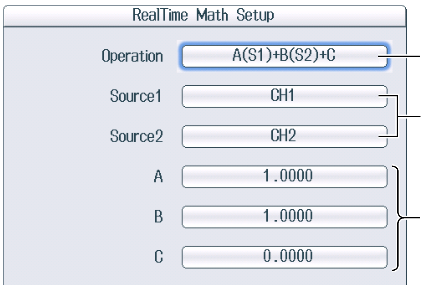


Select the operation.

Select the math source waveforms.

Basic Arithmetic with Coefficients (A(S1)+B(S2)+C, A(S1)−B(S2)+C, A(S1)*B(S2)+C, and A(S1)/B(S2)+C)

The following screen appears when you select a basic arithmetic operation with coefficients.



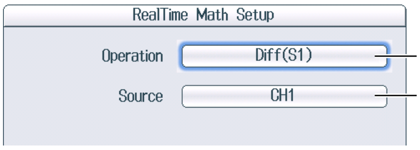
Select the operation.

Select the math source waveforms.

Set the coefficients (using the jog shuttle).

Differentiation (Diff(S1))

The following screen appears when you select the differentiation function.

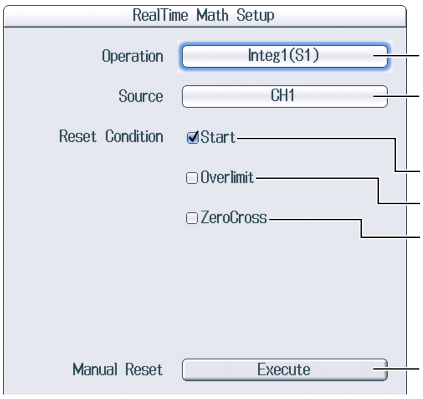


Select the function.

Select the math source waveform.

Integration (Integ1(S1) and Integ2(S2))

The following screen appears when you select an integration function.



Select the function.

Select the math source waveform.

Reset conditions for the integration result

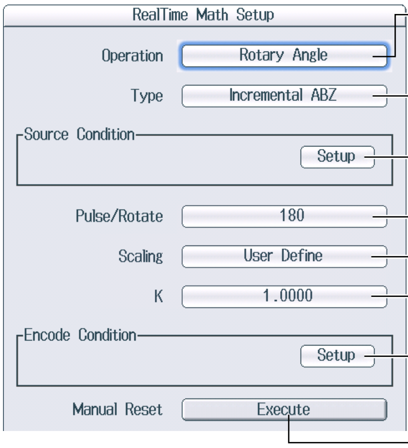
- **When waveform acquisition starts**
- **When "Value/Div" exceeds +10 div or falls below –10 div**
- **When the math source waveform crosses zero and an edge is generated**

Resets the integration result

Angle of Rotation (Rotary Angle)

The following screen appears when you select the angle-of-rotation function.

- **When the Encoding Type Is Incremental ABZ, Incremental AZ, Absolute 8bit, or Absolute 16bit**



Select the function.

Select the encoding type (Incremental ABZ, Incremental AZ, Absolute 8bit, Absolute 16bit).

Set the source conditions.

Set the number of pulses per rotation (using the jog shuttle).

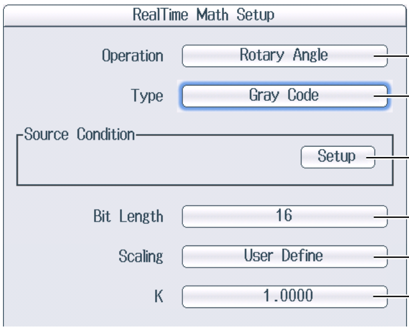
Select the scale (Radian, Degree, User Define).

Set the size of the scale (only when Scaling is set to User Define) **(using the jog shuttle).**

Set the encoding conditions.
You can set the conditions when the encoding type is ABZ or AZ.

Resets the math result

- **When the Encoding Type Is Gray Code**



Select the function.

Select the encoding type (Gray Code).

Set the source conditions.

Set the bit length (using the jog shuttle).

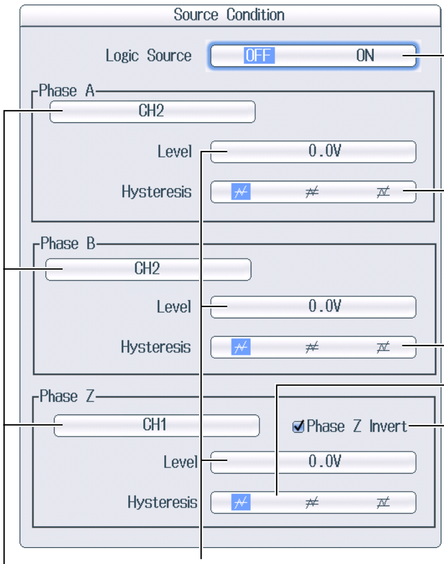
Select the scale (Radian, Degree, User Define).

Set the size of the scale (only when Scaling is set to User Define) **(using the jog shuttle).**

Setting the Source Conditions

Under Source Condition, press **Setup** to display the following screen.

- **When the Encoding Type Is Incremental ABZ or Incremental AZ and When the Logic Source Is Off**



Turn logic sources off.

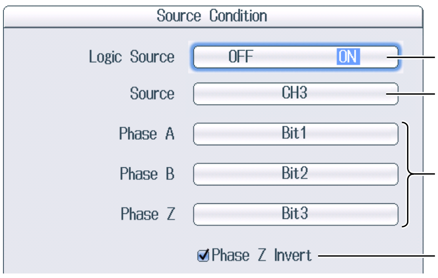
Set the hysteresis (, ,).

Select the check box when the Z-phase input is inverted.

Set the signal level that you want to count (using the jog shuttle).

Select the signal channels for phases A, B, and Z of the analog waveform module.

- **When the Encoding Type Is Incremental ABZ or Incremental AZ and When the Logic Source Is On**



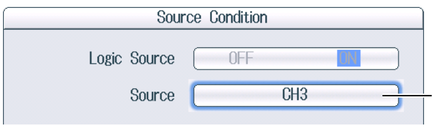
Turn logic sources on.

Select the input channel of the logic module.
The channels of installed logic modules are displayed.

Select the bits of logic signals of phases A, B, and Z (Bit1 to Bit8).

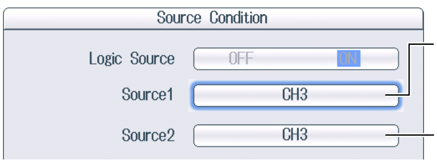
Select the check box when the Z-phase input is inverted.

- **When the Encoding Type Is Absolute 8bit**



Select the input channel of the logic module.
The channels of installed logic modules are displayed.

- **When the Encoding Type Is Absolute 16bit or Gray Code**



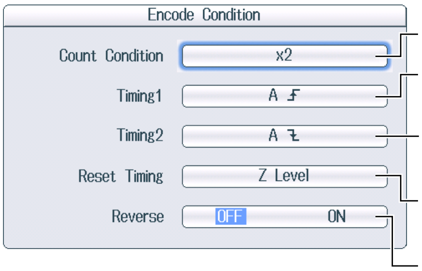
Select the math source logic signal (least significant 8 bits).
The channels of installed logic modules are displayed.

Select the math source logic signal (most significant 8 bits).
The channels of installed logic modules are displayed.

* When the bit length of Gray Code is 8 or less, the Source2 setting is ignored.

Setting the Encoding Conditions

Under Encode Condition, press **Setup** to display the following screen.



Set the count condition (x4, x2, x1).

Select the edge to count pulses on (A↑, A↓, B↑, B↓).
This is displayed when Count Condition is set to x2 or x1.

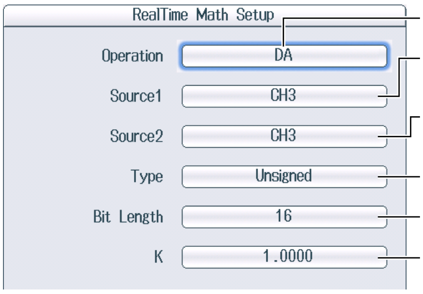
Select the edge to count pulses on (A↑, A↓, B↑, B↓).
This is displayed when Count Condition is set to x2.

Select the edge that you want to use to trigger a reset operation (A↑, A↓, B↑, B↓, Z Level).

Turns rotation direction inversion on and off

Logic Signal to Analog Waveform Conversion (DA)

The following screen appears when you select the logic signal to analog waveform conversion function.



Select the function.

Select the math source logic signal (least significant 8 bits).
The channels of installed logic modules are displayed.

Select the math source logic signal (most significant 8 bits).
The channels of installed logic modules are displayed.

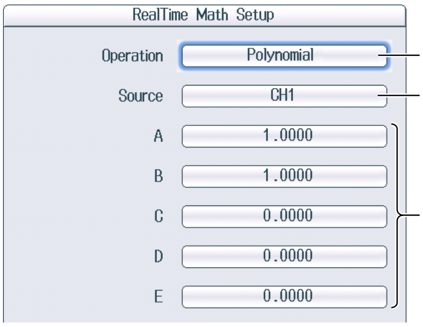
Select the conversion method (Unsigned, Signed, Offset Binary).

Set the bit length (using the jog shuttle).

Set the coefficient (using the jog shuttle).

Quartic Polynomial (Polynomial)

The following screen appears when you select the quartic polynomial function.



Select the function.

Select the math source waveform.

Set the coefficients (using the jog shuttle).

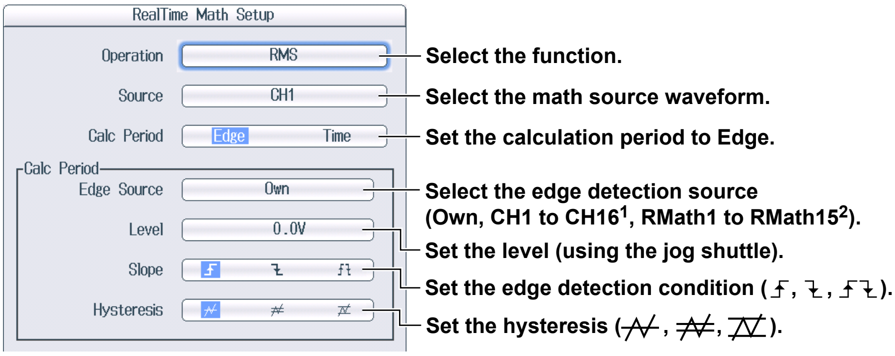
3

Configuring Real Time Math Settings

RMS Value (RMS)

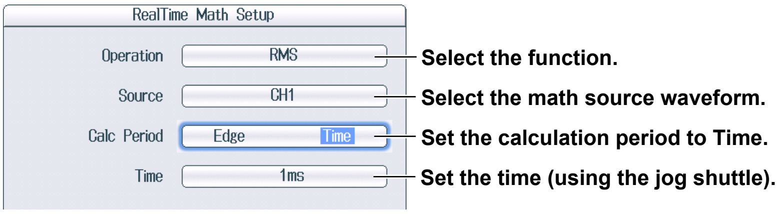
The following screen appears when you select the RMS value function.

- **If the Calculation Period Is Edge**



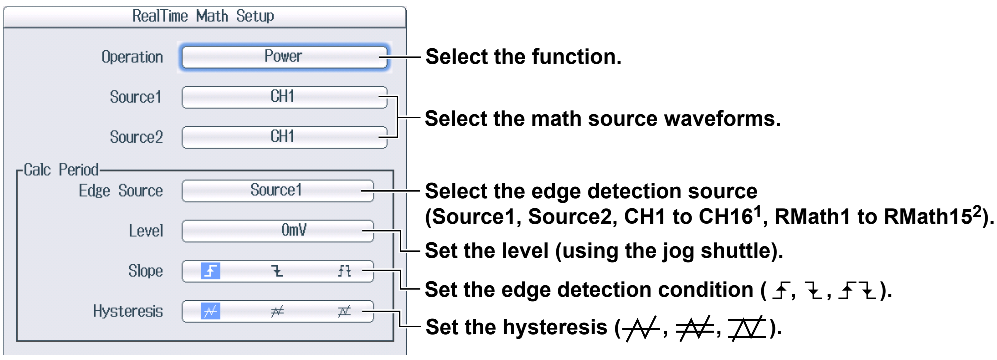
1 You can select channels in which input modules that support basic arithmetic are installed.
2 You can select channels whose numbers are smaller than the channel you are operating.

- **If the Calculation Period Is Time**



Effective Power (Power)

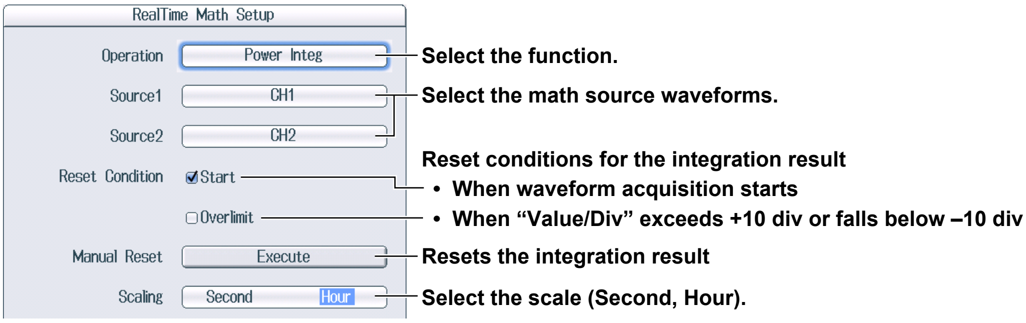
The following screen appears when you select the effective power function.



1 You can select channels in which input modules that support basic arithmetic are installed.
2 You can select channels whose numbers are smaller than the channel you are operating.

Effective Power Integration (Power Integ)

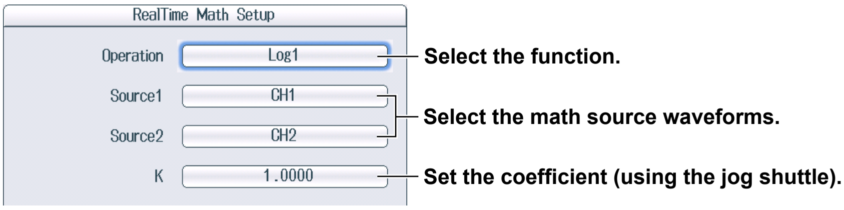
The following screen appears when you select the effective power integration function.



Common Logarithm (Log1 and Log2)

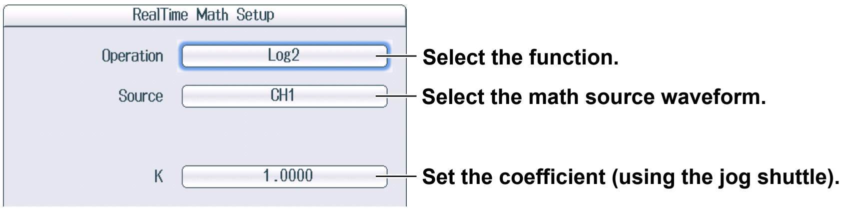
- **Log1**

The following screen appears when you select the common logarithm function (Log1).



- **Log2**

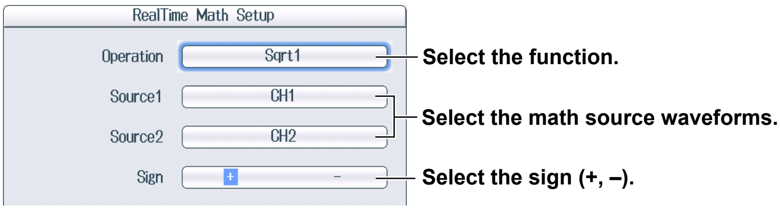
The following screen appears when you select the common logarithm function (Log2).



Square Root (Sqrt1 and Sqrt2)

- **Sqrt1**

The following screen appears when you select the square root function (Sqrt1).

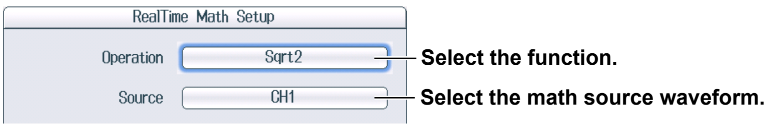


Note

When you set Sign to +, the square root of "$S1^2 + S2^2$" is calculated.
When you set Sign to –, the square root of "$S1^2 – S2^2$" is calculated.

- **Sqrt2**

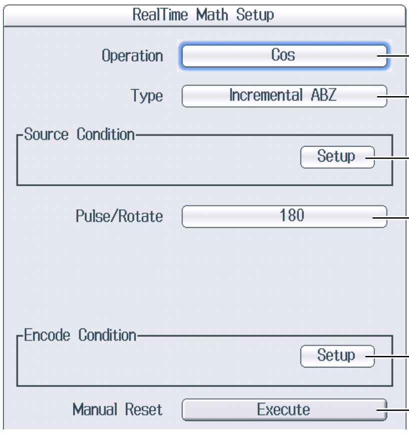
The following screen appears when you select the square root function (Sqrt2).



Cosine (Cos) and Sine (Sin)

The following screen appears when you select the cosine or sine function.

- **When the Encoding Type Is Incremental ABZ, Incremental AZ, Absolute 8bit, or Absolute 16bit**



Select the function.

Select the encoding type (Incremental ABZ, Incremental AZ, Absolute 8bit, Absolute 16bit).

Set the source conditions.

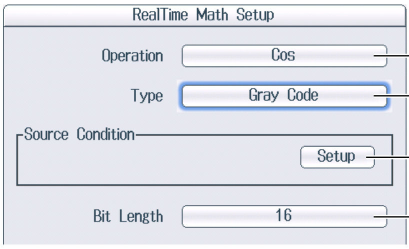
Set the number of pulses per rotation (using the jog shuttle).

Set the encoding conditions.*

Resets the math result *

* You can set the conditions when the encoding type is ABZ or AZ.

- **When the Encoding Type Is Gray Code**



Select the function.

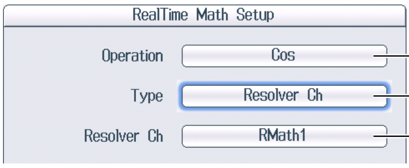
Select the encoding type (Gray Code).

Set the source conditions.

Set the bit length (using the jog shuttle).

- **When the Encoding Type Is Resolver Ch**

You can only configure the settings when there is a channel that has been defined with the resolver function.



Select the function.

Select the encoding type (Resolver Ch).

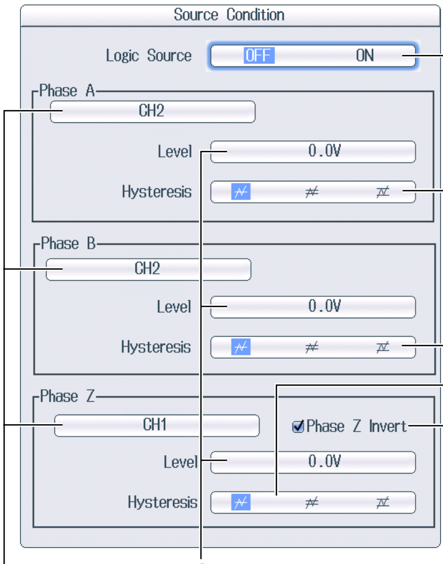
Select the resolver channel*
The channels that have been defined with the resolver function are displayed.

* You can select channels whose numbers are smaller than the channel you are operating.

Setting the Source Conditions

Under Source Condition, press **Setup** to display the following screen.

- **When the Encoding Type Is Incremental ABZ or Incremental AZ and When the Logic Source Is Off**



Turn logic sources off.

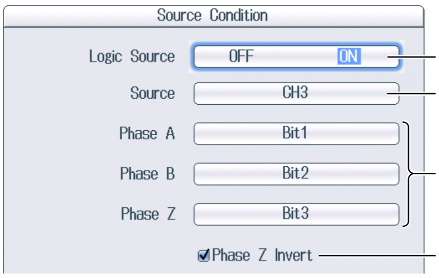
Set the hysteresis (, ,).

Select the check box when the Z-phas

Set the signal level that you want to count (using the jog shuttle).

Select the signal channels for phases A, B, and Z of the analog waveform module.

- **When the Encoding Type Is Incremental ABZ or Incremental AZ and When the Logic Source Is On**



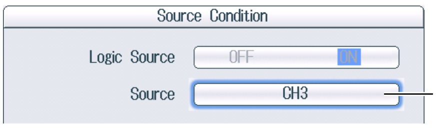
Turn logic sources on.

Select the input channel of the logic module.
The channels of installed logic modules are displayed.

Select the bits of logic signals of phases A, B, and Z (Bit1 to Bit8).

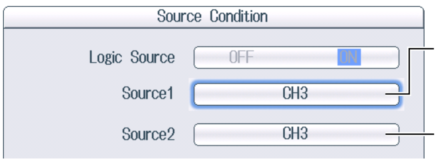
Select the check box when the Z-phase input is inverted.

- **When the Encoding Type Is Absolute Encode 8bit**



Select the input channel of the logic module.
The channels of installed logic modules are displayed.

- **When the Encoding Type Is Absolute Encode 16bit or Gray Code**



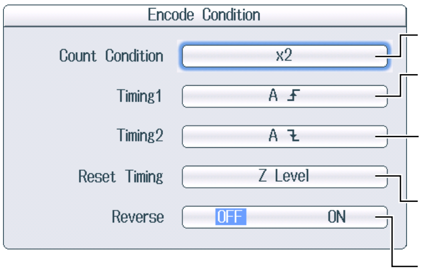
Select the math source logic signal (least significant 8 bits).
The channels of installed logic modules are displayed.

Select the math source logic signal (most significant 8 bits).
The channels of installed logic modules are displayed.

* When the bit length of Gray Code is 8 or less, the Source2 setting is ignored.

Setting the Encoding Conditions

Under Encode Condition, press **Setup** to display the following screen.



Set the count condition (x4, x2, x1).

Select the edge to count pulses on (A↑, A↓, B↑, B↓).
This is displayed when Count Condition is set to x2 or x1.

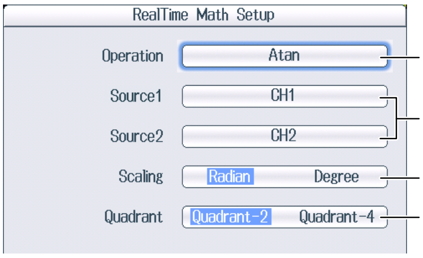
Select the edge to count pulses on (A↑, A↓, B↑, B↓).
This is displayed when Count Condition is set to x2.

Select the edge that you want to use to trigger a reset operation (A↑, A↓, B↑, B↓, Z Level).

Turns rotation direction inversion on and off

Arc Tangent (Atan)

The following screen appears when you select the arc tangent function.



Select the function.

Select the math source waveforms.

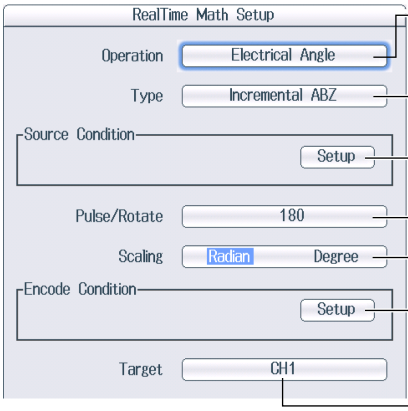
Select the scale (Radian, Degree).

Select the quadrant range (Quadrant-2, Quadrant-4).

Electrical Angle (Electrical Angle)

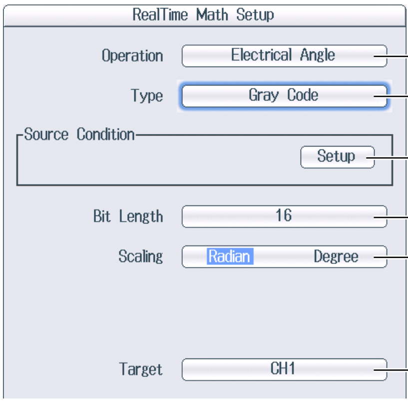
The following screen appears when you select the electrical angle function.

- **When the Encoding Type Is Incremental ABZ, Incremental AZ, Absolute 8bit, or Absolute 16bit**



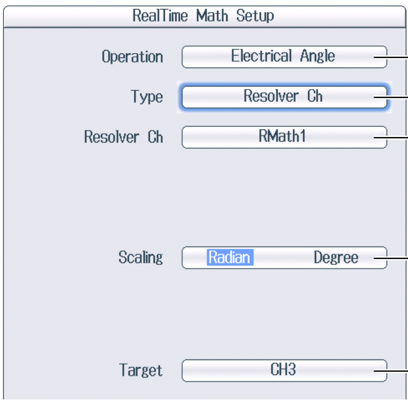
Select the function.
Select the encoding type (Incremental ABZ, Incremental AZ, Absolute 8bit, Absolute 16bit).
Set the source conditions.
Set the number of pulses per rotation (using the jog shuttle).
Select the scale (Radian, Degree).
Set the encoding conditions.
You can set the conditions when the encoding type is ABZ or AZ.
Select the target (CH1 to CH16[1], RMath1 to RMath15[2]).

- **When the Encoding Type Is Gray Code**



Select the function.
Select the encoding type (Gray Code).
Set the source conditions.
Set the bit length (using the jog shuttle).
Select the scale (Radian, Degree).
Select the target (CH1 to CH16[1], RMath1 to RMath15[2]).

- **When the Encoding Type Is Resolver Ch**
  You can only configure the settings when there is a channel that has been defined with the resolver function.



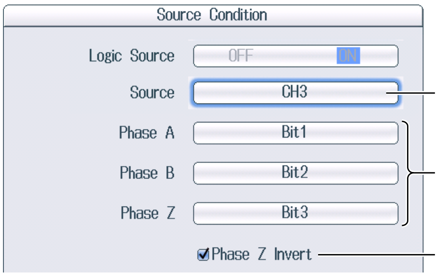
Select the function.
Select the encoding type (Resolver Ch).
Select the resolver channel[2]
The channels that have been defined with the resolver function are displayed.
Select the scale (Radian, Degree).
Select the target (CH1 to CH16[1], RMath1 to RMath15[2]).

1 You can select channels in which input modules that support basic arithmetic are installed.
2 You can select channels whose numbers are smaller than the channel you are operating.

Setting the Source Conditions

Under Source Condition, press **Setup** to display the following screen.

- **When the Encoding Type is Incremental ABZ or Incremental AZ**



Select the input channel of the logic module.
The channels of installed logic modules are displayed.

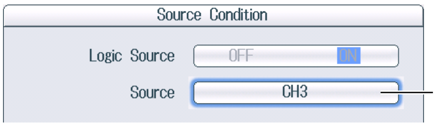
Select the bits of logic signals of phases A, B, and Z (Bit1 to Bit8).

Select the check box when the Z-phase input is inverted.

Note

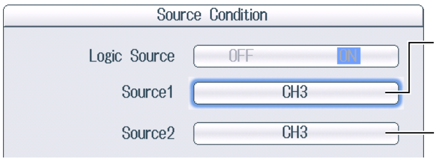
You cannot use analog waveforms as sources.

- **When the Encoding Type Is Absolute 8bit**



Select the input channel of the logic module.
The channels of installed logic modules are displayed.

- **When the Encoding Type Is Absolute 16bit or Gray Code**



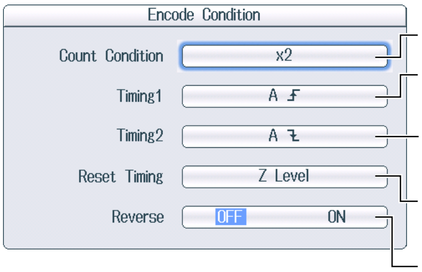
Select the math source logic signal (least significant 8 bits).
The channels of installed logic modules are displayed.

Select the math source logic signal (most significant 8 bits).
The channels of installed logic modules are displayed.

* When the bit length of Gray Code is 8 or less, the Source2 setting is ignored.

Setting the Encoding Conditions

Under Encode Condition, press **Setup** to display the following screen.



Set the count condition (x4, x2, x1).

Select the edge to count pulses on (A ↑, A ↓, B ↑, B ↓).
This is displayed when Count Condition is set to x2 or x1.

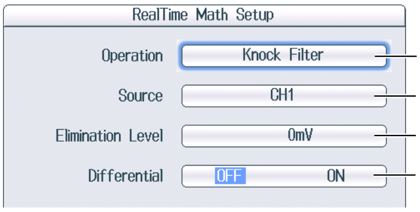
Select the edge to count pulses on (A ↑, A ↓, B ↑, B ↓).
This is displayed when Count Condition is set to x2.

Select the edge that you want to use to trigger a reset operation (A ↑, A ↓, B ↑, B ↓, Z Level).

Turns rotation direction inversion on and off

Knocking Filter (Knock Filter; only on the DL850EV)

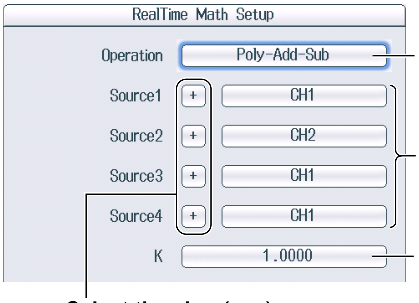
The following screen appears when you select the knocking filter function.



- **Select the function.**
- **Select the math source waveform.**
- **Set the elimination level (using the jog shuttle).**
- **Turns differentiation on and off**

Polynomial with a Coefficient (Poly-Add-Sub)

The following screen appears when you select the polynomial with a coefficient function.

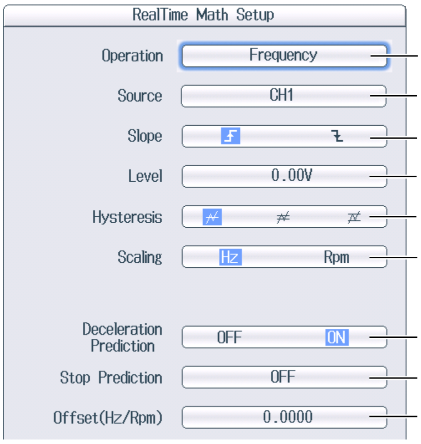


- **Select the function.**
- **Select the math source waveforms.**
- **Set the coefficient (using the jog shuttle).**

Select the sign (+, –).
Press SET to switch between the positive and negative signs.

Frequency (Frequency)

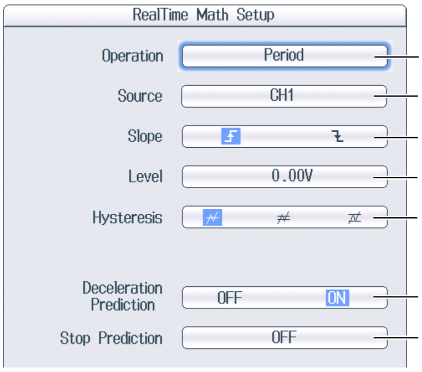
The following screen appears when you select the frequency function.



- **Select the function.**
- **Select the math source waveform.**
- **Set the edge detection condition (,).**
- **Set the level (using the jog shuttle).**
- **Set the hysteresis (, ,).**
- **Select the scale (Hz, Rpm).**
- **Select the deceleration prediction (OFF, ON).**
- **Select the stop prediction (OFF, 2, 4, 8, 16).**
- **Set the offset value (using the jog shuttle).**

Period (Period)

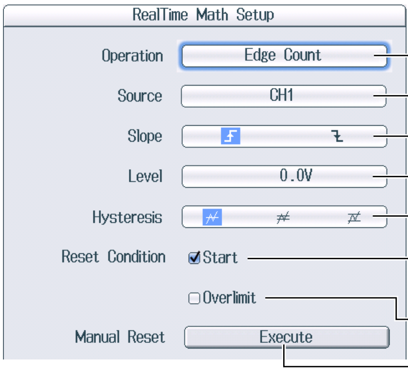
The following screen appears when you select the period function.



- Operation: **Select the function.**
- Source: **Select the math source waveform.**
- Slope: **Set the edge detection condition (rising, falling).**
- Level: **Set the level (using the jog shuttle).**
- Hysteresis: **Set the hysteresis (three hysteresis levels).**
- Deceleration Prediction: **Select the deceleration prediction (OFF, ON).**
- Stop Prediction: **Select the stop prediction (OFF, 2, 4, 8, 16).**

Edge Count (Edge Count)

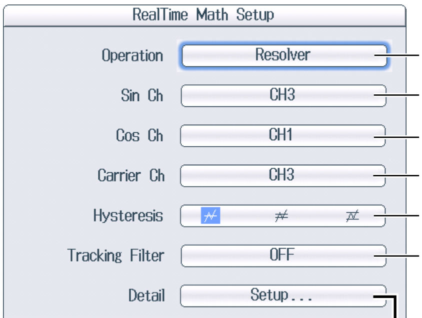
The following screen appears when you select the edge count function.



- Operation: **Select the function.**
- Source: **Select the math source waveform.**
- Slope: **Set the edge detection condition (rising, falling).**
- Level: **Set the level (using the jog shuttle).**
- Hysteresis: **Set the hysteresis (three hysteresis levels).**
- Reset Condition: **Edge count result reset conditions**
  - **When the edge count operation begins** (Start)
  - **When "Value/Div" exceeds +10 div or falls below –10 div** (Overlimit)
- Manual Reset: **Resets the edge count result**

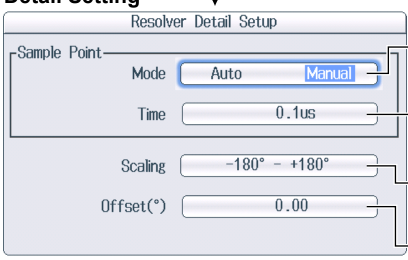
Resolver (Resolver)

The following screen appears when you select the resolver function.



- Operation: **Select the function.**
- Sin Ch: **Select the sine phase signal (CH1 to CH16[1], RMath1 to RMath15[2]).**
- Cos Ch: **Select the cosine phase signal (CH1 to CH16[1], RMath1 to RMath15[2]).**
- Carrier Ch: **Select the excitation signal (CH1 to CH16[1], RMath1 to RMath15[2]).**
- Hysteresis: **Set the hysteresis (three hysteresis levels).**
- Tracking Filter: **Select the tracking filter (OFF, 2kHz, 1kHz, 250Hz, 100Hz).**

Detail Setting



Configure the sample point.
- **Set the Mode (Auto, Manual).**

Only when Mode is set to Manual
- **Set the move time of the sample point (using the jog shuttle).**

Select the scale (–180° – +180°, 0° – 360°, –π – +π, 0 – 2π).

Set the offset value (using the jog shuttle).

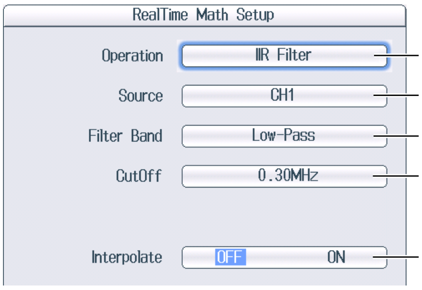
1 You can select channels in which input modules that support basic arithmetic are installed.

2 You can select channels whose numbers are smaller than the channel you are operating.

IIR Filter (IIR Filter)

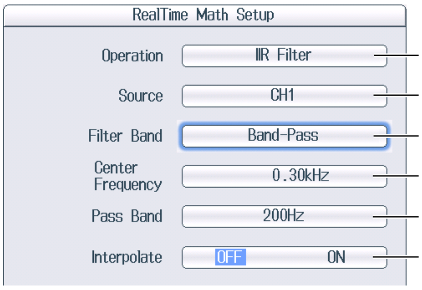
The following screen appears when you select the IIR filter function.

- **When Filter Band Is Set to Low-Pass or High-Pass**



Select the function.
Select the math source waveform.
Set the filter band (Low-pass, High-Pass).
Set the cutoff frequency (using the jog shuttle).
Turns interpolation on and off.

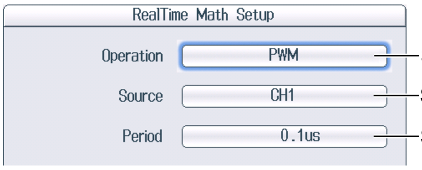
- **When Filter Band Is Set to Band-Pass**



Select the function.
Select the math source waveform.
Set the filter band (Band-pass).
Set the center frequency (using the jog shuttle).
Set the bandwidth (using the jog shuttle).
Turns interpolation on and off.

Demodulation of the Pulse Width Modulated Signal (PWM)

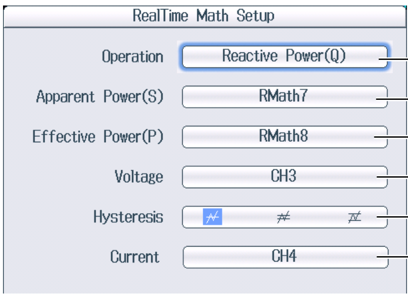
When you select the function that is used to demodulate pulse width modulated signals, the following screen appears.



Select the function.
Select the math source waveform.
Set the period (using the jog shuttle).

Reactive Power (Reactive Power(Q))

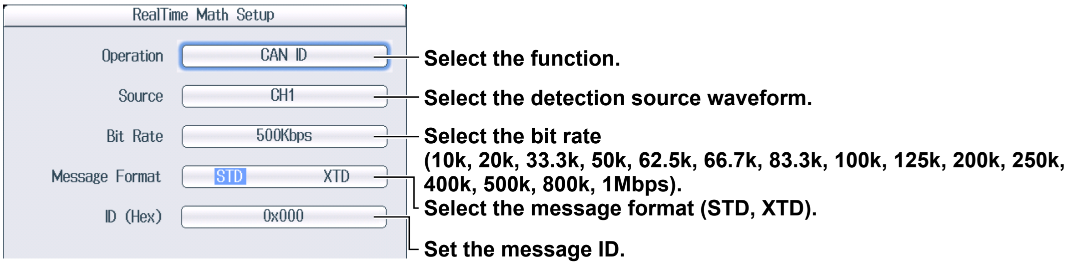
The following screen appears when you select the reactive power (Q) function.



Select the function.
Select the real time math channel (RMath channel) used to calculate the apparent power.
Select the real time math channel (RMath channel) used to calculate the effective power.
Select the voltage channel used to derive the reactive power.
Set the hysteresis for the selected voltage. (, ,)
Select the current channel used to derive the reactive power.

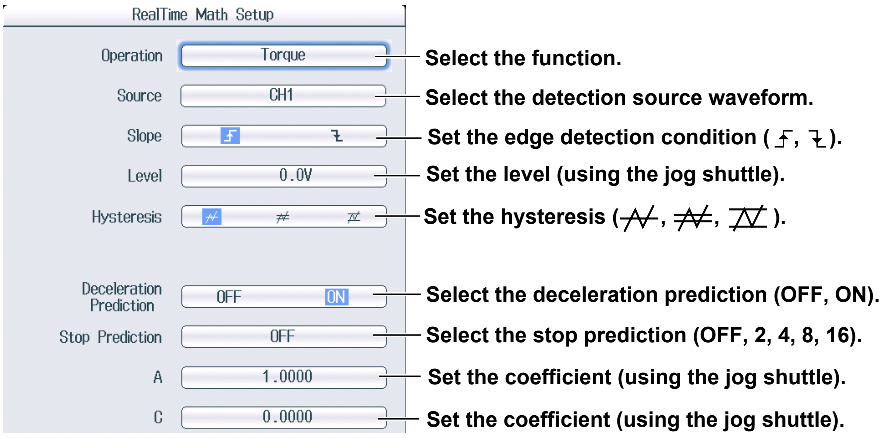
CAN ID Detection (CAN ID)

The following screen appears when you select the CAN ID function.



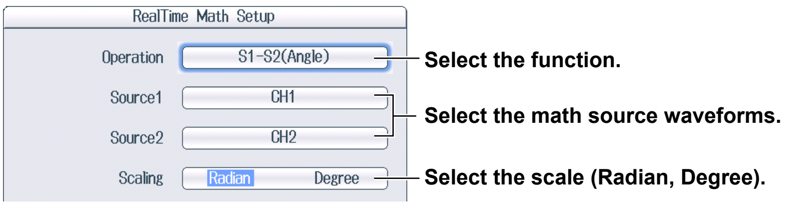
Torque (Torque)

The following screen appears when you select the torque function.



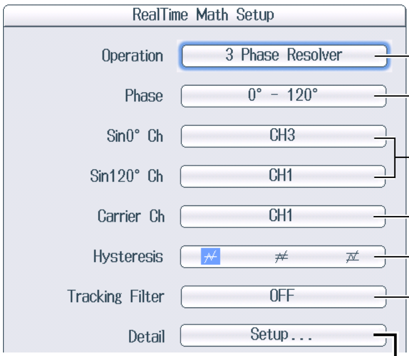
Angle Difference (S1−S2(Angle))

The following screen appears when you select the angle difference function.



3 Phase Resolver (3 Phase Resolver)

The following screen appears when you select the 3 phase resolver function.



Select the function.

Select the phase of the sine signal (0°– 120°, 0°– 240°, 120°– 240°).

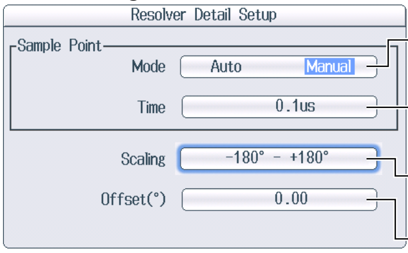
Select the sine phase signal (CH1 to CH16,[1] RMath1 to RMath15[2]).

Select the excitation signal (CH1 to CH16,[1] RMath1 to RMath15[2]).

Set the hysteresis (, ,).

Select the tracking filter (OFF, 2kHz, 1kHz, 250Hz, 100Hz).

Detail Setting



Configure the sample point.

- Set the Mode (Auto, Manual).

Only when Mode is set to Manual

- Set the move time of the sample point (using the jog shuttle).

Select the scale (–180° – +180° , 0° – 360° , –π – +π , 0 – 2π).

Set the offset value (using the jog shuttle).

1 You can select channels in which input modules that support basic arithmetic are installed.

2 You can select channels whose numbers are smaller than the channel you are operating.

4 Configuring the Power Math Feature

Power Math

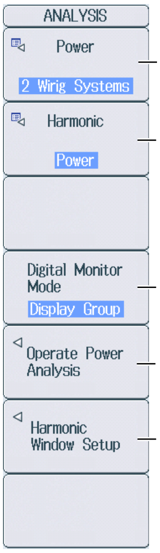
This section explains the following settings (which are used when performing power math).

- Power analysis: Analyzes rms voltage, power, phase difference, and other types of physical quantities.
- Harmonic analysis: Analyzes the harmonics of rms values (voltage and current) and the harmonics of active power.
- CH menu: Display settings of waveforms output to sub channels.

For details on how various physical quantities are determined, see the appendix.

ANALYSIS Menu

Press **ANALYSIS** to display the following menu.



Configure power analysis.

Configure harmonic analysis.

Set the numeric monitor (Display Group, Power, Harmonic).

Set the Power analysis operation.
Not displayed when the power analysis mode is set to OFF

Configure the harmonic analysis window.
Not displayed when the harmonic analysis mode is set to OFF

Power Analysis (Power)

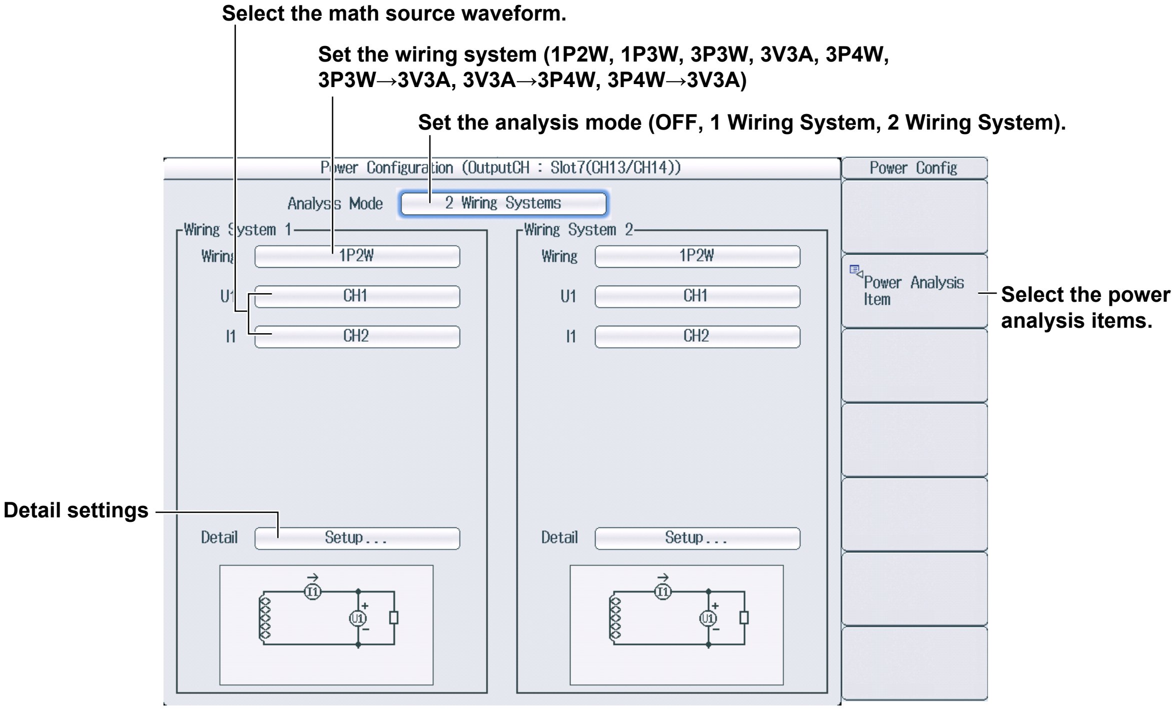
The following settings (which are used when analyzing power) are explained.

- Power analysis mode
- Power analysis items
- Power analysis reset

Setting the Power Analysis Mode (Power)

Press the **Power** soft key to display the following screen.

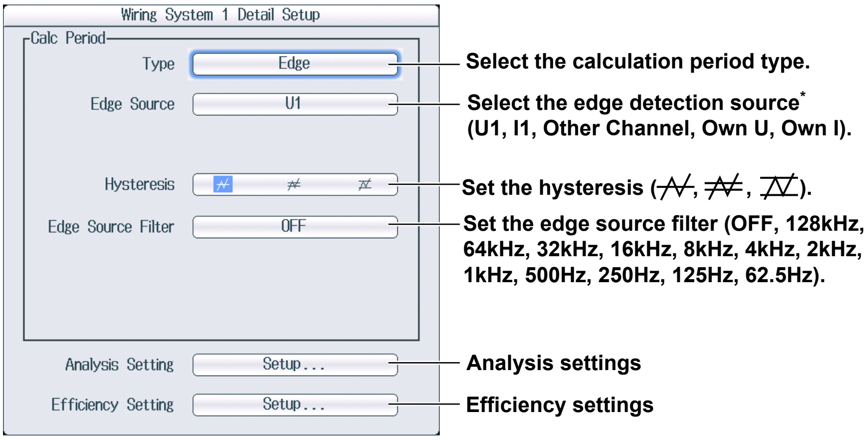
Display example when the analysis mode is set to 2 Wiring System



Detail Setting (Detail)

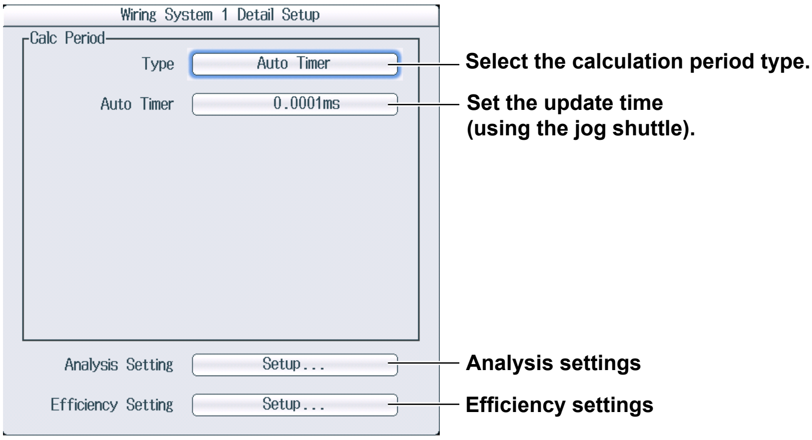
Press **Setup...** to display the following screen.

- **When the calculation period type is set to Edge**

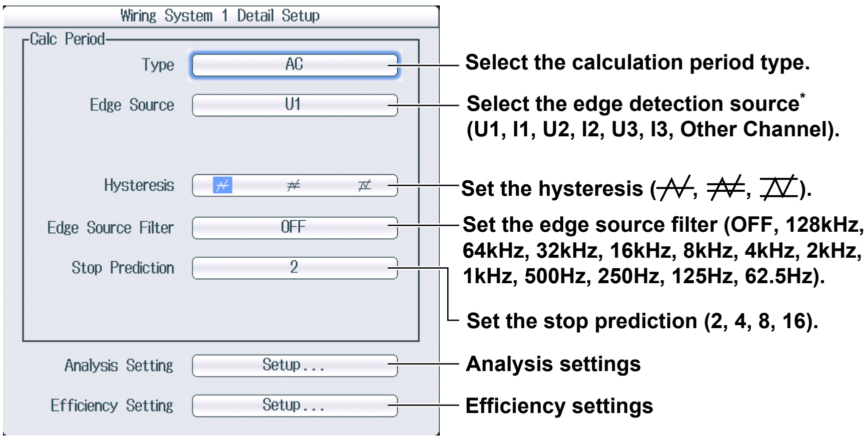


* Other Channel can be specified when the wiring system is 1P2W.
Own U and Own I can be specified when the wiring system is not 1P2W.

- **When the calculation period type is set to Auto Timer**

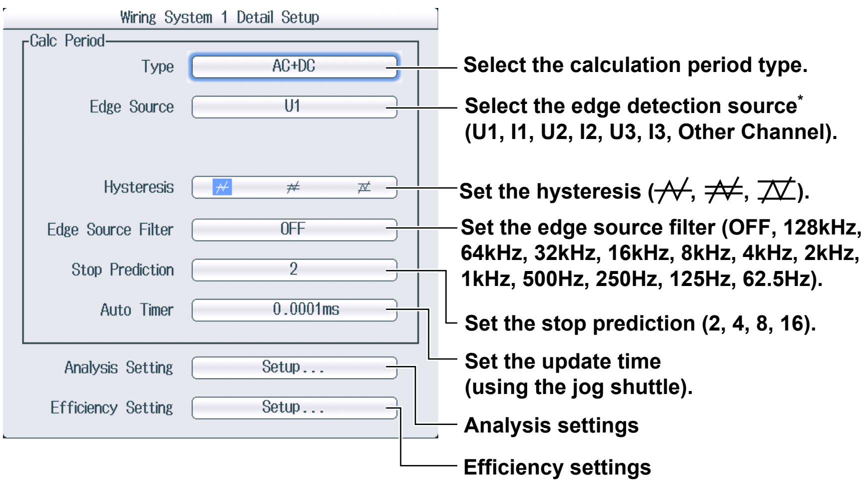


- **When the calculation period type is set to AC**



* Other Channel can be specified when the wiring system is 1P2W.

- **When the calculation period type is set to AC+DC**



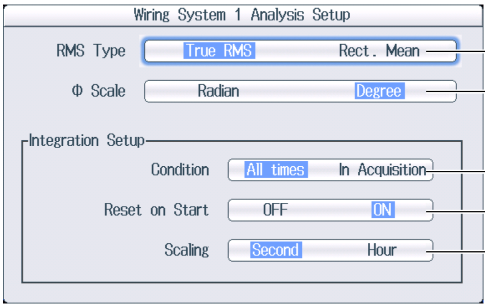
* Other Channel can be specified when the wiring system is 1P2W.

4

Configuring the Power Math Feature

Analysis Setting (Analysis Setting)

Press **Setup...** to display the following screen.

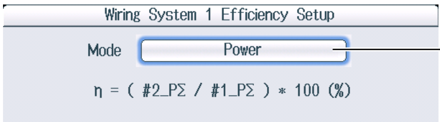


Select the RMS type (True RMS, Rect. Mean).
Select the φ scale (Radian, Degree).
Set the integration condition (All times, In Acquisition)
Set reset-at-start (OFF, ON).
Set the scaling (Second, Hour).

Efficiency Setting (Efficiency Setting)

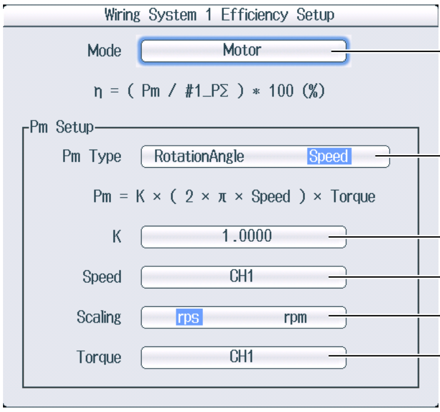
Press **Setup...** to display the following screen.

- **When the efficiency mode is set to Power**



Select the efficiency mode (OFF, Power, Motor).

- **When the efficiency mode is set to Motor**



Select the efficiency mode (OFF, Power, Motor).
Select the Pm type (RotationAngle, Speed).
Set coefficient K (using the jog shuttle).
Select the channel used to derive the rotating speed.
Select the scaling (rps, rpm).
Select the channel used to derive the torque.

Selecting Power Analysis Items (Power Analysis Item)

Press the **Power Analysis Item** soft key to display the following screen.

Display example when the analysis mode is set to 2 Wiring Systems and the wiring system is set to 1P2W

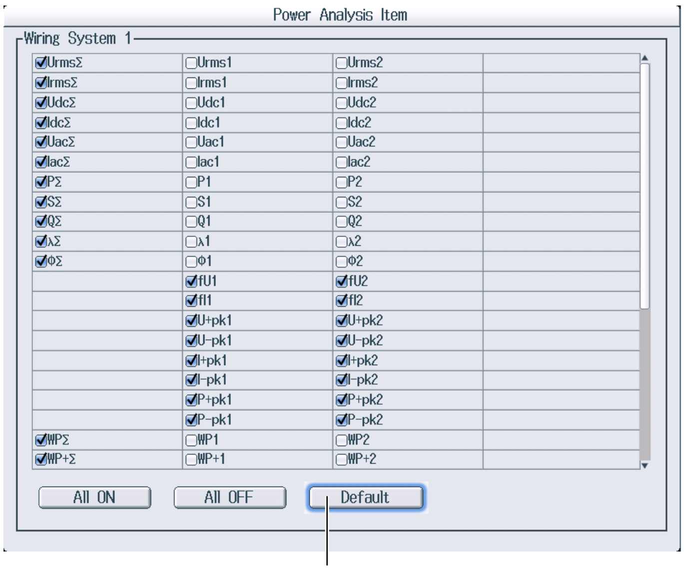
Set all output items to ON (select the check boxes).

Set all output items to OFF (clear the check boxes).

Output items

Set all output items.
See “CH Menu” later in this section.

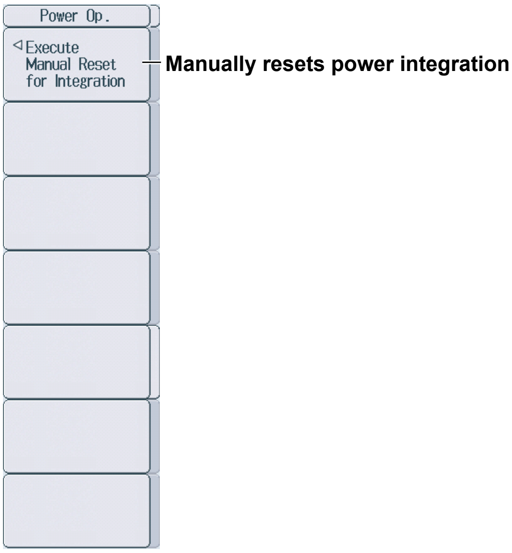
Display example when the analysis mode is set to 1 Wiring System and the wiring system is set to 1P3W



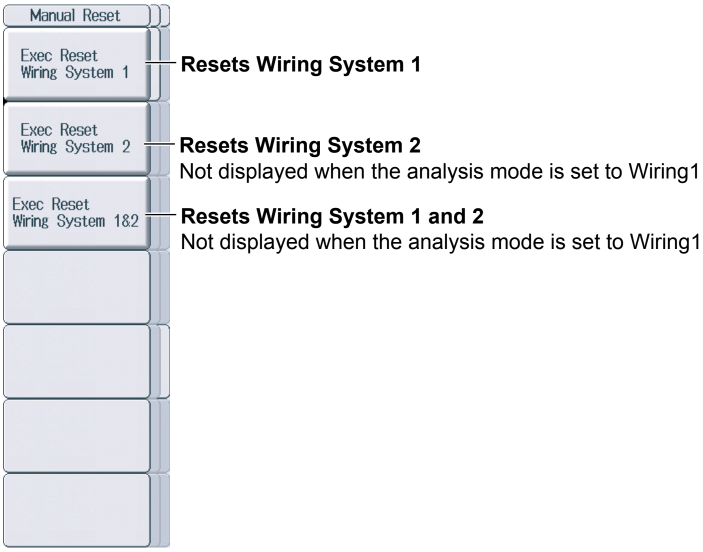
Resets the output item selection to the default condition.
This is available when the wiring system is not 1P2W.

Power Analysis Reset (Operate Power Analysis)

Press the **Operate Power Analysis** soft key to display the following screen.



Press the **Execute Manual Reset for Integration** soft key to display the following screen.



Harmonic Analysis (Harmonics)

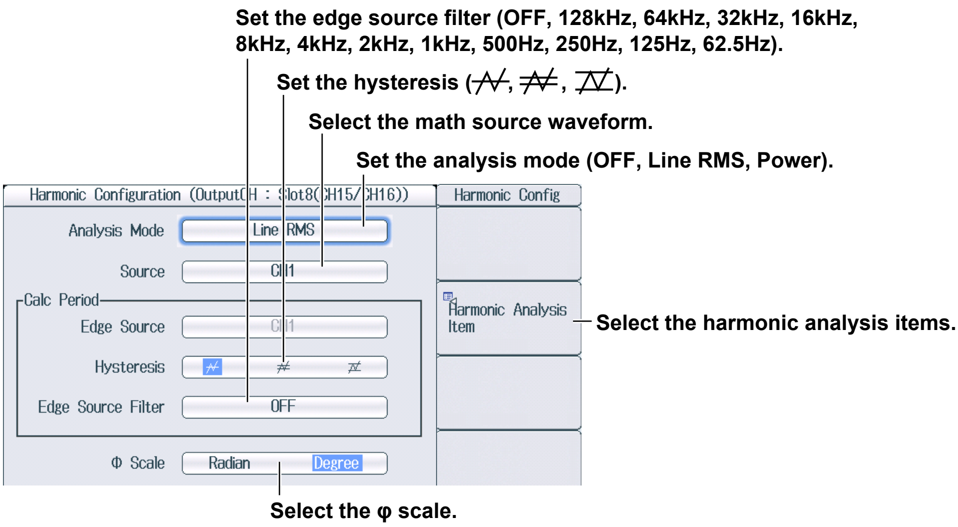
The following settings (which are used when analyzing harmonics) are explained.

- Harmonic analysis mode
- Harmonic analysis items
- Harmonic analysis window

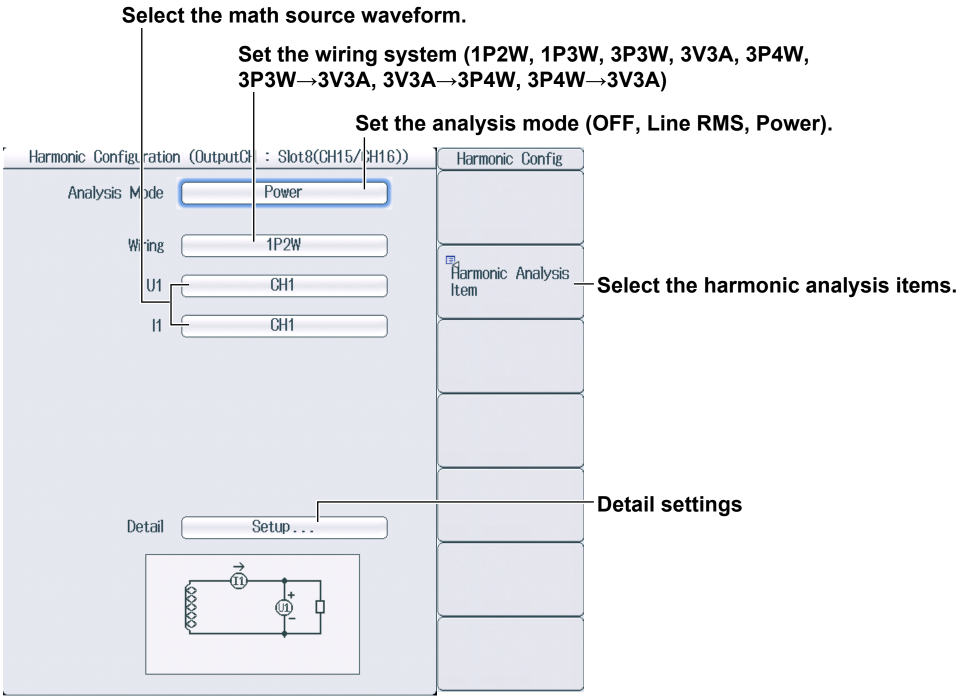
Setting the Harmonic Analysis Mode (Harmonic)

Press the **Harmonic** soft key to display the following screen.

- **When Analysis Mode is set to Line RMS**

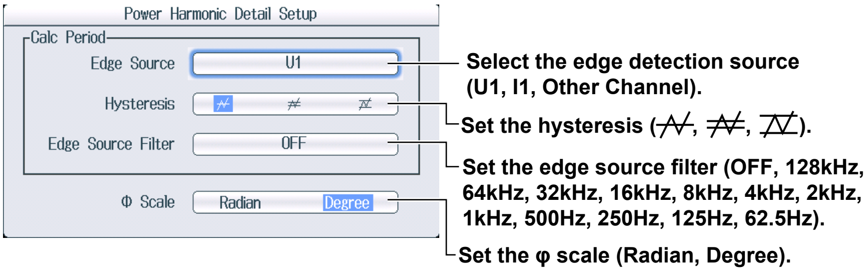


- **When Analysis Mode is set to Power**



Detail Setting (Detail)

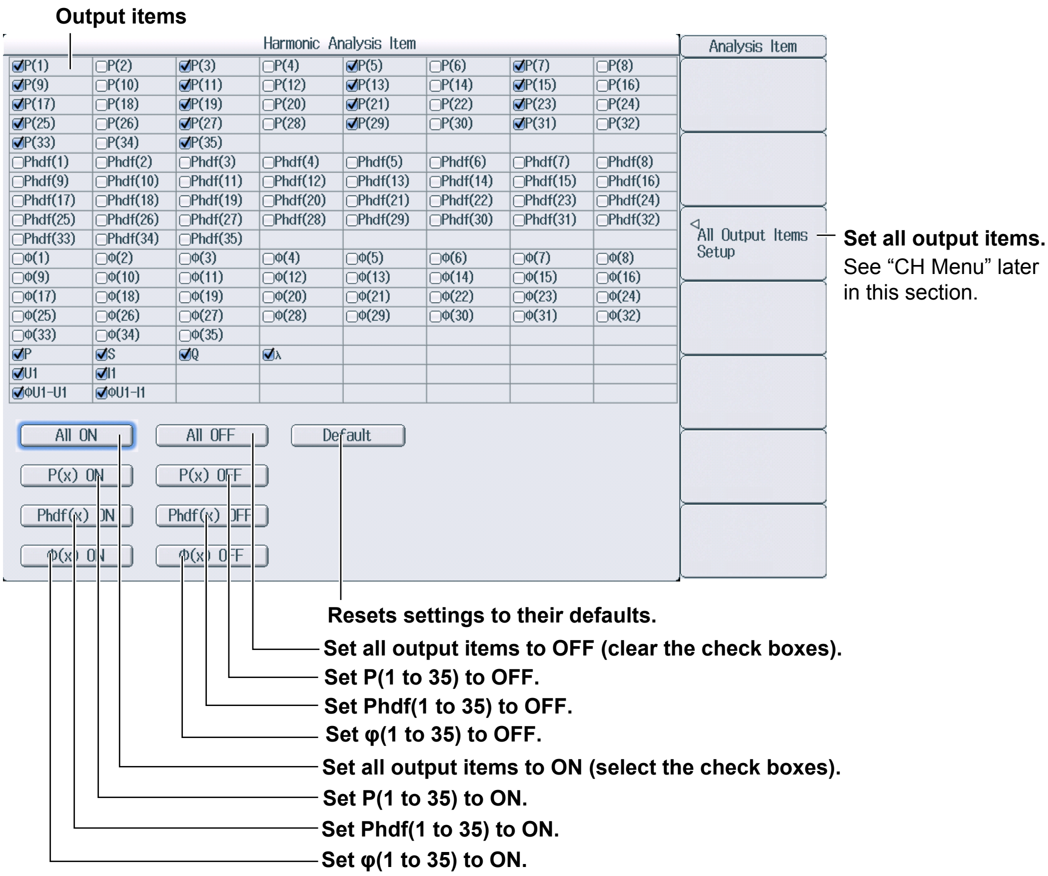
Press **Setup...** to display the following screen.



Selecting Harmonic Analysis Items (Harmonic Analysis Item)

Press the **Harmonic Analysis Item** soft key to display the following screen.

Display example when the analysis mode is set to Power and the wiring system is set to 1P2W



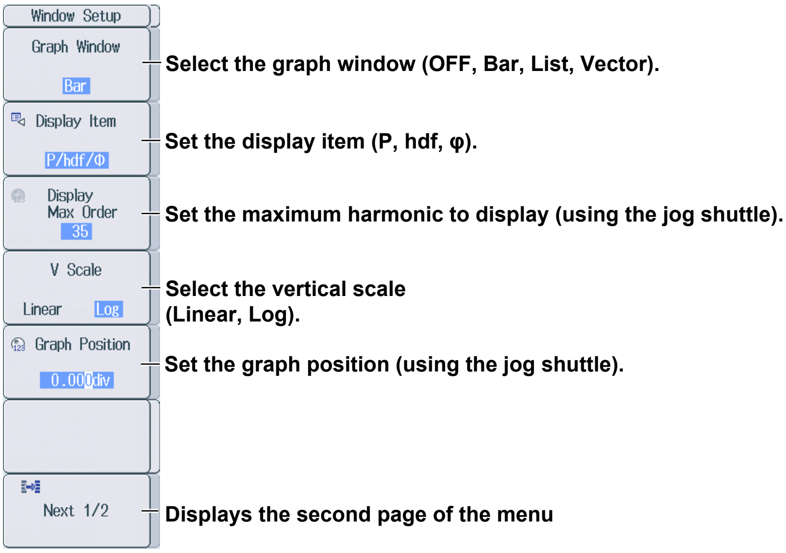
Harmonic Analysis Window Setup (Harmonic Window Setup)

There are three methods to display the harmonic analysis results.

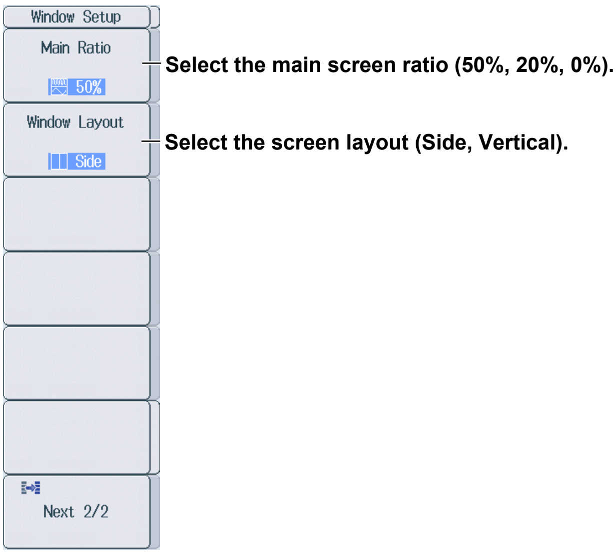
- Bar: A bar graph is displayed for the calculated harmonic value of each harmonic up to the 40th harmonic.
- Vector: The relationship of the phase difference and size (rms value) between the fundamental waves U(1) and I(1) of the element is displayed with vectors.
- List: A numerical list is displayed for the calculated harmonic value of each harmonic up to the 40th harmonic.

Bar

Press the **Harmonic Window Setup** soft key and then **Bar** to display the following menu.



Press the **Next** soft key to display the second page of the menu.



List

Press the **Harmonic Window Setup** soft key and then **List** to display the following menu.

Select the graph window (OFF, Bar, List, Vector).

Set the display item (P, hdf, φ).

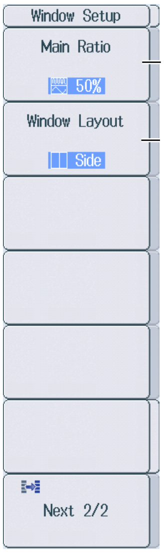
Set the maximum harmonic to display (using the jog shuttle).

Set the starting harmonic to list (using the jog shuttle).

Set the graph position (using the jog shuttle).

Displays the second page of the menu

Press the **Next** soft key to display the second page of the menu.

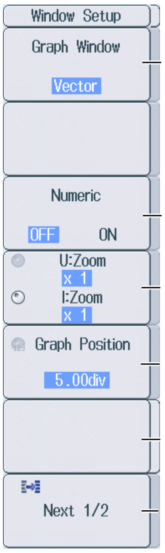


Select the main screen ratio (50%, 20%, 0%).

Select the screen layout (Side, Vertical).

Vector

Press the **Harmonic Window Setup** soft key and then **Vector** to display the following menu.



Select the graph window (OFF, Bar, List, Vector).

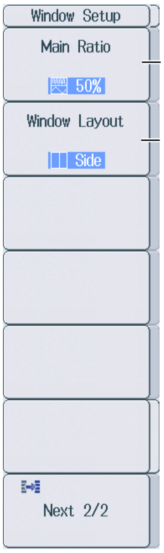
Turns the numeric display on or off

Set the zoom position (using the jog shuttle).

Set the graph position (using the jog shuttle).

Displays the second page of the menu

Press the **Next** soft key to display the second page of the menu.



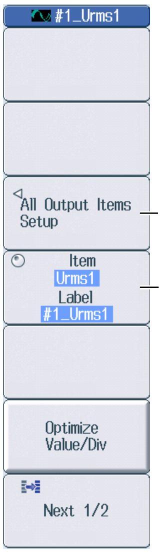
Select the main screen ratio (50%, 20%, 0%).

Select the screen layout (Side, Vertical).

CH Menu

Press a key from **CH13** to **CH16**. The following menu appears.

CH13 and CH14 are power analysis channels. CH15 and CH16 are harmonic analysis channels.



Set all output items.

Set the item output display (using the jog shuttle).

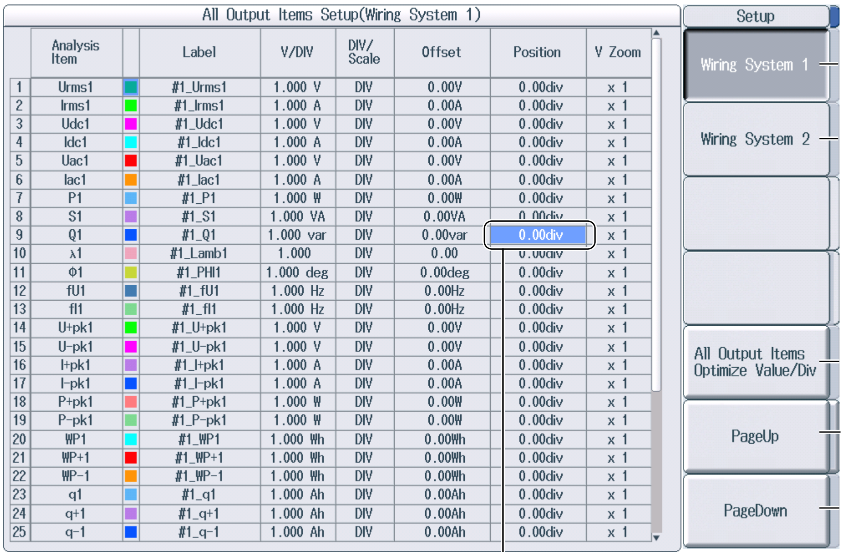
Note

When power analysis or harmonic analysis is enabled, CH13 to CH16 are fixed to ON, even if you press any of these keys.

All Output Items Setup (All Output Items Setup)

Press the **All Output Items Setup** soft key to display the following screen.

- **Setup screen for power analysis**



	Analysis Item		Label	V/DIV	DIV/ Scale	Offset	Position	V Zoom
1	Urms1		#1_Urms1	1.000 V	DIV	0.00V	0.00div	x 1
2	Irms1		#1_Irms1	1.000 A	DIV	0.00A	0.00div	x 1
3	Udc1		#1_Udc1	1.000 V	DIV	0.00V	0.00div	x 1
4	Idc1		#1_Idc1	1.000 A	DIV	0.00A	0.00div	x 1
5	Uac1		#1_Uac1	1.000 V	DIV	0.00V	0.00div	x 1
6	Iac1		#1_Iac1	1.000 A	DIV	0.00A	0.00div	x 1
7	P1		#1_P1	1.000 W	DIV	0.00W	0.00div	x 1
8	S1		#1_S1	1.000 VA	DIV	0.00VA	0.00div	x 1
9	Q1		#1_Q1	1.000 var	DIV	0.00var	0.00div	x 1
10	λ1		#1_Lamb1	1.000	DIV	0.00	0.00div	x 1
11	Φ1		#1_PHI1	1.000 deg	DIV	0.00deg	0.00div	x 1
12	fU1		#1_fU1	1.000 Hz	DIV	0.00Hz	0.00div	x 1
13	fI1		#1_fI1	1.000 Hz	DIV	0.00Hz	0.00div	x 1
14	U+pk1		#1_U+pk1	1.000 V	DIV	0.00V	0.00div	x 1
15	U-pk1		#1_U-pk1	1.000 V	DIV	0.00V	0.00div	x 1
16	I+pk1		#1_I+pk1	1.000 A	DIV	0.00A	0.00div	x 1
17	I-pk1		#1_I-pk1	1.000 A	DIV	0.00A	0.00div	x 1
18	P+pk1		#1_P+pk1	1.000 W	DIV	0.00W	0.00div	x 1
19	P-pk1		#1_P-pk1	1.000 W	DIV	0.00W	0.00div	x 1
20	WP1		#1_WP1	1.000 Wh	DIV	0.00Wh	0.00div	x 1
21	WP+1		#1_WP+1	1.000 Wh	DIV	0.00Wh	0.00div	x 1
22	WP-1		#1_WP-1	1.000 Wh	DIV	0.00Wh	0.00div	x 1
23	q1		#1_q1	1.000 Ah	DIV	0.00Ah	0.00div	x 1
24	q+1		#1_q+1	1.000 Ah	DIV	0.00Ah	0.00div	x 1
25	q-1		#1_q-1	1.000 Ah	DIV	0.00Ah	0.00div	x 1

Set all output items for Wiring System1.

Set all output items for Wiring System2.

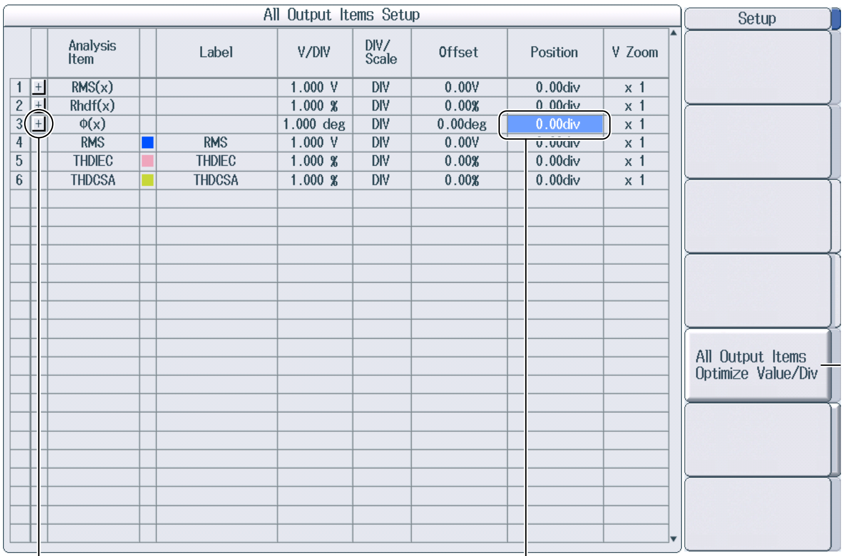
Optimizes the Value/Div settings of all items

Moves the displayed range of the screen up

Moves the displayed range of the screen down

Use the jog shuttle to move the cursor to the item you want to set.

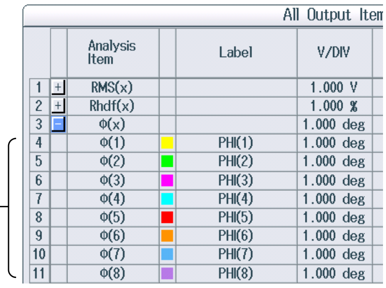
- **Setup screen for harmonic analysis**



Optimizes the Value/Div settings of all items

Use the jog shuttle to move the cursor to the item you want to set.

Move the cursor to "–" and press SET to display the items that have been set to ON when harmonic analysis items were selected.



Displays the items that have been set to ON

5 Commands

List of Commands

Command	Function	Page
ANALysis Group		
:ANALysis<x>?	Queries all power math (power analysis or harmonic analysis) settings.	5-9
:ANALysis<x>:HARMonic?	Queries harmonic analysis setting of the power math feature.	5-9
:ANALysis<x>:HARMonic:GRAPh?	Queries all settings related to the harmonic analysis result display.	5-9
:ANALysis<x>:HARMonic:GRAPh:DITem?	Queries all analysis items settings of the harmonic analysis result display.	5-9
:ANALysis<x>:HARMonic:GRAPh:DITem:HDF	Sets or queries whether percentage content (HDF) is displayed in the harmonic analysis result display.	5-9
:ANALysis<x>:HARMonic:GRAPh:DITem:P	Sets or queries whether active power (P) is displayed in the harmonic analysis result display.	5-9
:ANALysis<x>:HARMonic:GRAPh:DITem:PHI	Sets or queries whether phase angle (φ) is displayed in the harmonic analysis result display.	5-9
:ANALysis<x>:HARMonic:GRAPh:DITem:RMS	Sets or queries whether rms values (RMS) is displayed in the harmonic analysis result display.	5-9
:ANALysis<x>:HARMonic:GRAPh:LSTart	Sets or queries whether list starting harmonic is displayed in the harmonic analysis result display (window settings).	5-10
:ANALysis<x>:HARMonic:GRAPh:MAXorder	Sets or queries the maximum displayed harmonic in the harmonic analysis result display (window settings).	5-10
:ANALysis<x>:HARMonic:GRAPh:MODE	Sets or queries the graph mode in the harmonic analysis result display (window settings).	5-10
:ANALysis<x>:HARMonic:GRAPh:NUMeric	Sets or queries whether numeric string is displayed when the graph mode is set to Vector in the harmonic analysis result display (window settings).	5-10
:ANALysis<x>:HARMonic:GRAPh:POSition	Sets or queries the graph position in the harmonic analysis result display (window settings).	5-10
:ANALysis<x>:HARMonic:GRAPh:SCALe	Sets or queries the vertical scale when the graph mode is set to Bar in the harmonic analysis result display (window settings).	5-10
:ANALysis<x>:HARMonic:GRAPh:IZOom	Sets or queries the current zoom when the graph mode is set to Vector in the harmonic analysis result display (window settings).	5-10
:ANALysis<x>:HARMonic:GRAPh:UZOom	Sets or queries the voltage zoom when the graph mode is set to Vector in the harmonic analysis result display (window settings).	5-11
:ANALysis<x>:HARMonic:MODE	Sets or queries the analysis mode in harmonic analysis settings.	5-11
:ANALysis<x>:HARMonic:POWer:<Parameter 1>:LABel	Sets or queries the label of an analysis item in harmonic analysis (for Power mode).	5-11
:ANALysis<x>:HARMonic:POWer:<Parameter 1>:OFFSet	Sets or queries the offset of an analysis item in harmonic analysis (for Power mode).	5-11
:ANALysis<x>:HARMonic:POWer:<Parameter 1>:OPTimize	Optimizes Value/Div of an analysis item in harmonic analysis (for Power mode).	5-11
:ANALysis<x>:HARMonic:POWer:<Parameter 1>:POSition	Sets or queries the position of an analysis item in harmonic analysis (for Power mode).	5-12
:ANALysis<x>:HARMonic:POWer:<Parameter 1>:SCALe	Sets or queries the scale boundaries (upper and lower) of an analysis item in harmonic analysis (for Power mode).	5-12
:ANALysis<x>:HARMonic:POWer:<Parameter 1>:STATe	Sets or queries the on/off status of an analysis item in harmonic analysis (for Power mode).	5-12
:ANALysis<x>:HARMonic:POWer:<Parameter 1>:VARiable	Sets or queries the DIV/Scale setting of an analysis item in harmonic analysis (for Power mode).	5-12
:ANALysis<x>:HARMonic:POWer:<Parameter 1>:VDIV	Sets or queries the V/DIV setting of an analysis item in harmonic analysis (for Power mode).	5-12
:ANALysis<x>:HARMonic:POWer:<Parameter 1>:ZOOM	Sets or queries the vertical zoom (V Zoom) of an analysis item in harmonic analysis (for Power mode).	5-13
:ANALysis<x>:HARMonic:POWer:<Parameter 2>:OFFSet	Sets or queries the offset of an analysis item (P, Phdf, and φ of all harmonics) in harmonic analysis (for Power mode).	5-13
:ANALysis<x>:HARMonic:POWer:<Parameter 2>:POSition	Sets the position of an analysis item (P, Phdf, and φ of all harmonics) in harmonic analysis (for Power mode).	5-13
:ANALysis<x>:HARMonic:POWer:<Parameter 2>:SCALe	Sets the scale boundaries (upper and lower) of an analysis item (P, Phdf, and φ of all harmonics) in harmonic analysis (for Power mode).	5-13

Command	Function	Page
:ANALysis<x>:HARMonic:POWer:<Parameter 2>:STATe	Sets the on/off status of an analysis item (P, Phdf, and φ of all harmonics) in harmonic analysis (for Power mode).	5-13
:ANALysis<x>:HARMonic:POWer:<Parameter 2>:VARiable	Sets the DIV/Scale setting of an analysis item (P, Phdf, and φ of all harmonics) in harmonic analysis (for Power mode).	5-13
:ANALysis<x>:HARMonic:POWer:<Parameter 2>:VDIV	Sets the V/DIV setting of an analysis item (P, Phdf, and φ of all harmonics) in harmonic analysis (for Power mode).	5-14
:ANALysis<x>:HARMonic:POWer:<Parameter 2>:ZOOM	Sets the vertical zoom (V Zoom) of an analysis item (P, Phdf, and φ of all harmonics) in harmonic analysis (for Power mode).	5-14
:ANALysis<x>:HARMonic:POWer:SOURce:I1	Sets or queries source channel I1 in harmonic analysis (for Power mode).	5-14
:ANALysis<x>:HARMonic:POWer:SOURce:I2	Sets or queries source channel I2 in harmonic analysis (for Power mode).	5-14
:ANALysis<x>:HARMonic:POWer:SOURce:I3	Sets or queries source channel I3 in harmonic analysis (for Power mode).	5-14
:ANALysis<x>:HARMonic:POWer:SOURce:U1	Sets or queries source channel U1 in harmonic analysis (for Power mode).	5-14
:ANALysis<x>:HARMonic:POWer:SOURce:U2	Sets or queries source channel U2 in harmonic analysis (for Power mode).	5-15
:ANALysis<x>:HARMonic:POWer:SOURce:U3	Sets or queries source channel U3 in harmonic analysis (for Power mode).	5-15
:ANALysis<x>:HARMonic:POWer:TERM?	Queries all calculation period settings in harmonic analysis (for Power mode).	5-15
:ANALysis<x>:HARMonic:POWer:TERM:ESFilter	Sets or queries the edge source filter for the calculation period in harmonic analysis (for Power mode).	5-15
:ANALysis<x>:HARMonic:POWer:TERM:HYSTeresis	Sets or queries the hysteresis for the calculation period in harmonic analysis (for Power mode).	5-15
:ANALysis<x>:HARMonic:POWer:TERM:ESOurce	Sets or queries the edge detection source for the calculation period in harmonic analysis (for Power mode).	5-15
:ANALysis<x>:HARMonic:POWer:WIRing	Sets or queries the wiring system in harmonic analysis (for Power mode).	5-16
:ANALysis<x>:HARMonic:PSCale	Sets or queries the φ (phase difference) scale in harmonic analysis (for Power mode).	5-16
:ANALysis<x>:HARMonic:LRMS?	Queries all settings related to the harmonic analysis (for Line RMS mode).	5-16
:ANALysis<x>:HARMonic:LRMS:<Parameter 1>:LABel	Sets or queries the label of an analysis item in harmonic analysis (for Line RMS mode).	5-16
:ANALysis<x>:HARMonic:LRMS:<Parameter 1>:OPTimize	Optimizes Value/Div of an analysis item in harmonic analysis (for Line RMS mode).	5-16
:ANALysis<x>:HARMonic:LRMS:<Parameter 1>:OFFSet	Sets or queries the offset of an analysis item in harmonic analysis (for Line RMS mode).	5-16
:ANALysis<x>:HARMonic:LRMS:<Parameter 1>:POSition	Sets or queries the position of an analysis item in harmonic analysis (for Line RMS mode).	5-16
:ANALysis<x>:HARMonic:LRMS:<Parameter 1>:SCALe	Sets or queries the scale boundaries (upper and lower) of an analysis item in harmonic analysis (for Line RMS mode).	5-17
:ANALysis<x>:HARMonic:LRMS:<Parameter 1>:STATe	Sets or queries the on/off status of an analysis item in harmonic analysis (for Line RMS mode).	5-17
:ANALysis<x>:HARMonic:LRMS:<Parameter 1>:VARiable	Sets or queries the DIV/Scale setting of an analysis item in harmonic analysis (for Line RMS mode).	5-17
:ANALysis<x>:HARMonic:LRMS:<Parameter 1>:VDIV	Sets or queries the V/DIV setting of an analysis item in harmonic analysis (for Line RMS mode).	5-17
:ANALysis<x>:HARMonic:LRMS:<Parameter 1>:ZOOM	Sets or queries the vertical zoom (V Zoom) of an analysis item in harmonic analysis (for Line RMS mode).	5-17
:ANALysis<x>:HARMonic:LRMS:<Parameter 2>:OFFSet	Sets the offset of an analysis item (RMS, Rhdf, and φ of all harmonics) in harmonic analysis (for Line RMS mode).	5-18
:ANALysis<x>:HARMonic:LRMS:<Parameter 2>:POSition	Sets the position of an analysis item (RMS, Rhdf, and φ of all harmonics) in harmonic analysis (for Line RMS mode).	5-18
:ANALysis<x>:HARMonic:LRMS:<Parameter 2>:SCALe	Sets the scale boundaries (upper and lower) of an analysis item (RMS, Rhdf, and φ of all harmonics) in harmonic analysis (for Line RMS mode).	5-18
:ANALysis<x>:HARMonic:LRMS:<Parameter 2>:STATe	Sets the on/off status of an analysis item (RMS, Rhdf, and φ of all harmonics) in harmonic analysis (for Line RMS mode).	5-18
:ANALysis<x>:HARMonic:LRMS:<Parameter 2>:VARiable	Sets the DIV/Scale setting of an analysis item (RMS, Rhdf, and φ of all harmonics) in harmonic analysis (for Line RMS mode).	5-18
:ANALysis<x>:HARMonic:LRMS:<Parameter 2>:VDIV	Sets the V/DIV setting of an analysis item (RMS, Rhdf, and φ of all harmonics) in harmonic analysis (for Line RMS mode).	5-18

Command	Function	Page
:ANALysis<x>:HARMonic:LRMS:<Parameter 2>:ZOOM	Sets the vertical zoom (V Zoom) of an analysis item (RMS, Rhdf, and φ of all harmonics) in harmonic analysis (for Line RMS mode).	5-18
:ANALysis<x>:HARMonic:LRMS:SOURce	Sets or queries source channel in harmonic analysis (for Line RMS mode).	5-19
:ANALysis<x>:HARMonic:LRMS:TERM?	Queries all calculation period settings in harmonic analysis (for Line RMS mode).	5-19
:ANALysis<x>:HARMonic:LRMS:TERM:ESFilter	Sets or queries the edge source filter for the calculation period in harmonic analysis (for Line RMS mode).	5-19
:ANALysis<x>:HARMonic:LRMS:TERM:HYSTeresis	Sets or queries the hysteresis for the calculation period in harmonic analysis (for Line RMS mode).	5-19
:ANALysis<x>:MODE	Sets or queries the power math mode.	5-19
:ANALysis<x>:OPTimize	Optimizes Value/Div of all analysis items of power math (power analysis or harmonic analysis).	5-19
:ANALysis<x1>:POWer<x2>?	Queries all power analysis settings (Wiring System1 or Wiring System2) of power math.	5-19
:ANALysis<x1>:POWer<x2>:EFFiciency?	Queries all efficiency settings of power analysis (Wiring System1 or Wiring System2).	5-19
:ANALysis<x1>:POWer<x2>:EFFiciency:MODE	Sets or queries the efficiency mode of power analysis.	5-20
:ANALysis<x1>:POWer<x2>:EFFiciency:MOTor	Sets or queries the motor efficiency calculation method of power analysis.	5-20
:ANALysis<x1>:POWer<x2>:EFFiciency:RANgle	Sets or queries the rotation angle source for the motor efficiency calculation (rotation angle mode) of power analysis.	5-20
:ANALysis<x1>:POWer<x2>:EFFiciency:SCALing	Sets or queries the scaling for the motor efficiency calculation (rotation angle mode) of power analysis.	5-20
:ANALysis<x1>:POWer<x2>:EFFiciency:SPEed	Sets or queries the rotation speed source for the motor efficiency calculation (rotation speed mode) of power analysis.	5-20
:ANALysis<x1>:POWer<x2>:EFFiciency:SSCaling (Speed Scaling)	Sets or queries the scaling for the motor efficiency calculation (rotation speed mode) of power analysis.	5-20
:ANALysis<x1>:POWer<x2>:EFFiciency:TORQue	Sets or queries the torque source for the motor efficiency calculation of power analysis.	5-21
:ANALysis<x1>:POWer<x2>:INTegration?	Queries all integration settings of power analysis.	5-21
:ANALysis<x1>:POWer<x2>:INTegration:CALExecute	Calibrates the integration calculation of power analysis.	5-21
:ANALysis<x1>:POWer<x2>:INTegration:CONDition	Sets or queries the integration condition for the power analysis integration.	5-21
:ANALysis<x1>:POWer<x2>:INTegration:MRESet	Manually resets the integrated value of power analysis.	5-21
:ANALysis<x1>:POWer<x2>:INTegration:RCONdition	Sets or queries whether the integrated value is reset when the power analysis integration starts.	5-21
:ANALysis<x1>:POWer<x2>:INTegration:SCALing	Sets or queries the scaling for the power analysis integration.	5-21
:ANALysis<x1>:POWer<x2>:<Parameter>:{PH1|PH2|PH3|SIGMa}:LABel	Sets or queries the analysis item power supply analysis label of power analysis.	5-22
:ANALysis<x1>:POWer<x2>:<Parameter>:{PH1|PH2|PH3|SIGMa}:OFFSet	Sets or queries the offset of an analysis item in power analysis.	5-22
:ANALysis<x1>:POWer<x2>:<Parameter>:{PH1|PH2|PH3|SIGMa}:OPTimize	Optimizes Value/Div of an analysis item in power analysis.	5-23
:ANALysis<x1>:POWer<x2>:<Parameter>:{PH1|PH2|PH3|SIGMa}:POSition	Sets or queries the position of an analysis item in power analysis.	5-23
:ANALysis<x1>:POWer<x2>:<Parameter>:{PH1|PH2|PH3|SIGMa}:SCALe	Sets or queries the scale boundaries (upper and lower) of an analysis item in power analysis.	5-23
:ANALysis<x1>:POWer<x2>:<Parameter>:{PH1|PH2|PH3|SIGMa}:STATe	Sets or queries the on/off status of an analysis item in power analysis.	5-23
:ANALysis<x1>:POWer<x2>:<Parameter>:{PH1|PH2|PH3|SIGMa}:VARiable	Sets or queries the DIV/Scale setting of an analysis item in power supply analysis.	5-23
:ANALysis<x1>:POWer<x2>:<Parameter>:{PH1|PH2|PH3|SIGMa}:VDIV	Sets or queries the V/DIV setting of an analysis item in power analysis.	5-23
:ANALysis<x1>:POWer<x2>:<Parameter>:{PH1|PH2|PH3|SIGMa}:ZOOM	Sets or queries the vertical zoom (V Zoom) of an analysis item in power analysis.	5-24

Command	Function	Page
:ANALysis<x1>:POWer<x2>:PSCale	Sets or queries the φ (phase difference) scale in power analysis.	5-24
:ANALysis<x1>:POWer<x2>:RTYPe	Sets or queries the RMS type of an analysis item in power analysis.	5-24
:ANALysis<x1>:POWer<x2>:SOURce:I1	Sets or queries source channel I1 in power analysis.	5-24
:ANALysis<x1>:POWer<x2>:SOURce:I2	Sets or queries source channel I2 in power analysis.	5-24
:ANALysis<x1>:POWer<x2>:SOURce:I3	Sets or queries source channel I3 in power analysis.	5-24
:ANALysis<x1>:POWer<x2>:SOURce:U1	Sets or queries source channel U1 in power analysis.	5-24
:ANALysis<x1>:POWer<x2>:SOURce:U2	Sets or queries source channel U2 in power analysis.	5-25
:ANALysis<x1>:POWer<x2>:SOURce:U3	Sets or queries source channel U3 in power analysis.	5-25
:ANALysis<x1>:POWer<x2>:TERM?	Queries all calculation period settings of power analysis (Wiring System1 or Wiring System2).	5-25
:ANALysis<x1>:POWer<x2>:TERM:ATIMer	Sets or queries the update time of the calculation period in power analysis.	5-25
:ANALysis<x1>:POWer<x2>:TERM:ESFilter	Sets or queries the edge source filter for the calculation period in power analysis.	5-25
:ANALysis<x1>:POWer<x2>:TERM:HYSTeresis	Sets or queries the hysteresis for the calculation period in power analysis.	5-25
:ANALysis<x1>:POWer<x2>:TERM:ESOurce	Sets or queries the edge detection source channel for the calculation period in power analysis.	5-25
:ANALysis<x1>:POWer<x2>:TERM:STOPpredict	Sets or queries the stop prediction of the calculation period in power analysis.	5-26
:ANALysis<x1>:POWer<x2>:TERM:TYPE	Sets or queries the calculation period type in power analysis.	5-26
:ANALysis<x1>:POWer<x2>:TERM:OCHannel	Sets or queries the channel number when the edge detection source for the calculation period is set to Other Channel in power analysis.	5-26
:ANALysis<x1>:POWer<x2>:WIRing	Sets or queries the wiring system in power analysis.	5-26

RMATh CHANnel Group

Command	Function	Page
:CHANnel<x>:RMATh:AMINus:SCALe	Sets or queries the scale of the specified channel's angle difference operation.	5-27
:CHANnel<x1>:RMATh:ATANgent:SCALe	Sets or queries the scale of the specified channel's arc tangent operation.	5-27
:CHANnel<x>:RMATh:ATANgent:QUADrant	Sets or queries the quadrant range for the arctangent calculation of the specified channel.	5-27
:CHANnel<x>:RMATh:AVALue	Sets or queries coefficient A of the currently specified real time math operation.	5-27
:CHANnel<x>:RMATh:BVALue	Sets or queries coefficient B of the currently specified real time math operation.	5-27
:CHANnel<x>:RMATh:BWIDth:BAND	Sets or queries the band of the specified channel's digital filter.	5-27
:CHANnel<x>:RMATh:BWIDth:CFRequency	Sets or queries the center frequency of the bandpass filter of the specified channel's digital filter.	5-28
:CHANnel<x>:RMATh:BWIDth:CUToff	Sets or queries the cutoff frequency of the specified channel's digital filter.	5-28
:CHANnel<x>:RMATh:BWIDth:INTerpo	Sets or queries the interpolation function of the specified channel's digital filter.	5-29
:CHANnel<x>:RMATh:BWIDth:MEAN?	Queries all mean settings of the specified channel's digital filter.	5-29
:CHANnel<x>:RMATh:BWIDth:MEAN:SAMPle (Base Sample)	Sets or queries the sample of the mean of the specified channel's digital filter.	5-29
:CHANnel<x>:RMATh:BWIDth:MEAN:TAP	Sets or queries the taps of the mean of the specified channel's digital filter.	5-29
:CHANnel<x>:RMATh:BWIDth:MODE	Sets or queries the filter mode of the specified channel.	5-29
:CHANnel<x>:RMATh:BWIDth:PBANd (Pass Band)	Sets or queries the bandwidth of the bandpass filter of the specified channel's digital filter.	5-30
:CHANnel<x>:RMATh:BWIDth:TYPE	Sets or queries the digital filter type of the specified channel.	5-30
:CHANnel<x>:RMATh:CANId:BRATe (Bit Rate)	Sets or queries the CAN ID bit rate of the specified channel.	5-30
:CHANnel<x>:RMATh:CANId:MFORmat (Message Format)	Sets or queries the CAN ID message format of the specified channel.	5-30
:CHANnel<x>:RMATh:CANId:MID (Message ID)	Sets or queries the CAN ID message ID of the specified channel.	5-30

Command	Function	Page
:CHANnel<x>:RMATh:CANId:SOURce	Sets or queries the CAN ID detection source waveform of the specified channel.	5-30
:CHANnel<x>:RMATh:CVALue	Sets or queries coefficient C of the currently specified real time math operation.	5-31
:CHANnel<x>:RMATh:DA?	Queries all logic signal to analog waveform conversion settings.	5-31
:CHANnel<x>:RMATh:DA:BLENgth (Bit Length)	Sets or queries the logic signal to analog waveform conversion bit length.	5-31
:CHANnel<x1>:RMATh:DA:SOURce <x2>	Sets or queries the math source waveform that you want to convert into an analog waveform.	5-31
:CHANnel<x>:RMATh:DA:TYPE	Sets or queries the logic signal to analog waveform conversion method (type).	5-31
:CHANnel<x>:RMATh:DELay	Sets or queries the delay of the specified channel.	5-31
:CHANnel<x>:RMATh:DVALue	Sets or queries coefficient D of the currently specified real time math operation.	5-31
:CHANnel<x>:RMATh:ECOunt? (Edge Count)	Queries all reset condition settings for the specified channel’s edge count operation.	5-31
:CHANnel<x>:RMATh:ECOunt:MRESet:EXECute (Manual Reset)	Resets the counter of the specified channel’s edge count operation.	5-32
:CHANnel<x>:RMATh:ECOunt:OVERange	Sets or queries whether the edge count is reset when an over limit occurs for the specified channel’s edge count operation.	5-32
:CHANnel<x>:RMATh:ECOunt:SRESet (Start Reset)	Sets or queries whether the edge count is reset when the edge count operation starts for the specified channel.	5-32
:CHANnel<x>:RMATh:EVALue	Sets or queries coefficient E of the currently specified real time math operation.	5-32
:CHANnel<x>:RMATh:FREQ?	Queries all the settings for the specified channel’s frequency, period, torque, and edge count (excluding reset) operations.	5-32
:CHANnel<x>:RMATh:FREQ:BIT	Sets or queries the math source waveform (the source bit) for the specified channel’s frequency, period, torque, and edge count operations (when the source is a logic channel).	5-32
:CHANnel<x>:RMATh:FREQ:DECeleration	Sets or queries whether frequency, period, and torque, computation’s deceleration prediction is turned on.	5-32
:CHANnel<x>:RMATh:FREQ:HYSTeresis	Sets or queries the detection hysteresis for the specified channel’s frequency, period, torque, and edge count operations.	5-33
:CHANnel<x>:RMATh:FREQ:LEVel	Sets or queries the detection level for the specified channel’s frequency, period, torque, and edge count operations.	5-33
:CHANnel<x>:RMATh:FREQ:OFFSet	Sets or queries the frequency/period calculation offset.	5-33
:CHANnel<x>:RMATh:FREQ:PROTate (Pulse per Rotate)	Sets or queries the number of pulses per rotation for the specified channel’s frequency operation.	5-33
:CHANnel<x>:RMATh:FREQ:SCALe	Sets or queries the scale of the specified channel’s frequency operation.	5-33
:CHANnel<x>:RMATh:FREQ:SLOPe	Sets or queries the detection slope for the specified channel’s frequency, period, torque, and edge count operations.	5-33
:CHANnel<x>:RMATh:FREQ:SOURce	Sets or queries the math source waveform for the specified channel’s frequency, period, torque, and edge count operations.	5-33
:CHANnel<x>:RMATh:FREQ:STOPpredict	Sets or queries whether frequency, torque, and period computation’s stop prediction is turned on.	5-33
:CHANnel<x1>:RMATh:IFILter?	Queries all IIR filter operation settings.	5-34
:CHANnel<x1>:RMATh:IFILter:BAND	Sets or queries the band of the IIR filter operation.	5-34
:CHANnel<x1>:RMATh:IFILter:CUToff	Sets or queries the cutoff frequency of the IIR filter operation.	5-34
:CHANnel<x1>:RMATh:IFILter:CFRequency	Sets or queries the center frequency of the bandpass filter of the IIR filter operation.	5-34
:CHANnel<x1>:RMATh:IFILter:PBANd	Sets or queries the bandwidth of the bandpass filter of the IIR filter operation.	5-34
:CHANnel<x1>:RMATh:IFILter:INTerpo	Sets or queries whether interpolation is used with the IIR filter operation.	5-34
:CHANnel<x>:RMATh:INTegral?	Queries all integration settings of the specified channel.	5-35
:CHANnel<x>:RMATh:INTegral:MRESet:EXECute (Manual Reset)	Resets the integrated value of the specified channel.	5-35
:CHANnel<x>:RMATh:INTegral:OVERange	Sets or queries whether the integrated value is reset when an over limit occurs for the specified channel.	5-35
:CHANnel<x>:RMATh:INTegral:SRESet (Start Reset)	Sets or queries whether the integrated value is reset when integration starts for the specified channel.	5-35
:CHANnel<x>:RMATh:INTegral:ZRESet?	Queries all settings related to the integrated value being reset when the signal crosses zero in integration of the specified channel.	5-35

Command	Function	Page
:CHANnel<x>:RMATh:INTegral:ZRESet:HYSTeresis	Sets or queries the hysteresis that is used for resetting the integrated value when the signal crosses zero for the specified channel.	5-35
:CHANnel<x>:RMATh:INTegral:ZRESet:MODE	Sets or queries whether the integrated value is reset when the signal crosses zero for the specified channel.	5-35
:CHANnel<x>:RMATh:INTegral:ZRESet:SLOPe	Sets or queries the slope that is used for resetting the integrated value when the signal crosses zero for the specified channel.	5-35
:CHANnel<x>:RMATh:KNOCkflt?	Queries all knocking filter settings of the specified channel.	5-36
:CHANnel<x>:RMATh:KNOCkflt:DIFFerential	Sets or queries the differentiation on/off status of the specified channel's knocking filter.	5-36
:CHANnel<x>:RMATh:KNOCkflt:ELEVel	Sets or queries the elimination level of the specified channel's knocking filter.	5-36
:CHANnel<x>:RMATh:LABel	Sets or queries the label of the specified RMath channel (the specified channel when real time math is turned on).	5-36
:CHANnel<x>:RMATh:MAVG (Moving Average)	Sets or queries the on/off status of the mean of the specified RMath channel (the specified channel when real time math is turned on).	5-36
:CHANnel<x>:RMATh:MODE	Sets or queries the real time math on/off status of the specified channel.	5-36
:CHANnel<x>:RMATh:OFFSet	Sets or queries the offset of the specified RMath channel (the specified channel when real time math is turned on).	5-36
:CHANnel<x>:RMATh:OPERation	Sets or queries the operation of the specified real time math channel.	5-37
:CHANnel<x>:RMATh:OPTimize	Optimizes the vertical scale of the specified channel that will be used in real time math.	5-37
:CHANnel<x>:RMATh:PASub:SIGN	Sets or queries the signs of the sources for the polynomial with a coefficient operation of the specified channel.	5-37
:CHANnel<x>:RMATh:PINTegral?	Queries all effective power integration settings of the specified channel.	5-37
:CHANnel<x>:RMATh:PINTegral:MRESet:EXECute	Resets the effective power integration of the specified channel.	5-37
:CHANnel<x>:RMATh:PINTegral:OVERange	Sets or queries whether the integrated power value of the specified channel is reset when an over limit occurs during effective power integration.	5-37
:CHANnel<x>:RMATh:PINTegral:SCALe	Sets the reference time for the effective power integration of the specified channel.	5-37
:CHANnel<x>:RMATh:PINTegral:SRESet	Sets or queries whether the integrated value is reset when the effective power integration starts for the specified channel.	5-38
:CHANnel<x>:RMATh:POSition	Sets or queries the vertical position of the specified RMath channel (the specified channel when real time math is turned on).	5-38
:CHANnel<x>:RMATh:POWer?	Queries all effective power calculation period settings of the specified channel.	5-38
:CHANnel<x>:RMATh:POWer:TERM:EBIT	Sets or queries the effective power calculation period's edge detection math source waveform (detection bit) of the specified channel (when a logic channel is being used as the edge detection channel).	5-38
:CHANnel<x>:RMATh:POWer:TERM:EHYSteresis	Sets or queries the effective power calculation period's detection hysteresis of the specified channel.	5-38
:CHANnel<x>:RMATh:POWer:TERM:ELEVel	Sets or queries the effective power calculation period's detection level of the specified channel.	5-38
:CHANnel<x>:RMATh:POWer:TERM:ESLope	Sets or queries the effective power calculation period's detection slope of the specified channel.	5-38
:CHANnel<x>:RMATh:POWer:TERM:ESOurce	Sets or queries the effective power calculation period's edge detection math source waveform of the specified channel.	5-39
:CHANnel<x1>:RMATh:PWM:PERiod	Sets or queries the period of the PWM operation.	5-39
:CHANnel<x>:RMATh:RANGle?	Queries all settings related to the angle-of-rotation, electrical angle, sine, and cosine operations of the specified channel.	5-39
:CHANnel<x>:RMATh:RANGle:BLENgth	Sets or queries the bit length when the encoding type is GRAY for the specified channel's angle-of-rotation, electrical angle, sine, and cosine operations.	5-39
:CHANnel<x>:RMATh:RANGle:CCONdition	Sets or queries the resolution for the specified channel's angle-of-rotation, electrical angle, sine, and cosine operations.	5-39
:CHANnel<x>:RMATh:RANGle:ETYPe (Edge Type)	Sets or queries the encoding type for the specified channel's angle-of-rotation, electrical angle, sine, and cosine operations.	5-39
:CHANnel<x1>:RMATh:RANGle:HYSTeresis<x2>	Sets or queries the slope for the specified math source waveform for the specified channel's angle-of-rotation, electrical angle, sine, and cosine operations.	5-40
:CHANnel<x1>:RMATh:RANGle:LEVel<x2>	Sets or queries the detection level for the specified math source waveform for the specified channel's angle-of-rotation, electrical angle, sine, and cosine operations.	5-40

Command	Function	Page
:CHANnel<x>:RMATh:RANGle:LOGic?	Queries all the math source waveform settings for the specified channel's angle-of-rotation, electrical angle, sine, and cosine operations.	5-40
:CHANnel<x>:RMATh:RANGle:LOGic:MODE	Sets or queries the math source waveform mode for the specified channel's angle-of-rotation, electrical angle, sine, and cosine operations.	5-40
:CHANnel<x1>:RMATh:RANGle:LOGic:SBIT<x2> (Source BIT)	Sets or queries the source bit when the math source waveform mode for the specified channel's angle-of-rotation, electrical angle, sine, and cosine operations is logic.	5-40
:CHANnel<x1>:RMATh:RANGle:LOGic:SOURce<x2>	Sets or queries the math source waveform when the math source waveform mode for the specified channel's angle-of-rotation, electrical angle, sine, and cosine operations is logic.	5-41
:CHANnel<x1>:RMATh:RANGle:MRESet:EXECute	Resets the angle of the specified channel's angle operations.	5-41
:CHANnel<x>:RMATh:RANGle:NLOGic (Negative Logic)	Sets or queries the on/off status of negative logic in angle operations.	5-41
:CHANnel<x>:RMATh:RANGle:PROTate (Pulse per Rotate)	Sets or queries the number of pulses per rotation for the specified channel's angle-of-rotation, electrical angle, sine, and cosine operations.	5-41
:CHANnel<x>:RMATh:RANGle:REVerse	Sets or queries whether the rotation direction is inverted for the specified channel's angle-of-rotation, electrical angle, sine, and cosine operations.	5-41
:CHANnel<x1>:RMATh:RANGle:RSOurce (Resolver Source Ch)	Sets or queries the math source waveform when the encoding type of the angle-of-rotation, sine, and cosine operations is RESolver.	5-41
:CHANnel<x>:RMATh:RANGle:RTIMing (Reset Timing)	Sets or queries the timing that will be used to reset the number of rotations for the specified channel's angle-of-rotation, electrical angle, sine, and cosine operations.	5-42
:CHANnel<x1>:RMATh:RANGle:SCALe	Sets or queries the scale of the specified channel's angle-of-rotation and electrical angle operations.	5-42
:CHANnel<x>:RMATh:RANGle:SLOGic (Source Logic)	Sets or queries the math source waveform type for the specified channel's angle-of-rotation, electrical angle, sine, and cosine operations.	5-42
:CHANnel<x1>:RMATh:RANGle:SOURce<x2>	Sets or queries the math source waveform when the math source waveform mode for the specified channel's angle-of-rotation, electrical angle, sine, and cosine operations is not logic.	5-42
:CHANnel<x1>:RMATh:RANGle:TIMing<x2> (Edge Timing)	Sets or queries the edge detection timing for the specified channel's angle-of-rotation, electrical angle, sine, and cosine operations.	5-42
:CHANnel<x>:RMATh:RANGle:ZINVert	Sets or queries whether the Z phase is inverted for the specified channel's angle-of-rotation, electrical angle, sine, and cosine operations.	5-42
:CHANnel<x1>:RMATh:RESolver?	Queries all resolver operation settings.	5-42
:CHANnel<x1>:RMATh:RESolver:PHASe	Sets or queries the angle combination of 3 phase resolver operation.	5-43
:CHANnel<x1>:RMATh:RESolver:OFFSet	Sets or queries the offset angle of resolver operation.	5-43
:CHANnel<x1>:RMATh:RESolver:SOURce<x2>	Sets or queries the math source waveform of the resolver operation.	5-43
:CHANnel<x1>:RMATh:RESolver:SMODe(Sample Mode)	Sets or queries the sample mode of the resolver operation.	5-43
:CHANnel<x1>:RMATh:RESolver:HYSTeresis	Sets or queries the hysteresis of the resolver operation when the sample mode is set to AUTO.	5-43
:CHANnel<x1>:RMATh:RESolver:STIMe(Sampling Time)	Sets or queries the time from the excitation waveform edge of the resolver operation when the sample mode is set to MANual.	5-43
:CHANnel<x1>:RMATh:RESolver:TFILter	Sets or queries the tracking filter of the resolver operation.	5-44
:CHANnel<x1>:RMATh:RESolver:SCALe	Sets or queries the scale of the resolver operation.	5-44
:CHANnel<x>:RMATh:RMS?	Queries all RMS calculation period settings of the specified channel.	5-44
:CHANnel<x>:RMATh:RMS:TERM:EBIT	Sets or queries the edge detection math source waveform (the detection bit) for when the RMS calculation period of the specified channel is set to edge (when a logic channel is being used as the edge detection channel).	5-44
:CHANnel<x>:RMATh:RMS:TERM:EHYSteresis	Sets or queries the detection hysteresis for when the RMS calculation period of the specified channel is set to edge.	5-44
:CHANnel<x>:RMATh:RMS:TERM:ELEVel	Sets or queries the detection level for when the RMS calculation period of the specified channel is set to edge.	5-44
:CHANnel<x>:RMATh:RMS:TERM:ESLope	Sets or queries the detection slope for when the RMS calculation period of the specified channel is set to edge.	5-44
:CHANnel<x>:RMATh:RMS:TERM:ESOurce	Sets or queries the edge detection math source waveform for when the RMS calculation period of the specified channel is set to edge.	5-45

Command	Function	Page
:CHANnel<x>:RMATh:RMS:TERM:MODE	Sets or queries the RMS calculation period mode of the specified channel.	5-45
:CHANnel<x>:RMATh:RMS:TERM:TIME	Sets or queries the interval for when the RMS calculation period of the specified channel is set to time.	5-45
:CHANnel<x>:RMATh:RPOWer:SOURce<x2>	Sets or queries the apparent-power, effective-power, voltage, or current channel used to calculate the reactive power of the specified channel.	5-45
:CHANnel<x>:RMATh:RPOWer:VOLTage:HYSTeresis	Sets or queries the hysteresis of the voltage channel used to calculate the reactive power of the specified channel.	5-45
:CHANnel<x1>:RMATh:SC<x2>	Sets or queries source waveforms 1 to 3 of the currently specified real time math operation.	5-46
:CHANnel<x>:RMATh:SC4	Sets or queries source waveform 4 for the polynomial with a coefficient operation of the specified real time math channel.	5-46
:CHANnel<x>:RMATh:SCALe	Sets or queries the two ends of the scale of the specified RMath channel (the specified channel when real time math is turned on).	5-46
:CHANnel<x1>:RMATh:SQRT1:SIGN	Sets or queries the sign for the specified channel's square root operation.	5-46
:CHANnel<x>:RMATh:UNIT	Sets or queries the unit string of the specified RMath channel (the specified channel when real time math is turned on).	5-46
:CHANnel<x>:RMATh:VARiable	Sets or queries the vertical scale setup method of the specified RMath channel (the specified channel when real time math is turned on).	5-46
:CHANnel<x>:RMATh:VDIV	Sets or queries the value/div setting of the specified RMath channel (the specified channel when real time math is turned on).	5-46
:CHANnel<x>:RMATh:ZOOM	Sets or queries the vertical zoom factor of the specified RMath channel (the specified channel when real time math is turned on).	5-47

ANALysis Group

The commands in this group deal with power math. You can perform the same operations and make the same settings and queries that you can make by pressing ANALYSIS on the front panel or by accessing the menus for channels RMATh13 to RMATh16.

:ANALysis<x>?

Function Queries all power math (power analysis or harmonic analysis) settings.

Syntax `:ANALysis<x>?`
<x> = 1 or 2
When <x> = 1: All power analysis settings
When <x> = 2: All harmonic analysis settings

Description This command is valid on models with the /G5 option.

:ANALysis<x>:HARMonic?

Function Queries harmonic analysis setting of the power math feature.

Syntax `:ANALysis<x>:HARMonic?`
<x> = 2

Description This command is valid on models with the /G5 option.

:ANALysis<x>:HARMonic:GRAPh?

Function Queries all settings related to the harmonic analysis result display.

Syntax `:ANALysis<x>:HARMonic:GRAPh?`
<x> = 2

Description This command is valid on models with the /G5 option.

:ANALysis<x>:HARMonic:GRAPh:DITem?

Function Queries all analysis items settings of the harmonic analysis result display.

Syntax `:ANALysis<x>:HARMonic:GRAPh:DITem?`

Description This command is valid on models with the /G5 option.

:ANALysis<x>:HARMonic:GRAPh:DITem:HDF

Function Sets or queries whether percentage content (HDF) is displayed in the harmonic analysis result display.

Syntax
```
:ANALysis<x>:HARMonic:GRAPh:DITem:HDF {<Boolean>}
:ANALysis<x>:HARMonic:GRAPh:DITem:HDF?
```
<x> = 2

Example
```
:ANALYSIS2:HARMONIC:GRAPH:DITEM:HDF 1
:ANALYSIS2:HARMONIC:GRAPH:DITEM:HDF?
-> :ANALYSIS2:HARMONIC:GRAPH:DITEM:HDF 1
```

Description This command is valid on models with the /G5 option.

:ANALysis<x>:HARMonic:GRAPh:DITem:P

Function Sets or queries whether active power (P) is displayed in the harmonic analysis result display.

Syntax
```
:ANALysis<x>:HARMonic:GRAPh:DITem:P {<Boolean>}
:ANALysis<x>:HARMonic:GRAPh:DITem:P?
```
<x> = 2

Example
```
:ANALYSIS2:HARMONIC:GRAPH:DITEM:P 1
:ANALYSIS2:HARMONIC:GRAPH:DITEM:P?
-> :ANALYSIS2:HARMONIC:GRAPH:DITEM:P 1
```

Description This command is valid on models with the /G5 option.

:ANALysis<x>:HARMonic:GRAPh:DITem:PHI

Function Sets or queries whether phase angle (φ) is displayed in the harmonic analysis result display.

Syntax
```
:ANALysis<x>:HARMonic:GRAPh:DITem:PHI {<Boolean>}
:ANALysis<x>:HARMonic:GRAPh:DITem:PHI?
```
<x> = 2

Example
```
:ANALYSIS2:HARMONIC:GRAPH:DITEM:PHI 1
:ANALYSIS2:HARMONIC:GRAPH:DITEM:PHI?
-> :ANALYSIS2:HARMONIC:GRAPH:DITEM:PHI 1
```

Description This command is valid on models with the /G5 option.

:ANALysis<x>:HARMonic:GRAPh:DITem:RMS

Function Sets or queries whether rms values (RMS) is displayed in the harmonic analysis result display.

Syntax
```
:ANALysis<x>:HARMonic:GRAPh:DITem:RMS {<Boolean>}
:ANALysis<x>:HARMonic:GRAPh:DITem:RMS?
```
<x> = 2

Example
```
:ANALYSIS2:HARMONIC:GRAPH:DITEM:RMS 1
:ANALYSIS2:HARMONIC:GRAPH:DITEM:RMS?
-> :ANALYSIS2:HARMONIC:GRAPH:DITEM:RMS 1
```

Description This command is valid on models with the /G5 option.

:ANALysis<x>:HARMonic:GRAPh:LSTart

Function Sets or queries whether list starting harmonic is displayed in the harmonic analysis result display (window settings).

Syntax
```
:ANALysis<x>:HARMonic:GRAPh:LSTart
{<NRf>}
:ANALysis<x>:HARMonic:GRAPh:LSTart?
```
<x> = 2
<NRf> to 1 to 40 (/35) (up to 40 for RMS, up to 35 for Power)

Example
```
:ANALYSIS2:HARMONIC:GRAPH:LSTART 2
:ANALYSIS2:HARMONIC:GRAPH:LSTART?
-> :ANALYSIS2:HARMONIC:GRAPH:
LSTART 2
```

Description This command is valid on models with the /G5 option.

:ANALysis<x>:HARMonic:GRAPh:MAXorder

Function Sets or queries the maximum displayed harmonic in the harmonic analysis result display (window settings).

Syntax
```
:ANALysis<x>:HARMonic:GRAPh:MAXorder
{<NRf>}
:ANALysis<x>:HARMonic:GRAPh:MAXord
er?
```
<x> = 2
<NRf> to 1 to 40 (/35) (up to 40 for RMS, up to 35 for Power)

Example
```
:ANALYSIS2:HARMONIC:GRAPH:
MAXORDER 11
:ANALYSIS2:HARMONIC:GRAPH:MAXORDER?
-> :ANALYSIS2:HARMONIC:GRAPH:MAXORD
ER 11
```

Description This command is valid on models with the /G5 option.

:ANALysis<x>:HARMonic:GRAPh:MODE

Function Sets or queries the graph mode in the harmonic analysis result display (window settings).

Syntax
```
:ANALysis<x>:HARMonic:GRAPh:MODE
{OFF|BAR|LIST|VECTor}
:ANALysis<x>:HARMonic:GRAPh:MODE?
```
<x> = 2

Example
```
:ANALYSIS2:HARMONIC:GRAPH:MODE BAR
:ANALYSIS2:HARMONIC:GRAPH:MODE?
-> :ANALYSIS2:HARMONIC:GRAPH:
MODE BAR
```

Description This command is valid on models with the /G5 option.

:ANALysis<x>:HARMonic:GRAPh:NUMeric

Function Sets or queries whether numeric string is displayed when the graph mode is set to Vector in the harmonic analysis result display (window settings).

Syntax
```
:ANALysis<x>:HARMonic:GRAPh:NUMeric
{<Boolean>}
:ANALysis<x>:HARMonic:GRAPh:NUMeric?
```
<x> = 2

Example

Description This command is valid on models with the /G5 option.

:ANALysis<x>:HARMonic:GRAPh:POSition

Function Sets or queries the graph position in the harmonic analysis result display (window settings).

Syntax
```
:ANALysis<x>:HARMonic:GRAPh:POSition
{<NRf>}
:ANALysis<x>:HARMonic:GRAPh:POSiti
on?
```
<x> = 2
<NRf> = –5 to 5 (in 10 div/display record length steps)

Example
```
:ANALYSIS2:HARMONIC:GRAPH:
POSITION -2
:ANALYSIS2:HARMONIC:GRAPH:POSITION?
-> :ANALYSIS2:HARMONIC:GRAPH:POSITI
ON -2.000000000000
```

Description This command is valid on models with the /G5 option.

:ANALysis<x>:HARMonic:GRAPh:SCALe

Function Sets or queries the vertical scale when the graph mode is set to Bar in the harmonic analysis result display (window settings).

Syntax
```
:ANALysis<x>:HARMonic:GRAPh:SCALe
{LINear|LOG}
:ANALysis<x>:HARMonic:GRAPh:SCALe?
```
<x> = 2

Example
```
:ANALYSIS2:HARMONIC:GRAPH:
SCALE LINEAR
:ANALYSIS2:HARMONIC:GRAPH:SCALE?
-> :ANALYSIS2:HARMONIC:GRAPH:
SCALE LINEAR
```

Description This command is valid on models with the /G5 option.

:ANALysis<x>:HARMonic:GRAPh:IZOom

Function Sets or queries the current zoom when the graph mode is set to Vector in the harmonic analysis result display (window settings).

Syntax
```
:ANALysis<x>:HARMonic:GRAPh:
IZOom {NRf}
:ANALysis<x>:HARMonic:GRAPh:IZOom?
```
<x> = 2
<NRf> = 0.1, 0.111, 0.125, 0.143, 0.167, 0.2, 0.25, 0.33, 0.4, 0.5, 0.556, 0.625, 0.667, 0.714, 0.8, 0.833, 1, 1.11, 1.25, 1.33, 1.43, 1.67, 2, 2.22, 2.5, 3.33, 4, 5, 6.67, 8, 10, 12.5, 16.7, 20, 25, 40, 50, 100

Example
```
:ANALYSIS2:HARMONIC:GRAPH:IZOOM 1
:ANALYSIS2:HARMONIC:GRAPH:IZOOM?
-> :ANALYSIS2:HARMONIC:GRAPH:IZOOM 1
```

Description This command is valid on models with the /G5 option.

:ANALysis<x>:HARMonic:GRAPh:UZOom

Function Sets or queries the voltage zoom when the graph mode is set to Vector in the harmonic analysis result display (window settings).

Syntax
```
:ANALysis<x>:HARMonic:GRAPh:
UZOom {NRf}
:ANALysis<x>:HARMonic:GRAPh:UZOom?
```
<x> = 2
<NRf> = 0.1, 0.111, 0.125, 0.143, 0.167, 0.2, 0.25, 0.33, 0.4, 0.5, 0.556, 0.625, 0.667, 0.714, 0.8, 0.833, 1, 1.11, 1.25, 1.33, 1.43, 1.67, 2, 2.22, 2.5, 3.33, 4, 5, 6.67, 8, 10, 12.5, 16.7, 20, 25, 40, 50, 100

Example
```
:ANALYSIS2:HARMONIC:GRAPH:UZOOM 1
:ANALYSIS2:HARMONIC:GRAPH:UZOOM? ->
:ANALYSIS2:HARMONIC:GRAPH:UZOOM 1
```

Description This command is valid on models with the /G5 option.

:ANALysis<x>:HARMonic:MODE

Function Sets or queries the analysis mode in harmonic analysis settings.

Syntax
```
:ANALysis<x>:HARMonic:MODE
{POWer|LRMS}
:ANALysis<x>:HARMonic:MODE?
```
<x> = 2

Example
```
:ANALYSIS2:HARMONIC:MODE LRMS
:ANALYSIS2:HARMONIC:MODE?
-> :ANALYSIS2:HARMONIC:MODE LRMS
```

Description This command is valid on models with the /G5 option.

:ANALysis<x>:HARMonic:POWer:<Parameter 1>:LABel

Function Sets or queries the label of an analysis item in harmonic analysis (for Power mode).

Syntax
```
:ANALysis<x>:HARMonic:POWer:<Paramet
er 1>:LABel {<String>}
:ANALysis<x>:HARMonic:POWer:<Paramet
er 1>:LABel?
```
<x> = 2
<String> = Up to 16 characters

Example
```
:ANALYSIS2:HARMONIC:POWER:PHDFK5:LAB
EL "Phdf(5)"
:ANALYSIS2:HARMONIC:POWER:PHDFK5:LAB
EL? -> :ANALYSIS2:HARMONIC:POWER:PHD
FK5:LABEL "Phdf(5)"
```

Description
- For the analysis items, see “Parameter 1 list.”
- This command is valid on models with the /G5 option.

<Parameter 1> list

When analysis mode is set to Power

<Parameter>		
PK<x>	Active power	<x>1 to 35
PHDFK<x>	Active power percentage content	<x>1 to 35
PHIK<x>	Phase angle	<x>1 to 35
P	Total active powers	
S	Total reactive powers	
Q	Total apparent powers	
LAMBda	Power factor	
URMS<x>	1st harmonic rms voltage (for displaying vectors)	<x>1 to 3
IRMS<x>	1st harmonic rms current (for displaying vectors)	<x>1 to 3
PHI_U1U<x>	1st harmonic voltage phase angle (for displaying vectors)	<x>1 to 3
PHI_U1I<x>	1st harmonic current phase angle (for displaying vectors)	<x>1 to 3

:ANALysis<x>:HARMonic:POWer:<Parameter 1>:OFFSet

Function Sets or queries the offset of an analysis item in harmonic analysis (for Power mode).

Syntax
```
:ANALysis<x>:HARMonic:POWer:<Paramet
er 1>:OFFSet {<NRf>}
:ANALysis<x>:HARMonic:POWer:<Paramet
er 1>:OFFSet?
```
<x> = 2
<NRf> = -5.00 to 5.00 (in 0.01 steps)

Example
```
:ANALYSIS2:HARMONIC:POWER:PK1:
OFFSET -50
:ANALYSIS2:HARMONIC:POWER:PK1:OFFS
ET? -> :ANALYSIS2:HARMONIC:POWER:PK1
:OFFSET -50.0000E+00
```

Description
- For the analysis items, see “Parameter 1 list.”
- This command is valid on models with the /G5 option.
- This command is valid when DIV/Scale is set to DIV.

:ANALysis<x>:HARMonic:POWer:<Parameter 1>:OPTimize

Function Optimizes Value/Div of an analysis item in harmonic analysis (for Power mode).

Syntax
```
:ANALysis<x>:HARMonic:POWer:<Paramet
er 1>:OPTimize
```
<x> = 2

Description
- For the analysis items, see “Parameter 1 list.”
- This command is valid on models with the /G5 option.

:ANALysis<x>:HARMonic:POWer:<Paramet er 1>:POSition

Function Sets or queries the position of an analysis item in harmonic analysis (for Power mode).

Syntax
```
:ANALysis<x>:HARMonic:POWer:<Paramet
er 1>:POSition {<NRf>}
:ANALysis<x>:HARMonic:POWer:<Paramet
er 1>:POSition?
```
<x> = 2
<NRf> = -5.00 to 5.00 (in 0.01 steps)

Example
```
:ANALYSIS2:HARMONIC:POWER:PK1:POSITI
ON 1
:ANALYSIS2:HARMONIC:POWER:PK1:POSITI
ON? -> :ANALYSIS2:HARMONIC:POWER:PK1
:POSITION 1.00
```

Description
- For the analysis items, see “Parameter 1 list.”
- This command is valid on models with the /G5 option.
- This command is valid when DIV/Scale is set to DIV.

:ANALysis<x>:HARMonic:POWer:<Paramet er 1>:SCALe

Function Sets or queries the scale boundaries (upper and lower) of an analysis item in harmonic analysis (for Power mode).

Syntax
```
:ANALysis<x>:HARMonic:POWer:<Paramet
er 1>:SCALe {<NRf>,<NRf>}
:ANALysis<x>:HARMonic:POWer:<Paramet
er 1>:SCALe?
```
<x> = 2
<NRf> = -9.9999E+30 to +9.9999E+30

Example
```
:ANALYSIS2:HARMONIC:POWER:PK1:
SCALE 400,0
:ANALYSIS2:HARMONIC:POWER:PK1:SCALE?
-> :ANALYSIS2:HARMONIC:POWER:PK1:SCA
LE 400.000E+00,0.00000E+00
```

Description
- For the analysis items, see “Parameter 1 list.”
- This command is valid on models with the /G5 option.
- This command is valid when DIV/Scale is set to SPAN.

:ANALysis<x>:HARMonic:POWer:<Paramet er 1>:STATe

Function Sets or queries the on/off status of an analysis item in harmonic analysis (for Power mode).

Syntax
```
:ANALysis<x>:HARMonic:POWer:<Paramet
er 1>:STATe {<Boolean>}
:ANALysis<x>:HARMonic:POWer:<Paramet
er 1>:STATe?
```
<x> = 1

Example
```
:ANALYSIS2:HARMONIC:POWER:PK1:
STATE 1
:ANALYSIS2:HARMONIC:POWER:PK1:STATE?
-> :ANALYSIS2:HARMONIC:POWER:PK1:STA
TE 1
```

Description
- For the analysis items, see “Parameter 1 list.”
- This command is valid on models with the /G5 option.

:ANALysis<x>:HARMonic:POWer:<Paramet er 1>:VARiable

Function Sets or queries the DIV/Scale setting of an analysis item in harmonic analysis (for Power mode).

Syntax
```
:ANALysis<x>:HARMonic:POWer:<Paramet
er 1>:VARiable {<Boolean>}
:ANALysis<x>:HARMonic:POWer:<Paramet
er 1>:VARiable?
```
<x> = 2
On : SPAN Off : VDIV

Example
```
:ANALYSIS2:HARMONIC:POWER:PK1:VARIAB
LE 1
:ANALYSIS2:HARMONIC:POWER:PK1:VARIAB
LE? -> :ANALYSIS2:HARMONIC:POWER:PK1
:VARIABLE 1
```

Description
- For the analysis items, see “Parameter 1 list.”
- This command is valid on models with the /G5 option.

:ANALysis<x>:HARMonic:POWer:<Paramet er 1>:VDIV

Function Sets or queries the V/DIV setting of an analysis item in harmonic analysis (for Power mode).

Syntax
```
:ANALysis<x>:HARMonic:POWer:<Paramet
er 1>:VDIV {<NRf>}
:ANALysis<x>:HARMonic:POWer:<Paramet
er 1>:VDIV?
```
<x> = 2
<NRf> = 1e-20 to 5e20

Example
```
:ANALYSIS2:HARMONIC:POWER:PK1:
VDIV 100
:ANALYSIS2:HARMONIC:POWER:PK1:VDIV?
-> :ANALYSIS2:HARMONIC:POWER:PK1:VD
IV 100
```

Description
- For the analysis items, see “Parameter 1 list.”
- This command is valid on models with the /G5 option.

:ANALysis<x>:HARMonic:POWer:<Parameter 1>:ZOOM

Function Sets or queries the vertical zoom (V Zoom) of an analysis item in harmonic analysis (for Power mode).

Syntax
```
:ANALysis<x>:HARMonic:POWer:<Parameter 1>:ZOOM {<NRf>}
:ANALysis<x>:HARMonic:POWer:<Parameter 1>:ZOOM?
```
<x> = 2
<NRf> = 0.1, 0.111, 0.125, 0.143, 0.167, 0.2, 0.25, 0.33, 0.4, 0.5, 0.556, 0.625, 0.667, 0.714, 0.8, 0.833, 1, 1.11, 1.25, 1.33, 1.43, 1.67, 2, 2.22, 2.5, 3.33, 4, 5, 6.67, 8, 10, 12.5, 16.7, 20, 25, 40, 50, 100

Example
```
:ANALYSIS2:HARMONIC:POWER:PK1:ZOOM 2
:ANALYSIS2:HARMONIC:POWER:PK1:ZOOM?
-> :ANALYSIS2:HARMONIC:POWER:PK1:ZOOM 2
```

Description
- For the analysis items, see “Parameter 1 list.”
- This command is valid on models with the /G5 option.
- This command is valid when DIV/Scale is set to DIV.

:ANALysis<x>:HARMonic:POWer:<Parameter 2>:OFFSet

Function Sets or queries the offset of an analysis item (P, Phdf, and φ of all harmonics) in harmonic analysis (for Power mode).

Syntax
```
:ANALysis<x>:HARMonic:POWer:<Parameter 2>:OFFSet {<NRf>}
```
<x> = 2

Example
```
:ANALYSIS2:HARMONIC:POWER:PALL:OFFSET 2.0
```

Description
- For the analysis items, see “Parameter 2 list.”
- This command is valid on models with the /G5 option.
- This command is valid when DIV/Scale is set to DIV.

<Parameter 2> list
When analysis mode is set to Power

<Parameter>	
PALL	Active power of all harmonics
PHDFALL	Active power percentage content of all harmonics
PHIALL	Phase angle of all harmonics

:ANALysis<x>:HARMonic:POWer:<Parameter 2>:POSition

Function Sets the position of an analysis item (P, Phdf, and φ of all harmonics) in harmonic analysis (for Power mode).

Syntax
```
:ANALysis<x>:HARMonic:POWer:<Parameter 2>:POSition {<NRf>}
```
<x> = 2
<NRf> = -5.00 to 5.00 (in 0.01 div steps)

Example
```
:ANALYSIS2:HARMONIC:POWER:PALL:POSITION 2.0
```

Description
- For the analysis items, see “Parameter 2 list.”
- This command is valid on models with the /G5 option.
- This command is valid when DIV/Scale is set to DIV.

:ANALysis<x>:HARMonic:POWer:<Parameter 2>:SCALe

Function Sets the scale boundaries (upper and lower) of an analysis item (P, Phdf, and φ of all harmonics) in harmonic analysis (for Power mode).

Syntax
```
:ANALysis<x>:HARMonic:POWer:<Parameter 2>:SCALe {<NRf>,<NRf>}
```
<x> = 2
<NRf> = -9.9999E+30 to +9.9999E+30

Example
```
:ANALYSIS2:HARMONIC:POWER:PALL:SCALE 10,-10
```

Description
- For the analysis items, see “Parameter 2 list.”
- This command is valid on models with the /G5 option.
- This command is valid when DIV/Scale is set to SPAN.

:ANALysis<x>:HARMonic:POWer:<Parameter 2>:STATe

Function Sets the on/off status of an analysis item (P, Phdf, and φ of all harmonics) in harmonic analysis (for Power mode).

Syntax
```
:ANALysis<x>:HARMonic:POWer:<Parameter 2>:STATe {<Boolean>}
```
<x> = 2

Example
```
:ANALYSIS2:HARMONIC:POWER:PALL:STATE 1
```

Description
- For the analysis items, see “Parameter 2 list.”
- This command is valid on models with the /G5 option.

:ANALysis<x>:HARMonic:POWer:<Parameter 2>:VARiable

Function Sets the DIV/Scale setting of an analysis item (P, Phdf, and φ of all harmonics) in harmonic analysis (for Power mode).

Syntax
```
:ANALysis<x>:HARMonic:POWer:<Parameter 2>:VARiable {<Boolean>}
```
<x> = 2
On : SPAN Off : VDIV

Example
```
:ANALYSIS2:HARMONIC:POWER:PALL:VARIABLE 1
```

Description
- For the analysis items, see “Parameter 2 list.”
- This command is valid on models with the /G5 option.

:ANALysis<x>:HARMonic:POWer:<Parameter 2>:VDIV

Function Sets the V/DIV setting of an analysis item (P, Phdf, and φ of all harmonics) in harmonic analysis (for Power mode).

Syntax `:ANALysis<x>:HARMonic:POWer:<Parameter 2>:VDIV {<NRf>}`
<x> = 2
<NRf> = 1e-20 to 5e20

Example `:ANALYSIS2:HARMONIC:POWER:PALL:VDIV 10.0`

Description
- For the analysis items, see "Parameter 2 list."
- This command is valid on models with the /G5 option.

:ANALysis<x>:HARMonic:POWer:<Parameter 2>:ZOOM

Function Sets the vertical zoom (V Zoom) of an analysis item (P, Phdf, and φ of all harmonics) in harmonic analysis (for Power mode).

Syntax `:ANALysis<x>:HARMonic:POWer:<Parameter 2>:ZOOM {<NRf>}`
<x> = 2
<NRf> = 0.1, 0.111, 0.125, 0.143, 0.167, 0.2, 0.25, 0.33, 0.4, 0.5, 0.556, 0.625, 0.667, 0.714, 0.8, 0.833, 1, 1.11, 1.25, 1.33, 1.43, 1.67, 2, 2.22, 2.5, 3.33, 4, 5, 6.67, 8, 10, 12.5, 16.7, 20, 25, 40, 50, 100

Example `:ANALYSIS2:HARMONIC:POWER:PALL:ZOOM 2.0`

Description
- For the analysis items, see "Parameter 2 list."
- This command is valid on models with the /G5 option.
- This command is valid when DIV/Scale is set to DIV.

:ANALysis<x>:HARMonic:POWer:SOURce:I1

Function Sets or queries source channel I1 in harmonic analysis (for Power mode).

Syntax `:ANALysis<x>:HARMonic:POWer:SOURce:I1 <NRf>`
`:ANALysis<x>:HARMonic:POWer:SOURce:I1?`
<x> = 2
<NRf> = 1 to 16

Example `:ANALYSIS2:HARMONIC:POWER:SOURCE:I1 2`
`:ANALYSIS2:HARMONIC:POWER:SOURCE:I1? -> :ANALYSIS2:HARMONIC:POWER:SOURCE:I1 2`

Description This command is valid on models with the /G5 option.

:ANALysis<x>:HARMonic:POWer:SOURce:I2

Function Sets or queries source channel I2 in harmonic analysis (for Power mode).

Syntax `:ANALysis<x>:HARMonic:POWer:SOURce:I2 <NRf>`
`:ANALysis<x>:HARMonic:POWer:SOURce:I2?`
<x> = 2
<NRf> = 1 to 16

Example `:ANALYSIS2:HARMONIC:POWER:SOURCE:I2 2`
`:ANALYSIS2:HARMONIC:POWER:SOURCE:I2? -> :ANALYSIS2:HARMONIC:POWER:SOURCE:I2 2`

Description
- This command is invalid when the wiring system is 1P2W.
- This command is valid on models with the /G5 option.

:ANALysis<x>:HARMonic:POWer:SOURce:I3

Function Sets or queries source channel I3 in harmonic analysis (for Power mode).

Syntax `:ANALysis<x>:HARMonic:POWer:SOURce:I3 <NRf>`
`:ANALysis<x>:HARMonic:POWer:SOURce:I3?`
<x> = 2
<NRf> = 1 to 16

Example `:ANALYSIS2:HARMONIC:POWER:SOURCE:I3 2`
`:ANALYSIS2:HARMONIC:POWER:SOURCE:I3? -> :ANALYSIS2:HARMONIC:POWER:SOURCE:I3 2`

Description
- This command is invalid when the wiring system is 1P2W, 1P3W, 3P3W, or 3P3W→3V3A.
- This command is valid on models with the /G5 option.

:ANALysis<x>:HARMonic:POWer:SOURce:U1

Function Sets or queries source channel U1 in harmonic analysis (for Power mode).

Syntax `:ANALysis<x>:HARMonic:POWer:SOURce:U1 <NRf>`
`:ANALysis<x>:HARMonic:POWer:SOURce:U1?`
<x> = 2
<NRf> = 1 to 16

Example `:ANALYSIS2:HARMONIC:POWER:SOURCE:U1 1`
`:ANALYSIS2:HARMONIC:POWER:SOURCE:U1? -> :ANALYSIS2:HARMONIC:POWER:SOURCE:U1 1`

Description This command is valid on models with the /G5 option.

:ANALysis<x>:HARMonic:POWer:SOURce:U2

Function Sets or queries source channel U2 in harmonic analysis (for Power mode).

Syntax
```
:ANALysis<x>:HARMonic:POWer:SOURce:U2 <NRf>
:ANALysis<x>:HARMonic:POWer:SOURce:U2?
```
<x> = 2
<NRf> = 1 to 16

Example
```
:ANALYSIS2:HARMONIC:POWER:SOURCE:U2 1
:ANALYSIS2:HARMONIC:POWER:SOURCE:U2?
-> :ANALYSIS2:HARMONIC:POWER:SOURCE:U2 1
```

Description
- This command is invalid when the wiring system is 1P2W.
- This command is valid on models with the /G5 option.

:ANALysis<x>:HARMonic:POWer:SOURce:U3

Function Sets or queries source channel U3 in harmonic analysis (for Power mode).

Syntax
```
:ANALysis<x>:HARMonic:POWer:SOURce:U3 <NRf>
:ANALysis<x>:HARMonic:POWer:SOURce:U3?
```
<x> = 2
<NRf> = 1 to 16

Example
```
:ANALYSIS2:HARMONIC:POWER:SOURCE:U3 1
:ANALYSIS2:HARMONIC:POWER:SOURCE:U3?
-> :ANALYSIS2:HARMONIC:POWER:SOURCE:U3 1
```

Description
- This command is invalid when the wiring system is 1P2W, 1P3W, 3P3W, or 3P3W→3V3A.
- This command is valid on models with the /G5 option.

:ANALysis<x>:HARMonic:POWer:TERM?

Function Queries all calculation period settings in harmonic analysis (for Power mode).

Syntax
```
:ANALysis<x>:HARMonic:POWer:TERM?
```

:ANALysis<x>:HARMonic:POWer:TERM:ESFilter

Function Sets or queries the edge source filter for the calculation period in harmonic analysis (for Power mode).

Syntax
```
:ANALysis<x>:HARMonic:POWer:TERM:ESFilter {OFF|<Frequency>}
:ANALysis<x>:HARMonic:POWer:TERM:ESFilter?
```
<x> = 2
<Frequency > = 62.5Hz, 125Hz, 250Hz, 500Hz, 1kHz, 2kHz,4kHz, 8kHz, 16kHz, 32kHz, 64kHz, 128kHz

Example
```
:ANALYSIS2:HARMONIC:POWER:TERM:ESFILTER 128KHZ
:ANALYSIS2:HARMONIC:POWER:TERM:ESFILTER? -> :ANALYSIS2:HARMONIC:POWER:TERM:ESFILTER 128E+03
```

Description This command is valid on models with the /G5 option.

:ANALysis<x>:HARMonic:POWer:TERM:HYSTeresis

Function Sets or queries the hysteresis for the calculation period in harmonic analysis (for Power mode).

Syntax
```
:ANALysis<x>:HARMonic:POWer:TERM:HYSTeresis {HIGH|LOW|MIDDle}
:ANALysis<x>:HARMonic:POWer:TERM:HYSTeresis?
```
<x> = 2

Example
```
:ANALYSIS2:HARMONIC:POWER:TERM:HYSTERESIS LOW
:ANALYSIS2:HARMONIC:POWER:TERM:HYSTERESIS? -> :ANALYSIS2:HARMONIC:POWER:TERM:HYSTERESIS LOW
```

Description This command is valid on models with the /G5 option.

:ANALysis<x>:HARMonic:POWer:TERM:ESOurce

Function Sets or queries the edge detection source for the calculation period in harmonic analysis (for Power mode).

Syntax
```
:ANALysis<x>:HARMonic:POWer:TERM:ESOurce {U1|U2|U3|I1|I2|I3}
:ANALysis<x>:HARMonic:POWer:TERM:ESOurce?
```
<x> = 2

Example
```
:ANALYSIS2:HARMONIC:POWER:TERM:ESOURCE U1
:ANALYSIS2:HARMONIC:POWER:TERM:ESOURCE? -> :ANALYSIS2:HARMONIC:POWER:TERM:ESOURCE U1
```

Description This command is valid on models with the /G5 option.

:ANALysis<x>:HARMonic:POWer:WIRing

Function Sets or queries the wiring system in harmonic analysis (for Power mode).

Syntax
```
:ANALysis<x>:HARMonic:POWer:WIRing
{(P1W2|P1W3|P3W3|V3A3|P3W4),(OFF|P
3W3_V3A3|DT_ST|ST_DT)}
```
<x> = 2
P1W2|P1W3|P3W3|V3A3|P3W4: wiring system selection
OFF|P3W3_V3A3|DT_ST|ST_DT: delta math selection

Example
```
:ANALYSIS2:HARMONIC:POWER:WIRING
P12W,OFF
:ANALYSIS2:HARMONIC:POWER:WIRING?
-> :ANALYSIS2:HARMONIC:POWER:WIRING
P1W2,OFF
```

Description
- Match the wiring system to the conversion source system of delta math.
- This command is valid on models with the /G5 option.

:ANALysis<x>:HARMonic:PSCale

Function Sets or queries the φ (phase difference) scale in harmonic analysis (for Power mode).

Syntax
```
:ANALysis<x>:HARMonic:PSCale
{DEGRee|RADian}
:ANALysis<x>:HARMonic:PSCale?
```
<x> = 2

Example
```
:ANALYSIS2:HARMONIC:PSCALE DEGREE
:ANALYSIS2:HARMONIC:PSCALE?
-> :ANALYSIS2:HARMONIC:PSCALE DEGREE
```

Description This command is valid on models with the /G5 option.

:ANALysis<x>:HARMonic:LRMS?

Function Queries all settings related to the harmonic analysis (for Line RMS mode).

Syntax
```
:ANALysis<x>:HARMonic:LRMS?
```

Description This command is valid on models with the /G5 option.

:ANALysis<x>:HARMonic:LRMS:<Paramet er 1>:LABel

Function Sets or queries the label of an analysis item in harmonic analysis (for Line RMS mode).

Syntax
```
:ANALysis<x>:HARMonic:LRMS:<Paramet
er 1>:LABel {<String>}
:ANALysis<x>:HARMonic:LRMS:<Paramet
er 1>:LABel?
```
<x> = 2
<String> = Up to 16 characters

Example
```
:ANALYSIS2:HARMONIC:LRMS:RMSK3:
LABEL "AAA"
:ANALYSIS2:HARMONIC:LRMS:RMSK3:LAB
EL? -> :ANALYSIS2:HARMONIC:LRMS:RMSK
3:LABEL "AAA"
```

Description
- For the analysis items, see “Parameter 1 list.”
- This command is valid on models with the /G5 option.

<Parameter 1> list

When the analysis mode is Line RMS

<Parameter>		
RMSK<x>	RMS Value (RMS)	<x>1 to 40
RHDFK<x>	RMS percentage content	<x>1 to 40
PHIK<x>	Phase angle	<x>1 to 40
RMS		
THDIec	(Firmware version 3.2 and later)	
THDCsa	(Firmware version 3.2 and later)	
HDFIec	Same as THDIec	
HDFCsa	Same as THDCsa	

:ANALysis<x>:HARMonic:LRMS:<Paramet er 1>:OPTimize

Function Optimizes Value/Div of an analysis item in harmonic analysis (for Line RMS mode).

Syntax
```
:ANALysis<x>:HARMonic:LRMS:<Paramet
er 1>:OPTimize
```
<x> = 2

Description
- For the analysis items, see “Parameter 1 list.”
- This command is valid on models with the /G5 option.

:ANALysis<x>:HARMonic:LRMS:<Paramet er 1>:OFFSet

Function Sets or queries the offset of an analysis item in harmonic analysis (for Line RMS mode).

Syntax
```
:ANALysis<x>:HARMonic:LRMS:
<Parameter 1>:OFFSet {<NRf>}
:ANALysis<x>:HARMonic:LRMS:<Paramet
er 1>:OFFSet?
```
<x> = 2

Example
```
:ANALYSIS2:HARMONIC:LRMS:RMSK3:OFFS
ET 1.0
:ANALYSIS2:HARMONIC:LRMS:RMSK3:OFFS
ET? -> :ANALYSIS2:HARMONIC:LRMS:RMSK
3:OFFSET 1.00000E+00
```

Description
- For the analysis items, see “Parameter 1 list.”
- This command is valid on models with the /G5 option.
- This command is valid when DIV/Scale is set to DIV.

:ANALysis<x>:HARMonic:LRMS:<Paramet er 1>:POSition

Function Sets or queries the position of an analysis item in harmonic analysis (for Line RMS mode).

Syntax
```
:ANALysis<x>:HARMonic:LRMS:<Paramet
er 1>:POSition {<NRf>}
:ANALysis<x>:HARMonic:LRMS:<Paramet
er 1>:POSition?
```
<x> = 2
<NRf> = -5.00 to 5.00 (in 0.01 div steps)

Example
```
:ANALYSIS2:HARMONIC:LRMS:RMSK3:POSIT
ION -1.2
:ANALYSIS2:HARMONIC:LRMS:RMSK3:POSIT
ION? -> :ANALYSIS2:HARMONIC:LRMS:RMS
K3:POSITION -1.20
```

Description
- For the analysis items, see “Parameter 1 list.”
- This command is valid on models with the /G5 option.
- This command is valid when DIV/Scale is set to DIV.

:ANALysis<x>:HARMonic:LRMS:<Parameter 1>:SCALe

Function: Sets or queries the scale boundaries (upper and lower) of an analysis item in harmonic analysis (for Line RMS mode).

Syntax:
```
:ANALysis<x>:HARMonic:LRMS:
<Parameter 1>:SCALe {<NRf>,<NRf>}
:ANALysis<x>:HARMonic:LRMS:<Paramet
er 1>:SCALe?
```
<x1> = 2
<NRf> = -9.9999E+30 to +9.9999E+30

Example:
```
:ANALYSIS2:HARMONIC:LRMS:RMSK3:
SCALE 4,0
:ANALYSIS2:HARMONIC:LRMS:RMSK3:SCA
LE? -> :ANALYSIS2:HARMONIC:LRMS:RMSK
3:SCALE 4.00000E+00,0.00000E+00
```

Description:
- For the analysis items, see “Parameter 1 list.”
- This command is valid on models with the /G5 option.
- This command is valid when DIV/Scale is set to SPAN.

:ANALysis<x>:HARMonic:LRMS:<Parameter 1>:STATe

Function: Sets or queries the on/off status of an analysis item in harmonic analysis (for Line RMS mode).

Syntax:
```
:ANALysis<x>:HARMonic:LRMS:<Paramet
er 1>:STATe {<Boolean>}
:ANALysis<x>:HARMonic:LRMS:<Paramet
er 1>:STATe?
```
<x> = 2

Example:
```
:ANALYSIS2:HARMONIC:LRMS:RMSK3:
STATE 1
:ANALYSIS2:HARMONIC:LRMS:RMSK3:STA
TE? -> :ANALYSIS2:HARMONIC:LRMS:RMSK
3:STATE 1
```

Description:
- For the analysis items, see “Parameter 1 list.”
- This command is valid on models with the /G5 option.

:ANALysis<x>:HARMonic:LRMS:<Parameter 1>:VARiable

Function: Sets or queries the DIV/Scale setting of an analysis item in harmonic analysis (for Line RMS mode).

Syntax:
```
:ANALysis<x>:HARMonic:LRMS:<Paramet
er 1>:VARiable {<Boolean>}
:ANALysis<x>:HARMonic:LRMS:<Paramet
er 1>:VARiable?
```
<x> = 2
On : SPAN Off : VDIV

Example:
```
:ANALYSIS2:HARMONIC:LRMS:RMSK3:VARIA
BLE 1
:ANALYSIS2:HARMONIC:LRMS:RMSK3:
VARIABLE? -> :ANALYSIS2:HARMONIC:
LRMS:RMSK3:VARIABLE 1
```

Description:
- For the analysis items, see “Parameter 1 list.”
- This command is valid on models with the /G5 option.

:ANALysis<x>:HARMonic:LRMS:<Parameter 1>:VDIV

Function: Sets or queries the V/DIV setting of an analysis item in harmonic analysis (for Line RMS mode).

Syntax:
```
:ANALysis<x>:HARMonic:LRMS:<Paramet
er 1>:VDIV {<NRf>}
:ANALysis<x>:HARMonic:LRMS:<Paramet
er 1>:VDIV?
```
<x> = 2
<NRf> = 1e-20 to 5e20

Example:
```
:ANALYSIS2:HARMONIC:LRMS:RMSK3:
VDIV 2
:ANALYSIS2:HARMONIC:LRMS:RMSK3:VDIV?
-> :ANALYSIS2:HARMONIC:LRMS:RMSK3:VD
IV 2.00000E+00
```

Description:
- For the analysis items, see “Parameter 1 list.”
- This command is valid on models with the /G5 option.

:ANALysis<x>:HARMonic:LRMS:<Parameter 1>:ZOOM

Function: Sets or queries the vertical zoom (V Zoom) of an analysis item in harmonic analysis (for Line RMS mode).

Syntax:
```
:ANALysis<x>:HARMonic:LRMS:<Paramet
er 1>:ZOOM {<NRf>}
:ANALysis<x>:HARMonic:LRMS:<Paramet
er 1>:ZOOM?
```
<x> = 2
<NRf> = 0.1, 0.111, 0.125, 0.143, 0.167, 0.2, 0.25, 0.33, 0.4, 0.5, 0.556, 0.625, 0.667, 0.714, 0.8, 0.833, 1, 1.11, 1.25, 1.33, 1.43, 1.67, 2, 2.22, 2.5, 3.33, 4, 5, 6.67, 8, 10, 12.5, 16.7, 20, 25, 40, 50, 100

Example:
```
:ANALYSIS2:HARMONIC:LRMS:RMSK3:
ZOOM 2
:ANALYSIS2:HARMONIC:LRMS:RMSK3:ZOOM?
-> :ANALYSIS2:HARMONIC:LRMS:RMSK3:ZO
OM 2.000
```

Description:
- For the analysis items, see “Parameter 1 list.”
- This command is valid on models with the /G5 option.
- This command is valid when DIV/Scale is set to DIV.

:ANALysis<x>:HARMonic:LRMS:<Parameter 2>:OFFSet

Function Sets the offset of an analysis item (RMS, Rhdf, and φ of all harmonics) in harmonic analysis (for Line RMS mode).

Syntax `:ANALysis<x>:HARMonic:LRMS:<Parameter 2>:OFFSet {<NRf>}`
<x> = 2

Example `:ANALYSIS2:HARMONIC:LRMS:RMSALL:OFFSET 1.0`

Description
- For the analysis items, see “Parameter 2 list.”
- This command is valid on models with the /G5 option.

<Parameter 2> list

When the analysis mode is Line RMS

<Parameter>	
RMSALL	RMS values of all harmonics
RHDFALL	Percentage content of all harmonics
PHIALL	Phase angle of all harmonics

:ANALysis<x>:HARMonic:LRMS:<Parameter 2>:POSition

Function Sets the position of an analysis item (RMS, Rhdf, and φ of all harmonics) in harmonic analysis (for Line RMS mode).

Syntax `:ANALysis<x>:HARMonic:LRMS:<Parameter 2>:POSition {<NRf>}`
<x> = 2
<NRf> = -5.00 to 5.00 (in 0.01 steps)

Example `:ANALYSIS2:HARMONIC:LRMS:RMSALL:POSITION 1.0`

Description
- For the analysis items, see “Parameter 2 list.”
- This command is valid on models with the /G5 option.
- This command is valid when DIV/Scale is set to DIV.

:ANALysis<x>:HARMonic:LRMS:<Parameter 2>:SCALe

Function Sets the scale boundaries (upper and lower) of an analysis item (RMS, Rhdf, and φ of all harmonics) in harmonic analysis (for Line RMS mode).

Syntax `:ANALysis<x>:HARMonic:LRMS:<Parameter 2>:SCALe {<NRf>,<NRf>}`
<x> = 2
<NRf> = -9.9999E+30 to +9.9999E+30

Example `:ANALYSIS2:HARMONIC:LRMS:RMSALL:SCALE 10.0,-10.0`

Description
- For the analysis items, see “Parameter 2 list.”
- This command is valid on models with the /G5 option.
- This command is valid when DIV/Scale is set to SPAN.

:ANALysis<x>:HARMonic:LRMS:<Parameter 2>:STATe

Function Sets the on/off status of an analysis item (RMS, Rhdf, and φ of all harmonics) in harmonic analysis (for Line RMS mode).

Syntax `:ANALysis<x>:HARMonic:LRMS:<Parameter 2>:STATe {<Boolean>}`
<x> = 2

Example `:ANALYSIS2:HARMONIC:LRMS:RMSALL:STATE 1`

Description
- For the analysis items, see “Parameter 2 list.”
- This command is valid on models with the /G5 option.

:ANALysis<x>:HARMonic:LRMS:<Parameter 2>:VARiable

Function Sets the DIV/Scale setting of an analysis item (RMS, Rhdf, and φ of all harmonics) in harmonic analysis (for Line RMS mode).

Syntax `:ANALysis<x>:HARMonic:LRMS:<Parameter 2:VARiable {<Boolean>}`
<x> = 2
On : SPAN Off : VDIV

Example `:ANALYSIS2:HARMONIC:LRMS:RMSALL:VARIABLE 1`

Description
- For the analysis items, see “Parameter 2 list.”
- This command is valid on models with the /G5 option.

:ANALysis<x>:HARMonic:LRMS:<Parameter 2>:VDIV

Function Sets the V/DIV setting of an analysis item (RMS, Rhdf, and φ of all harmonics) in harmonic analysis (for Line RMS mode).

Syntax `:ANALysis<x>:HARMonic:LRMS:<Parameter 2>:VDIV {<NRf>}`
<x> = 2
<NRf> = 1e-20 to 5e20

Example `:ANALYSIS2:HARMONIC:LRMS:RMSALL:VDIV 10.0`

Description
- For the analysis items, see “Parameter 2 list.”
- This command is valid on models with the /G5 option.

:ANALysis<x>:HARMonic:LRMS:<Parameter 2>:ZOOM

Function Sets the vertical zoom (V Zoom) of an analysis item (RMS, Rhdf, and φ of all harmonics) in harmonic analysis (for Line RMS mode).

Syntax `:ANALysis<x>:HARMonic:LRMS:<Parameter 2>:ZOOM {<NRf>}`
<x> = 2
<NRf> = 0.1, 0.111, 0.125, 0.143, 0.167, 0.2, 0.25, 0.33, 0.4, 0.5, 0.556, 0.625, 0.667, 0.714, 0.8, 0.833, 1, 1.11, 1.25, 1.33, 1.43, 1.67, 2, 2.22, 2.5, 3.33, 4, 5, 6.67, 8, 10, 12.5, 16.7, 20, 25, 40, 50, 100

Example `:ANALYSIS2:HARMONIC:LRMS:RMSALL:ZOOM 2`

Description
- For the analysis items, see “Parameter 2 list.”
- This command is valid on models with the /G5 option.
- This command is valid when DIV/Scale is set to DIV.

:ANALysis<x>:HARMonic:LRMS:SOURce

Function Sets or queries source channel in harmonic analysis (for Line RMS mode).

Syntax
```
:ANALysis<x>:HARMonic:LRMS:SOURce
{<NRf>}
:ANALysis<x>:HARMonic:LRMS:SOURce?
```
<x> = 2
<NRf> = 1 to 16

Example
```
:ANALYSIS2:HARMONIC:LRMS:SOURCE 1
:ANALYSIS2:HARMONIC:LRMS:SOURCE?
-> :ANALYSIS2:HARMONIC:LRMS:SOURCE 1
```

Description This command is valid on models with the /G5 option.

:ANALysis<x>:HARMonic:LRMS:TERM?

Function Queries all calculation period settings in harmonic analysis (for Line RMS mode).

Syntax
```
:ANALysis<x>:HARMonic:LRMS:TERM?
```

Description This command is valid on models with the /G5 option.

:ANALysis<x>:HARMonic:LRMS:TERM:ESFilter

Function Sets or queries the edge source filter for the calculation period in harmonic analysis (for Line RMS mode).

Syntax
```
:ANALysis<x>:HARMonic:LRMS:TERM:ESFi
lter {OFF|<Frequency>}
:ANALysis<x>:HARMonic:LRMS:TERM:ESFi
lter?
```
<x> = 2
<Frequency > = 62.5Hz, 125Hz, 250Hz, 500Hz, 1kkHz, 2kHz,4kHz, 8kHz, 16kHz, 32kHz, 64kHz, 128kHz

Example
```
:ANALYSIS2:HARMONIC:LRMS:TERM:ESFILT
ER 128KHZ
:ANALYSIS2:HARMONIC:LRMS:TERM:ESFILT
ER? -> :ANALYSIS2:HARMONIC:LRMS:TERM
:ESFILTER 128E+03
```

Description This command is valid on models with the /G5 option.

:ANALysis<x>:HARMonic:LRMS:TERM:HYSTeresis

Function Sets or queries the hysteresis for the calculation period in harmonic analysis (for Line RMS mode).

Syntax
```
:ANALysis<x>:HARMonic:LRMS:
TERM:HYSTeresis {HIGH|LOW|MIDDle}
:ANALysis<x>:HARMonic:LRMS:
TERM:HYSTeresis?
```
<x> = 2

Example
```
:ANALYSIS2:HARMONIC:LRMS:TERM:HYSTER
ESIS HIGH
:ANALYSIS2:HARMONIC:LRMS:TERM:HYSTER
ESIS? -> :ANALYSIS2:HARMONIC:LRMS:TE
RM:HYSTERESIS HIGH
```

Description This command is valid on models with the /G5 option.

:ANALysis<x>:MODE

Function Sets or queries the power math mode.

Syntax
```
:ANALysis<x>:MODE
{OFF|POWer1|POWer2|HARMonic}
:ANALysis<x>:MODE?
```
<x> = 1 or 2
When <x> = 1
OFF: Power analysis is disabled.
POWer1: Power analysis is set to 1 Wiring System mode.
POWer2: Power analysis is set to 2 Wiring Systems mode.
When <x> = 2
OFF: Harmonic analysis is disabled.
HARMonic: Harmonic analysis is enabled.

Example
```
:ANALYSIS1:MODE  POWER1
:ANALYSIS1:MODE? -> :ANALYSIS1:
MODE  POWER1
```

Description This command is valid on models with the /G5 option.

:ANALysis<x>:OPTimize

Function Optimizes Value/Div of all analysis items of power math (power analysis or harmonic analysis).

Syntax
```
:ANALysis<x>:OPTimize
```
<x> = 1 or 2
When <x> = 1: All analysis items of power analysis are optimized.
When <x> = 2: All analysis items of harmonic analysis are optimized.

Description This command is valid on models with the /G5 option.

:ANALysis<x1>:POWer<x2>?

Function Queries all power analysis settings (Wiring System1 or Wiring System2) of power math.

Syntax
```
:ANALysis<x1>:POWer<x2>?
```
<x1> = 1
<x2> = 1 or 2
When <x2> = 1: Wiring System1 settings
When <x2> = 2: Wiring System2 settings

Description This command is valid on models with the /G5 option.

:ANALysis<x1>:POWer<x2>:EFFiciency?

Function Queries all efficiency settings of power analysis (Wiring System1 or Wiring System2).

Syntax <x1> = 1 <x2> = 1 or 2
When <x2> = 1: All efficiency settings of Wiring System1
When <x2> = 2: All efficiency settings of Wiring System2

Description This command is valid on models with the /G5 option.

:ANALysis<x1>:POWer<x2>:EFFiciency:MODE

Function: Sets or queries the efficiency mode of power analysis.

Syntax:
```
:ANALysis<x1>:POWer<x2>:EFFiciency:M
ODE {OFF|POWer|MOTor}
:ANALysis<x1>:POWer<x2>:EFFiciency:M
ODE?
```
<x1> = 1 <x2> = 1 or 2

Example:
```
:ANALYSIS1:POWER1:EFFICIENCY:
MODE MOTOR
:ANALYSIS1:POWER1:EFFICIENCY:MODE?
-> :ANALYSIS1:POWER1:EFFICIENCY:
MODE MOTOR
```

Description: This command is valid on models with the /G5 option.

:ANALysis<x1>:POWer<x2>:EFFiciency:MOTor

Function: Sets or queries the motor efficiency calculation method of power analysis.

Syntax:
```
:ANALysis<x1>:POWer<x2>:EFFiciency:M
OTor {RANGle|SPEed}
:ANALysis<x1>:POWer<x2>:EFFiciency:M
OTor?
```
<x1> = 1 <x2> = 1 or 2
RANGle: Rotation angle
SPEed: Rotation speed

Example:
```
:ANALYSIS1:POWER1:EFFICIENCY:
MOTOR RANGLE
:ANALYSIS1:POWER1:EFFICIENCY:MOTOR?
-> :ANALYSIS1:POWER1:EFFICIENCY:
MOTOR RANGLE
```

Description: This command is valid on models with the /G5 option.

:ANALysis<x1>:POWer<x2>:EFFiciency:RANGle

Function: Sets or queries the rotation angle source for the motor efficiency calculation (rotation angle mode) of power analysis.

Syntax:
```
:ANALysis<x1>:POWer<x2>:EFFiciency:R
ANgle {RMATh<x3>}
:ANALysis<x1>:POWer<x2>:EFFiciency:R
ANgle?
```
<x1> = 1 <x2> = 1 or 2 <x3> = 1 to 16

Example:
```
:ANALYSIS1:POWER1:EFFICIENCY:
RANGLE RMATH9
:ANALYSIS1:POWER1:EFFICIENCY:RANGLE?
-> :ANALYSIS1:POWER1:EFFICIENCY:RANG
LE RMATH9
```

Description:
- This command is valid on models with the /G5 option.
- This key is valid when the Pm type is set to rotation angle.

:ANALysis<x1>:POWer<x2>:EFFiciency:SCALing

Function: Sets or queries the scaling for the motor efficiency calculation (rotation angle mode) of power analysis.

Syntax:
```
:ANALysis<x1>:POWer<x2>:EFFiciency:S
CALing {<NRf>}
:ANALysis<x1>:POWer<x2>:EFFiciency:S
CALing?
```
<x1> = 1 <x2> = 1 or 2
<NRf> = -9.999E+30 to +9.9999E+30

Example:
```
:ANALYSIS1:POWER1:EFFICIENCY:
SCALING 3.5
:ANALYSIS1:POWER1:EFFICIENCY:SCALI
NG? -> :ANALYSIS1:POWER1:EFFICIENCY:
SCALING 3.50000E+00
```

Description:
- This command is valid on models with the /G5 option.
- This key is valid when the Pm type is set to rotation angle.

:ANALysis<x1>:POWer<x2>:EFFiciency:SPEed

Function: Sets or queries the rotation speed source for the motor efficiency calculation (rotation speed mode) of power analysis.

Syntax:
```
:ANALysis<x1>:POWer<x2>:EFFiciency:S
PEed {<NRf>|RMATh<x3>}
:ANALysis<x1>:POWer<x2>:EFFiciency:S
PEed?
```
<x1> = 1 <x2> = 1 or 2 <x3> = 1 to 16
<NRf> = 1 to 16

Example:
```
:ANALYSIS1:POWER1:EFFICIENCY:SPEED 1
:ANALYSIS1:POWER1:EFFICIENCY:SPEED?
-> :ANALYSIS1:POWER1:EFFICIENCY:SPE
ED 1
```

Description:
- This command is valid on models with the /G5 option.
- This key is valid when the Pm type is set to rotation speed.

:ANALysis<x1>:POWer<x2>:EFFiciency:SSCaling (Speed Scaling)

Function: Sets or queries the scaling for the motor efficiency calculation (rotation speed mode) of power analysis.

Syntax:
```
:ANALysis<x1>:POWer<x2>:EFFiciency:S
SCale {RPS|RPM}
:ANALysis<x1>:POWer<x2>:EFFiciency:S
SCale
```
<x1> = 1 <x2> = 1 or 2

Example:
```
ANALYSIS1:POWER1:EFFICIENCY:
SSCALE RPM
ANALYSIS1:POWER1:EFFICIENCY:SSCALE?
-> ANALYSIS1:POWER1:EFFICIENCY:SSCA
LE RPM
```

Description: This command is valid on models with the /G5 option.

:ANALysis<x1>:POWer<x2>:EFFiciency:TORQue

Function Sets or queries the torque source for the motor efficiency calculation of power analysis.

Syntax
```
:ANALysis<x1>:POWer<x2>:EFFiciency:TORQue {<NRf>|RMATh<x3>}
:ANALysis<x1>:POWer<x2>:EFFiciency:TORQue?
```
<x1> = 1 <x2> = 1 or 2 <x3> = 1 to 16
<NRf> = 1 to 16

Example
```
:ANALYSIS1:POWER1:EFFICIENCY:TORQUE RMATH9
:ANALYSIS1:POWER1:EFFICIENCY:TORQUE? -> :ANALYSIS1:POWER1:EFFICIENCY:TORQUE RMATH9
```

Description This command is valid on models with the /G5 option.

:ANALysis<x1>:POWer<x2>:INTegration?

Function Queries all integration settings of power analysis.

Syntax
```
:ANALysis<x1>:POWer<x2>:INTegration?
```
<x1> = 1 <x2> = 1 or 2
When <x2> = 1: All integration settings of Wiring System1
When <x2> = 2: All integration settings of Wiring System2

Description This command is valid on models with the /G5 option.

:ANALysis<x1>:POWer<x2>:INTegration:CALExecute

Function Calibrates the integration calculation of power analysis.

Syntax
```
:ANALysis<x1>:POWer<x2>:INTegration:CALExecute
```
<x1> = 1 <x2> = 1 or 2

Example
```
ANALYSIS1:POWER1:INTEGRATION:CALEXECUTE
```

Description This command is valid on models with the /G5 option.

:ANALysis<x1>:POWer<x2>:INTegration:CONDition

Function Sets or queries the integration condition for the power analysis integration.

Syntax
```
:ANALysis<x1>:POWer<x2>:INTegration:CONDition {ALLTimes|IACQuisition}
:ANALysis<x1>:POWer<x2>:INTegration:CONDition?
```
<x1> = 1 <x2> = 1 or 2
ALLTimes: Integration at all times
IACQuisition: Integration only during measurement

Example
```
:ANALYSIS1:POWER1:INTEGRATION:CONDITION -> ALLTIMES
```

Description This command is valid on models with the /G5 option.

:ANALysis<x1>:POWer<x2>:INTegration:MRESet

Function Manually resets the integrated value of power analysis.

Syntax
```
:ANALysis<x1>:POWer<x2>:INTegration:MRESet
```
<x1> = 1 <x2> = 1 or 2

Example
```
:ANALYSIS1:POWER1:INTEGRATION:MRESET
```

Description This command is valid on models with the /G5 option.

:ANALysis<x1>:POWer<x2>:INTegration:RCONdition

Function Sets or queries whether the integrated value is reset when the power analysis integration starts.

Syntax
```
:ANALysis<x1>:POWer<x2>:INTegration:RCONdition {<Boolean>}
:ANALysis<x1>:POWer<x2>:INTegration:RCONdition?
```
<x1> = 1 <x2> = 1 or 2

Example
```
:ANALYSIS1:POWER1:INTEGRATION:RCONDITION 1
:ANALYSIS1:POWER1:INTEGRATION:RCONDITION? -> :ANALYSIS1:POWER1:INTEGRATION:RCONDITION 1
```

Description This command is valid on models with the /G5 option.

:ANALysis<x1>:POWer<x2>:INTegration:SCALing

Function Sets or queries the scaling for the power analysis integration.

Syntax
```
:ANALysis<x1>:POWer<x2>:INTegration:SCALing {SECond|HOUR}
:ANALysis<x1>:POWer<x2>:INTegration:SCALing?
```
<x1> = 1 <x2> = 1 or 2

Example
```
:ANALYSIS1:POWER1:INTEGRATION:SCALING SECOND
:ANALYSIS1:POWER1:INTEGRATION:SCALING? -> :ANALYSIS1:POWER1:INTEGRATION:SCALING SECOND
```

Description This command is valid on models with the /G5 option.

:ANALysis<x1>:POWer<x2>:<Parameter>:{PH1|PH2|PH3|SIGMa}:LABel

Function Sets or queries the analysis item power supply analysis label of power analysis.

Syntax
```
:ANALysis<x1>:POWer<x2>:<Parameter>
:{PH1|PH2|PH3|SIGMa}:LABel {<String>}
:ANALysis<x1>:POWer<x2>:<Parameter>
:{PH1|PH2|PH3|SIGMa}:LABel?
```
<x1> = 1 <x2> = 1 or 2
<String> = Up to 16 characters

Example
```
:ANALYSIS1:POWER1:URMS:PH1:
LABEL "AAA"
:ANALYSIS1:POWER1:URMS:PH1:LABEL?
-> :ANALYSIS1:POWER1:URMS:PH1:
LABEL "AAA"
```

Description
- For the analysis items, see “Parameter list.”
- This command is valid on models with the /G5 option.

<Parameter> When the analysis mode is set to 1 Wiring System

URMS	{PH1|PH2|PH3|SIGMa}
IRMS	{PH1|PH2|PH3|SIGMa}
UDC	{PH1|PH2|PH3|SIGMa}
IDC	{PH1|PH2|PH3|SIGMa}
UAC	{PH1|PH2|PH3|SIGMa}
IAC	{PH1|PH2|PH3|SIGMa}
P (Active Power)	{PH1|PH2|PH3|SIGMa}
S (Apparent Power)	{PH1|PH2|PH3|SIGMa}
Q (Reactive Power)	{PH1|PH2|PH3|SIGMa}
LAMBda (Power Factor : λ)	{PH1|PH2|PH3|SIGMa}
PHI (PhaseDifference : Φ)	{PH1|PH2|PH3|SIGMa}
FU	{PH1|PH2|PH3}
FI	{PH1|PH2|PH3}
UPPK (U+pk)	{PH1|PH2|PH3}
UMPK (U-pk)	{PH1|PH2|PH3}
IPPK (I+pk)	{PH1|PH2|PH3}
IMPK (I-pk)	{PH1|PH2|PH3}
PPPK (P+pk)	{PH1|PH2|PH3}
PMPK (P-pk)	{PH1|PH2|PH3}
WH (WattHours : WP)	{PH1|PH2|PH3|SIGMa}
WHP (WattHours : WP+)	{PH1|PH2|PH3|SIGMa}
WHM (WattHours : WP-)	{PH1|PH2|PH3|SIGMa}
AH (AmpereHours : q)	{PH1|PH2|PH3|SIGMa}
AHP (AmpereHours : q+)	{PH1|PH2|PH3|SIGMa}
AHM (AmpereHours : q-)	{PH1|PH2|PH3|SIGMa}
WS (Volt-ampere hours)	{PH1|PH2|PH3|SIGMa}
WQ (Var hours)	{PH1|PH2|PH3|SIGMa}
Z (Impedance of the load circuit)	{PH1|PH2|PH3|SIGMa}
RS (Series resistance of the load circuit)	{PH1|PH2|PH3|SIGMa}
XS (Series reactance of the load circuit)	{PH1|PH2|PH3|SIGMa}
RP (Parallel resistance of the load circuit)	{PH1|PH2|PH3|SIGMa}
XP (Parallel reactance of the load circuit)	{PH1|PH2|PH3|SIGMa}
PM (Motor drive efficiency)	
ETA (Efficiency)	
UUBF (Three-phase voltage unbalance factor)	
IUBF (Three-phase current unbalance factor)	
IN (Neutral line current)	
TIME (Integration time)	

<Parameter> When the analysis mode is set to 2 Wiring Systems

URMS	{PH1|SIGMa}
IRMS	{PH1|SIGMa}
UDC	{PH1|SIGMa}
IDC	{PH1|SIGMa}
UAC	{PH1|SIGMa}
IAC	{PH1|SIGMa}
P (Active Power)	{PH1|SIGMa}
S (Apparent Power)	{PH1|SIGMa}
Q (Reactive Power)	{PH1|SIGMa}
LAMBda (Power Factor λ)	{PH1|SIGMa}
PHI (PhaseDifference : Φ)	{PH1|SIGMa}
FU	{PH1|PH2|PH3}
FI	{PH1|PH2|PH3}
UPPK (U+pk)	{PH1|PH2|PH3}
UMPK (U-pk)	{PH1|PH2|PH3}
IPPK (I+pk)	{PH1|PH2|PH3}
IMPK (I-pk)	{PH1|PH2|PH3}
PPPK (P+pk)	{PH1|PH2|PH3}
PMPK (P-pk)	{PH1|PH2|PH3}
WH (WattHours : WP)	{PH1|SIGMa}
WHP (WattHours : WP+)	{PH1|SIGMa}
WHM (WattHours : WP-)	{PH1|SIGMa}
AH (AmpereHours : q)	{PH1|SIGMa}
AHP (AmpereHours : q+)	{PH1|SIGMa}
AHM (AmpereHours : q-)	{PH1|SIGMa}
WS (Volt-ampere hours)	{PH1|SIGMa}
WQ (Var hours)	{PH1|SIGMa}
Z (Impedance of the load circuit)	{PH1|SIGMa}
RS (Series resistance of the load circuit)	{PH1|SIGMa}
XS (Series reactance of the load circuit)	{PH1|SIGMa}
RP (Parallel resistance of the load circuit)	{PH1|SIGMa}
XP (Parallel reactance of the load circuit)	{PH1|SIGMa}
PM (Motor output (drive efficiency))	
ETA (Efficiency)	
UUBF (Three-phase voltage unbalance factor)	
IUBF (Three-phase current unbalance factor)	
IN (Neutral line current)	
TIME (Integration time)	

:ANALysis<x1>:POWer<x2>:<Parameter>:{PH1|PH2|PH3|SIGMa}:OFFSet

Function Sets or queries the offset of an analysis item in power analysis.

Syntax
```
:ANALysis<x1>:POWer<x2>:<Parameter>
:{PH1|PH2|PH3|SIGMa}:OFFSet {<NRf>}
:ANALysis<x1>:POWer<x2>:<Parameter>
:{PH1|PH2|PH3|SIGMa}:OFFSet?
```
<x1> = 1 <x2> = 1 or 2

Example
```
:ANALYSIS1:POWER1:URMS:PH1:OFFSET 1
:ANALYSIS1:POWER1:URMS:PH1:OFFSET?
-> :ANALYSIS1:POWER1:URMS:PH1:
OFFSET 1.00000E+00
```

Description
- For the analysis items, see “Parameter list.”
- This command is valid on models with the /G5 option.
- This command is valid when DIV/Scale is set to DIV.

:ANALysis<x1>:POWer<x2>:<Parameter>:{PH1|PH2|PH3|SIGMa}:OPTimize

Function Optimizes Value/Div of an analysis item in power analysis.

Syntax
```
:ANALysis<x1>:POWer<x2>:<Parameter>
:{PH1|PH2|PH3|SIGMa}:OPTimize}
```
<x1> = 1 <x2> = 1 or 2

Description
- For the analysis items, see "Parameter list."
- This command is valid on models with the /G5 option.

:ANALysis<x1>:POWer<x2>:<Parameter>:{PH1|PH2|PH3|SIGMa}:POSition

Function Sets or queries the position of an analysis item in power analysis.

Syntax
```
:ANALysis<x1>:POWer<x2>:<Parameter>
:{PH1|PH2|PH3|SIGMa}:POSition
{<NRf>}
:ANALysis<x1>:POWer<x2>:<Parameter>
:{PH1|PH2|PH3|SIGMa}:POSition?
```
<x1> = 1 <x2> = 1 or 2
<NRf> = -5.00 to 5.00 (in 0.01 steps)

Example
```
:ANALYSIS1:POWER1:URMS:PH1:
POSITION 0.5
:ANALYSIS1:POWER1:URMS:PH1:POSITION?
-> :ANALYSIS1:POWER1:URMS:PH1:POSITI
ON 0.50
```

Description
- For the analysis items, see "Parameter list."
- This command is valid on models with the /G5 option.
- This command is valid when DIV/Scale is set to DIV.

:ANALysis<x1>:POWer<x2>:<Parameter>:{PH1|PH2|PH3|SIGMa}:SCALe

Function Sets or queries the scale boundaries (upper and lower) of an analysis item in power analysis.

Syntax
```
:ANALysis<x1>:POWer<x2>:<Parameter>
:{PH1|PH2|PH3|SIGMa}:SCALe {<NRf>,
<NRf>}
:ANALysis<x1>:POWer<x2>:<Parameter>
:{PH1|PH2|PH3|SIGMa}:SCALe?
```
<x1> = 1 <x2> = 1 or 2
<NRf> = -9.9999E+30 to +9.9999E+30

Example
```
:ANALYSIS1:POWER1:URMS:PH1:
SCALE 4,-4
:ANALYSIS1:POWER1:URMS:PH1:SCALE?
-> :ANALYSIS1:POWER1:URMS:PH1:
SCALE 4.00000E+00,-4.00000E+00
```

Description
- For the analysis items, see "Parameter list."
- This command is valid on models with the /G5 option.
- This command is valid when DIV/Scale is set to SPAN.

:ANALysis<x1>:POWer<x2>:<Parameter>:{PH1|PH2|PH3|SIGMa}:STATe

Function Sets or queries the on/off status of an analysis item in power analysis.

Syntax
```
:ANALysis<x1>:POWer<x2>:<Parameter>
:{PH1|PH2|PH3|SIGMa}:STATe
{<Boolean>}
:ANALysis<x1>:POWer<x2>:<Parameter>
:{PH1|PH2|PH3|SIGMa}:STATe?
```
<x1> = 1 <x2> = 1 or 2

Example
```
:ANALYSIS1:POWER1:URMS:PH1:STATE 1
:ANALYSIS1:POWER1:URMS:PH1:STATE?
-> :ANALYSIS1:POWER1:URMS:PH1:
STATE 1
```

Description
- For the analysis items, see "Parameter list."
- This command is valid on models with the /G5 option.

:ANALysis<x1>:POWer<x2>:<Parameter>:{PH1|PH2|PH3|SIGMa}:VARiable

Function Sets or queries the DIV/Scale setting of an analysis item in power supply analysis.

Syntax
```
:ANALysis<x1>:POWer<x2>:<Paramet
er>:{PH1|PH2|PH3|SIGMa}:VARiable
{<Boolean>}
:ANALysis<x1>:POWer<x2>:<Parameter>:
{PH1|PH2|PH3|SIGMa}:VARiable?
```
<x1> = 1 <x2> = 1 or 2
On : SPAN Off : VDIV

Example
```
:ANALYSIS1:POWER1:URMS:PH1:
VARIABLE  1
:ANALYSIS1:POWER1:URMS:PH1:VARIABLE?
-> :ANALYSIS1:POWER1:URMS:PH1:VARIAB
LE  1
```

Description
- For the analysis items, see "Parameter list."
- This command is valid on models with the /G5 option.

:ANALysis<x1>:POWer<x2>:<Parameter>:{PH1|PH2|PH3|SIGMa}:VDIV

Function Sets or queries the V/DIV setting of an analysis item in power analysis.

Syntax
```
:ANALysis<x1>:POWer<x2>:<Parameter>:
{PH1|PH2|PH3|SIGMa}:VDIV {<NRf>}
:ANALysis<x1>:POWer<x2>:<Parameter>:
{PH1|PH2|PH3|SIGMa}:VDIV?
```
<x1> = 1 <x2> = 1 or 2
<NRf> = 1e-20 to 5e20

Example
```
:ANALYSIS1:POWER1:URMS:PH1:VDIV 2.0
:ANALYSIS1:POWER1:URMS:PH1:VDIV?
-> :ANALYSIS1:POWER1:URMS:PH1:
VDIV 2.0000E+00
```

Description
- For the analysis items, see "Parameter list."
- This command is valid on models with the /G5 option.

:ANALysis<x1>:POWer<x2>:<Parameter>:{PH1|PH2|PH3|SIGMa}:ZOOM

Function Sets or queries the vertical zoom (V Zoom) of an analysis item in power analysis.

Syntax
```
:ANALysis<x1>:POWer<x2>:<Parameter>
:{PH1|PH2|PH3|SIGMa}:ZOOM {<NRf>}
:ANALysis<x1>:POWer<x2>:<Parameter>
:{PH1|PH2|PH3|SIGMa}:ZOOM?
```
<x1> = 1 <x2> = 1 or 2
<NRf> = 0.1, 0.111, 0.125, 0.143, 0.167, 0.2, 0.25, 0.33, 0.4, 0.5, 0.556, 0.625, 0.667, 0.714, 0.8, 0.833, 1, 1.11, 1.25, 1.33, 1.43, 1.67, 2, 2.22, 2.5, 3.33, 4, 5, 6.67, 8, 10, 12.5, 16.7, 20, 25, 40, 50, 100

Example
```
:ANALYSIS1:POWER1:URMS:PH1:ZOOM 2.0
:ANALYSIS1:POWER1:URMS:PH1:ZOOM?
-> :ANALYSIS1:POWER1:URMS:PH1:
ZOOM 2.000
```
Description
- For the analysis items, see “Parameter list.”
- This command is valid on models with the /G5 option.
- This command is valid when DIV/Scale is set to DIV.

:ANALysis<x1>:POWer<x2>:PSCale

Function Sets or queries the φ (phase difference) scale in power analysis.

Syntax
```
:ANALysis<x1>:POWer<x2>:PSCale
{DEGRee|RADian}
:ANALysis<x1>:POWer<x2>:PSCale?
```
<x1> = 1 <x2> = 1 or 2

Example
```
:ANALYSIS1:POWER1:PSCALE RADIAN
:ANALYSIS1:POWER1:PSCALE?
-> :ANALYSIS1:POWER1:PSCALE RADIAN
```
Description This command is valid on models with the /G5 option.

:ANALysis<x1>:POWer<x2>:RTYPe

Function Sets or queries the RMS type of an analysis item in power analysis.

Syntax
```
:ANALysis<x1>:POWer<x2>:RTYPe
{TRMS|RMEan}
:ANALysis<x1>:POWer<x2>:RTYPe?
```
<x1> = 1 <x2> = 1 or 2
TRMS: True RMS (True RMS)
RMEan: Rectified mean value calibrated to the rms value (Rect. Mean)

Example
```
:ANALYSIS1:POWER1:RTYPE RMEAN
:ANALYSIS1:POWER1:RTYPE?
-> :ANALYSIS1:POWER1:RTYPE RMEAN
```
Description This command is valid on models with the /G5 option.

:ANALysis<x1>:POWer<x2>:SOURce:I1

Function Sets or queries source channel I1 in power analysis.

Syntax
```
:ANALysis<x1>:POWer<x2>:SOURce:
I1 <NRf>
:ANALysis<x1>:POWer<x2>:SOURce:I1?
```
<x1> = 1 <x2> = 1 or 2 <NRf> = 1 to 16

Example
```
:ANALYSIS1:POWER1:SOURCE:I1 2
:ANALYSIS1:POWER1:SOURCE:I1?
-> :ANALYSIS1:POWER1:SOURCE:I1 2
```
Description This command is valid on models with the /G5 option.

:ANALysis<x1>:POWer<x2>:SOURce:I2

Function Sets or queries source channel I2 in power analysis.

Syntax
```
:ANALysis<x1>:POWer<x2>:SOURce:
I2 <NRf>
:ANALysis<x1>:POWer<x2>:SOURce:I2?
```
<x1> = 1 <x2> = 1 or 2 <NRf> = 1 to 16

Example
```
:ANALYSIS1:POWER1:SOURCE:I2 2
:ANALYSIS1:POWER1:SOURCE:I2?
-> :ANALYSIS1:POWER1:SOURCE:I2 2
```
Description
- This command is invalid when the wiring system is 1P2W.
- This command is valid on models with the /G5 option.

:ANALysis<x1>:POWer<x2>:SOURce:I3

Function Sets or queries source channel I3 in power analysis.

Syntax
```
:ANALysis<x1>:POWer<x2>:SOURce:
I3 <NRf>
:ANALysis<x1>:POWer<x2>:SOURce:I3?
```
<x1> = 1 <x2> = 1 or 2 <NRf> = 1 to 16

Example
```
:ANALYSIS1:POWER1:SOURCE:I3 2
:ANALYSIS1:POWER1:SOURCE:I3?
-> :ANALYSIS1:POWER1:SOURCE:I3 2
```
Description
- This command is invalid when the wiring system is 1P2W, 1P3W, 3P3W, or 3P3W→3V3A.
- This command is valid on models with the /G5 option.

:ANALysis<x1>:POWer<x2>:SOURce:U1

Function Sets or queries source channel U1 in power analysis.

Syntax
```
:ANALysis<x1>:POWer<x2>:SOURce:
U1 <NRf>
:ANALysis<x1>:POWer<x2>:SOURce:U1?
```
<x1> = 1 <x2> = 1 or 2 <NRf> = 1 to 16

Example
```
:ANALYSIS1:POWER1:SOURCE:U1 1
:ANALYSIS1:POWER1:SOURCE:U1?
-> :ANALYSIS1:POWER1:SOURCE:U1 1
```
Description This command is valid on models with the /G5 option.

:ANALysis<x1>:POWer<x2>:SOURce:U2

Function Sets or queries source channel U2 in power analysis.

Syntax :ANALysis<x1>:POWer<x2>:SOURce:
U2 <NRf>
:ANALysis<x1>:POWer<x2>:SOURce:U2?
<x1> = 1 <x2> = 1 or 2 <NRf> = 1 to 16

Example :ANALYSIS1:POWER1:SOURCE:U2 1
:ANALYSIS1:POWER1:SOURCE:U2?
-> :ANALYSIS1:POWER1:SOURCE:U2 1

Description
- This command is invalid when the wiring system is 1P2W.
- This command is valid on models with the /G5 option.

:ANALysis<x1>:POWer<x2>:SOURce:U3

Function Sets or queries source channel U3 in power analysis.

Syntax :ANALysis<x1>:POWer<x2>:SOURce:
U3 <NRf>
:ANALysis<x1>:POWer<x2>:SOURce:U3?
<x1> = 1 <x2> = 1 or 2 <NRf> = 1 to 16

Example :ANALYSIS1:POWER1:SOURCE:U3 1
:ANALYSIS1:POWER1:SOURCE:U3?
-> :ANALYSIS1:POWER1:SOURCE:U3 1

Description
- This command is invalid when the wiring system is 1P2W, 1P3W, 3P3W, or 3P3W→3V3A.
- This command is valid on models with the /G5 option.

:ANALysis<x1>:POWer<x2>:TERM?

Function Queries all calculation period settings of power analysis (Wiring System1 or Wiring System2).

Syntax :ANALysis<x1>:POWer<x2>:TERM?
<x1> = 1
<x2> = 1 or 2
When <x2> = 1: Calculation period setting of Wiring System1
When <x2> = 2: Calculation period setting of Wiring System2

Description This command is valid on models with the /G5 option.

:ANALysis<x1>:POWer<x2>:TERM:ATIMer

Function Sets or queries the update time of the calculation period in power analysis.

Syntax :ANALysis<x1>:POWer<x2>:ATIMer
{<Time>}
:ANALysis<x1>:POWer<x2>:ATIMer?
<x1> = 1 <x2> = 1 or 2
<NRf> = 100ns to 500ms

Example :ANALYSIS1:POWER1:TERM:ATIMER 50e-3
:ANALYSIS1:POWER1:TERM:ATIMER?
-> :ANALYSIS1:POWER1:TERM:
ATIMER 50e-3

Description
- This command is valid when the calculation period type is set to Auto Timer or AC+DC.
- This command is valid on models with the /G5 option.

:ANALysis<x1>:POWer<x2>:TERM:ESFilter

Function Sets or queries the edge source filter for the calculation period in power analysis.

Syntax :ANALysis<x1>:POWer<x2>:TERM:
FILTer {OFF|<Frequency>}
:ANALysis<x1>:POWer<x2>:
TERM:ESFilter?
<x1> = 1 <x2> = 1 or 2
<Frequency > = 62.5Hz, 125Hz, 250Hz, 500Hz, 1kkHz, 2kHz,4kHz, 8kHz, 16kHz, 32kHz, 64kHz, 128kHz

Example :ANALYSIS1:POWER1:TERM:
ESFILTER 128kHz
:ANALYSIS1:POWER1:TERM:ESFILTER?
-> :ANALYSIS1:POWER1:TERM:
ESFILTER 128E+03

Description
- This command is invalid when the calculation period type is set to Auto Timer.
- This command is valid on models with the /G5 option.

:ANALysis<x1>:POWer<x2>:TERM:HYSTeresis

Function Sets or queries the hysteresis for the calculation period in power analysis.

Syntax :ANALysis<x1>:POWer<x2>:TERM:HYSTere
sis {HIGH|LOW|MIDDle}
:ANALysis<x1>:POWer<x2>:TERM:HYSTere
sis?
<x1> = 1 <x2> = 1 or 2

Example :ANALYSIS1:POWER1:TERM:
HYSTERESIS MIDDLE
:ANALYSIS1:POWER1:TERM:HYSTERESIS?
-> :ANALYSIS1:POWER1:TERM:
HYSTERESIS MIDDLE

Description
- This command is invalid when the calculation period type is set to Auto Timer.
- This command is valid on models with the /G5 option.

:ANALysis<x1>:POWer<x2>:TERM:ESOurce

Function Sets or queries the edge detection source channel for the calculation period in power analysis.

Syntax :ANALysis<x1>:POWer<x2>:TERM:
ESOurce {OWNU|OWNI|U1|U2|U3|I1|I2|I3
|OTHer}
:ANALysis<x1>:POWer<x2>:TERM:ESOur
ce?
<x1> = 1 <x2> = 1 or 2

Example :ANALYSIS1:POWER1:TERM:ESOURCE OWNU
:ANALYSIS1:POWER1:TERM:ESOURCE?
-> :ANALYSIS1:POWER1:TERM:
ESOURCE OWNU

Description
- This command is invalid when the calculation period type is set to Auto Timer.
- This command is valid on models with the /G5 option.

:ANALysis<x1>:POWer<x2>:TERM:STOPpredict

Function Sets or queries the stop prediction of the calculation period in power analysis.

Syntax
```
:ANALysis<x1>:POWer<x2>:TERM:STOPpredict <NRf>
:ANALysis<x1>:POWer<x2>:TERM:STOPpredict?
```
<x1> = 1 <x2> = 1 or 2
<NRf> = 2, 4, 8, 16

Example
```
:ANALYSIS1:POWER1:TERM:STOPPREDICT 8
:ANALYSIS1:POWER1:TERM:STOPPREDICT?
-> :ANALYSIS1:POWER1:TERM:STOPPREDICT 8
```

Description
- This command is valid when the calculation period type is set to AC or AC+DC.
- This command is valid on models with the /G5 option.

:ANALysis<x1>:POWer<x2>: TERM:TYPE

Function Sets or queries the calculation period type in power analysis.

Syntax
```
:ANALysis<x1>:POWer<x2>:TERM:TYPE {EDGE|ATIMer|AC|AC_DC}
:ANALysis<x1>:POWer<x2>:TERM:TYPE?
```
<x1> = 1 <x2> = 1 or 2

Example
```
:ANALYSIS1:POWER1:TERM:TYPE AC_DC
:ANALYSIS1:POWER1:TERM:TYPE?
-> :ANALYSIS1:POWER1:TERM:TYPE AC_DC
```

Description This command is valid on models with the /G5 option.

:ANALysis<x1>:POWer<x2>:TERM:OCHannel

Function Sets or queries the channel number when the edge detection source for the calculation period is set to Other Channel in power analysis.

Syntax
```
:ANALysis<x1>:POWer<x2>:TERM:OCHannel {<NRf>}
:ANALysis<x1>:POWer<x2>:TERM:OCHannel?
```
<x1> = 1 <x2> = 1 or 2
<NRf> = 1 to 16

Example
```
:ANALYSIS1:POWER1:TERM:OCHANNEL 1
:ANALYSIS1:POWER1:TERM:OCHANNEL?
-> :ANALYSIS1:POWER1:TERM:OCHANNEL  1
```

Description
- This command is invalid when the calculation period type is set to Auto Timer.
- This command is valid on models with the /G5 option.

:ANALysis<x1>:POWer<x2>:WIRing

Function Sets or queries the wiring system in power analysis.

Syntax
```
:ANALysis<x1>:POWer<x2>:WIRing {P1W2|P1W3|P3W3|V3A3|P3W4},{OFF| P3W3_V3A3|DT_ST|ST_DT}
:ANALysis<x1>:POWer<x2>:WIRing?
```
<x1> = 1 <x2> = 1 or 2
P1W2|P1W3|P3W3|V3A3|P3W4: wiring system selection
OFF|P3W3_V3A3|DT_ST|ST_DT: delta math selection

Example
```
:ANALysis1:POWer1:WIRing P3W3,OFF
:ANALysis1:POWer1:WIRing? ->
:ANALYSIS1:POWER1:WIRING P34W,ST_DT
```

Description
- Match the wiring system to the conversion source system of delta math.
- This command is valid on models with the /G5 option.

RMATh CHANnel Group

The commands in this group deal with real time math. You can perform the same operations and make the same settings and queries that you can make from the Filter/Delay Setup menu that you access by pressing a key from CH1 to CH16 on the front panel or by accessing the menus for channels RMATh1 to RMATh16.

:CHANnel<x>:RMATh:AMINus:SCALe

Function Sets or queries the scale of the specified channel's angle difference operation.

Syntax
```
:CHANnel<x>:RMATh:AMINus:
SCALe {DEGRee|RADian}
:CHANnel<x>:RMATh:AMINus:SCALe?
```
<x> = 1 to 16

Example
```
:CHANNEL1:RMATH:AMINUS:SCALE DEGREE
:CHANNEL1:RMATH:AMINUS:SCALE?
-> :CHANNEL1:RMATH:AMINUS:
   SCALE DEGREE
```

Description This command is valid on models with the /G3 or /G5 option.

:CHANnel<x1>:RMATh:ATANgent:SCALe

Function Sets or queries the scale of the specified channel's arc tangent operation.

Syntax
```
:CHANnel<x>:RMATh:ATANgent:
SCALe {DEGRee|RADian}
:CHANnel<x>:RMATh:ATANgent:SCALe?
```
<x1> = 1 to 16

Example
```
:CHANNEL1:RMATH:ATANGENT:
SCALE DEGREE
:CHANNEL1:RMATH:ATANGENT:SCALE?
-> :CHANNEL1:RMATH:ATANGENT:
   SCALE DEGREE
```

Description This command is valid on models with the /G3 or /G5 option.

:CHANnel<x>:RMATh:ATANgent:QUADrant

Function Sets or queries the quadrant range for the arctangent calculation of the specified channel.

Example
```
:CHANnel<x>:RMATh:ATANgent:
QUADrant {2|4}
:CHANnel<x>:RMATh:ATANgent:QUADrant?
```
<x> = 1 to 16

Example
```
:CHANNEL:RMATH:ATANGENT:QUADRANT 2
:CHANNEL:RMATH:ATANGENT:QUADRANT?
-> :CHANNEL:RMATH:ATANGENT:
   QUADRANT 2
```

Description This command is valid on models with the /G3 or /G5 option.

:CHANnel<x>:RMATh:AVALue

Function Sets or queries coefficient A of the currently specified real time math operation.

Syntax
```
:CHANnel<x>:RMATh:AVALue {<NRf>}
:CHANnel<x>:RMATh:AVALue?
```
<x> = 1 to 16
<NRf> = –9.9999E+30 to +9.9999E+30

Example
```
:CHANNEL1:RMATH:AVALUE +1.0000E+30
:CHANNEL1:RMATH:AVALUE?
-> :CHANNEL1:RMATH:AVALUE+ 1.0000E+30
```

Description This command is valid on models with the /G3 or /G5 option.

:CHANnel<x>:RMATh:BVALue

Function Sets or queries coefficient B of the currently specified real time math operation.

Syntax
```
:CHANnel<x>:RMATh:BVALue {<NRf>}
:CHANnel<x>:RMATh:BVALue?
```
<x> = 1 to 16
<NRf> = –9.9999E+30 to +9.9999E+30

Example
```
CHANNEL1:RMATH:BVALUE +1.0000E+30
CHANNEL1:RMATH:BVALUE?
-> CHANNEL1:RMATH:BVALUE +1.0000E+30
```

Description This command is valid on models with the /G3 or /G5 option.

:CHANnel<x>:RMATh:BWIDth:BAND

Function Sets or queries the band of the specified channel's digital filter.

Syntax
```
:CHANnel<x>:RMATh:BWIDth:
BAND {BPASs|HPASs|LPASs}
:CHANnel<x>:RMATh:BWIDth:BAND?
```
<x> = 1 to 16

Example
```
:CHANNEL1:RMATH:BWIDTH:BAND BPASS
:CHANNEL1:RMATH:BWIDTH:BAND?
-> :CHANNEL1:RMATH:BWIDTH:BAND BPASS
```

Description
- This command is valid on models with the /G3 or /G5 option.
- You cannot set this setting for the channels of an installed 16-CH voltage input module, 16-CH temperature/voltage input module, logic input module, CAN bus monitor module, CAN & LIN bus monitor module, or CAN/CAN FD monitor module.
- When the digital filter type is "GAUSs," you can only select LPASs.

:CHANnel<x>:RMATh:BWIDth:CFRequency

Function Sets or queries the center frequency of the bandpass filter of the specified channel's digital filter.

Syntax
```
:CHANnel<x>:RMATh:BWIDth:
CFRequency {<Frequency>}
:CHANnel<x>:RMATh:BWIDth:CFRequency?
```
<x> = 1 to 16
<Frequency>:
When TYPE is set to IIR
60Hz to 300kHz
Resolution 20Hz (60Hz to 1.18kHz)
200Hz (1.2kHz to 11.8kHz)
2kHz (12kHz to 294kHz)
When TYPE is set to SHARp
300Hz to 300kHz
Resolution 20Hz (300Hz to 2.98kHz)
200Hz (3kHz to 29.8kHz)
2kHz (30kHz to 290kHz)

Example
```
:CHANNEL1:RMATH:BWIDTH:
CFREQUENCY 300Hz
:CHANNEL1:RMATH:BWIDTH:
CFREQUENCY?
-> :CHANNEL1:RMATH:BWIDTH:
  CFREQUENCY 300Hz
```

Description
- This command is valid on models with the /G3 or /G5 option.
- You cannot set this setting for the channels of an installed 16-CH voltage input module, 16-CH temperature/voltage input module, logic input module, CAN bus monitor module, CAN & LIN bus monitor module, or CAN/CAN FD monitor module.

:CHANnel<x>:RMATh:BWIDth:CUToff

Function Sets or queries the cutoff frequency of the specified channel's digital filter.

Syntax
```
:CHANnel<x>:RMATh:BWIDth:
{CUToff|<Frequency>}
:CHANnel<x>:RMATh:BWIDth:CUToff?
```
<x> = 1 to 16
<Frequency>:
When TYPE is set to GAUSs or when TYPE is set to SHARp and BAND is set to LPASs
2Hz to 300kHz
Resolution 0.2Hz (2Hz to 29.8Hz)
2Hz (30Hz to 298Hz)
20Hz (300Hz to 2.98kHz)
200Hz (3kHz to 29.8kHz)
2kHz (30kHz to 300kHz)
When TYPE is set to SHARp and BAND is set to HPASs
200Hz to 300kHz
Resolution 20Hz (200Hz to 2.98kHz)
200Hz (3kHz to 29.8kHz)
2kHz (30kHz to 300kHz)
When TYPE is set to IIR and BAND is set to LPASs
2Hz to 300kHz
Resolution 2Hz (2Hz to 298Hz)
20Hz (300Hz to 2.98kHz)
200Hz (3kHz to 29.8kHz)
2kHz (30kHz to 300kHz)
When TYPE is set to IIR and BAND is set to HPASs
20Hz to 300kHz
Resolution 20Hz (20Hz to 2.98kHz)
200Hz (3kHz to 29.8kHz)
2kHz (30kHz to 300kHz)

Example
```
:CHANNEL1:RMATH:BWIDTH:CUTOFF 300kHz
:CHANNEL1:RMATH:BWIDTH:CUTOFF?
-> :CHANNEL1:RMATH:BWIDTH:
  CUTOFF 300kHz
```

Description
- This command is valid on models with the /G3 or /G5 option.
- You cannot set this setting for the channels of an installed 16-CH voltage input module, 16-CH temperature/voltage input module, logic input module, CAN bus monitor module, CAN & LIN bus monitor module, or CAN/CAN FD monitor module.
- When the digital filter type is "GAUSs," you can only select LPASs.

:CHANnel<x>:RMATh:BWIDth:INTerpo

Function Sets or queries the interpolation function of the specified channel's digital filter.

Syntax :CHANnel<x>:RMATh:BWIDth:INTerpo {<Boolean>}
:CHANnel<x>:RMATh:BWIDth:INTerpo?
<x> = 1 to 16

Example :CHANNEL1:RMATH:BWIDTH:INTERPO 1
:CHANNEL1:RMATH:BWIDTH:INTERPO?
-> :CHANNEL1:RMATH:BWIDTH:INTERPO 1

Description
- This command is valid on models with the /G3 or /G5 option.
- You cannot set this setting for the channels of an installed 16-CH voltage input module, 16-CH temperature/voltage input module, logic input module, CAN bus monitor module, CAN & LIN bus monitor module, or CAN/CAN FD monitor module.

:CHANnel<x>:RMATh:BWIDth:MEAN?

Function Queries all mean settings of the specified channel's digital filter.

Syntax :CHANnel<x>:RMATh:BWIDth:MEAN?

Description This command is valid on models with the /G3 or /G5 option.

:CHANnel<x>:RMATh:BWIDth:MEAN:SAMPle (Base Sample)

Function Sets or queries the sample of the mean of the specified channel's digital filter.

Syntax :CHANnel<x>:RMATh:BWIDth:MEAN:SAMPle <Frequency>
:CHANnel<x>:RMATh:BWIDth:MEAN:SAMPle?
<x> = 1 to 16
<Frequency>: 1MHz, 100kHz, 10kHz, 1kHz

Example :CHANNEL1:RMATH:BWIDTH:MEAN:SAMPLE 1MHz
:CHANNEL1:RMATH:BWIDTH:MEAN:SAMPLE?
-> :CHANNEL1:RMATH:BWIDTH:MEAN:SAMPLE 1MHz

Description
- This command is valid on models with the /G3 or /G5 option.
- You cannot set this setting for the channels of an installed 16-CH Voltage input module, 16-CH temperature/voltage input module, logic input module, CAN bus monitor module, CAN & LIN bus monitor module, or CAN/CAN FD monitor module.

:CHANnel<x>:RMATh:BWIDth:MEAN:TAP

Function Sets or queries the taps of the mean of the specified channel's digital filter.

Syntax :CHANnel<x>:RMATh:BWIDth:MEAN:TAP {<NRf>}
:CHANnel<x>:RMATh:BWIDth:MEAN:TAP?
<x> = 1 to 16
<NRf> = 2, 4, 8, 16, 32, 64, 128

Example :CHANNEL1:RMATH:BWIDTH:MEAN:TAP 4
:CHANNEL1:RMATH:BWIDTH:MEAN:TAP?
-> :CHANNEL1:RMATH:BWIDTH:MEAN:TAP 4

Description
- This command is valid on models with the /G3 or /G5 option.
- You cannot set this setting for the channels of an installed 16-CH voltage input module, 16-CH temperature/voltage input module, logic input module, CAN bus monitor module, CAN & LIN bus monitor module, or CAN/CAN FD monitor module.

:CHANnel<x>:RMATh:BWIDth:MODE

Function Sets or queries the filter mode of the specified channel.

Syntax :CHANnel<x>:RMATh:BWIDth:MODE {LPF|DIGital}
:CHANnel<x>:RMATh:BWIDth:MODE?
<x> = 1 to 16

Example :CHANNEL1:RMATH:BWIDTH:MODE LPF
:CHANNEL1:RMATH:BWIDTH:MODE
-> :CHANNEL1:RMATH:BWIDTH:MODE LPF

Description
- This command is valid on models with the /G3 or /G5 option.
- You cannot set this setting for the channels of an installed 16-CH voltage input module, 16-CH temperature/voltage input module, logic input module, CAN bus monitor module, CAN & LIN bus monitor module, or CAN/CAN FD monitor module.

:CHANnel<x>:RMATh:BWIDth:PBANd (Pass Band)

Function Sets or queries the bandwidth of the bandpass filter of the specified channel’s digital filter.

Syntax
```
:CHANnel<x>:RMATh:BWIDth:
PBANd {<Frequency>}
:CHANnel<x>:RMATh:BWIDth:PBANd?
```
<x> = 1 to 16
<Frequency>:
When TYPE is set to IIR
200kHz, 150kHz, 100kHz, 50kHz, 20kHz, 15kHz, 10kHz, 5kHz, 2kHz, 1.5kHz, 1kHz, 500Hz, 200Hz, 100Hz
When TYPE is set to SHARp
200kHz, 150kHz, 100kHz, 50kHz, 20kHz, 15kHz, 10kHz, 5kHz, 2kHz, 1.5kHz, 1kHz, 500Hz, 200Hz

Example
```
:CHANNEL1:RMATH:BWIDTH:PBAND 200Hz
:CHANNEL1:RMATH:BWIDTH:PBAND?
-> :CHANNEL1:RMATH:BWIDTH:
   PBAND 200Hz
```

Description
- This command is valid on models with the /G3 or /G5 option.
- You cannot set this setting for the channels of an installed 16-CH voltage input module, 16-CH temperature/voltage input module, logic input module, CAN bus monitor module, CAN & LIN bus monitor module, or CAN/CAN FD monitor module.
- When the center frequency is changed, if the frequency approaches the bandwidth limit, the bandwidth is changed.

:CHANnel<x>:RMATh:BWIDth:TYPE

Function Sets or queries the digital filter type of the specified channel.

Syntax
```
:CHANnel<x>:RMATh:BWIDth:
TYPE {GAUSs|IIR|SHARp|MEAN}
:CHANnel<x>:RMATh:BWIDth:TYPE?
```
<x> = 1 to 16

Example
```
:CHANNEL1:RMATH:BWIDTH:TYPE IIR
:CHANNEL1:RMATH:BWIDTH:TYPE?
-> :CHANNEL1:RMATH:BWIDTH:TYPE IIR
```

Description
- This command is valid on models with the /G3 or /G5 option.
- You cannot set this setting for the channels of an installed 16-CH voltage input module, 16-CH temperature/voltage input module, logic input module, CAN bus monitor module, CAN & LIN bus monitor module, or CAN/CAN FD monitor module.

:CHANnel<x>:RMATh:CANId:BRATe (Bit Rate)

Function Sets or queries the CAN ID bit rate of the specified channel.

Syntax
```
:CHANnel<x>:RMATh:CANId:
BRATe {<NRf>}
:CHANnel<x>:RMATh:CANId:BRATe?
```
<x> = 1 to 16
<NRf> = 10000, 20000, 33300, 50000, 62500, 66700, 83300, 100000, 125000, 200000, 250000, 400000, 500000, 800000, 1000000

Example
```
:CHANNEL:RMATH:CANID:BRATE 500000
:CHANNEL:RMATH:CANID:BRATE?
-> :CHANNEL:RMATH:CANID:BRATE 500000
```

Description This command is valid on models with the /G3 or /G5 option.

:CHANnel<x>:RMATh:CANId:MFORmat (Message Format)

Function Sets or queries the CAN ID message format of the specified channel.

Syntax
```
:CHANnel<x>:RMATh:CANId:
MFORmat {STANDard|EXTended}
:CHANnel<x>:RMATh: CANId:MFORmat?
```
<x> = 1 to 16

Example
```
:CHANNEL:RMATH:CANID:MFORMAT STANDARD
:CHANNEL:RMATH:CANID:MFORMAT?
-> :CHANNEL:RMATH:CANID:
   MFORMAT STANDARD
```

Description This command is valid on models with the /G3 or /G5 option.

:CHANnel<x>:RMATh:CANId:MID (Message ID)

Function Sets or queries the CAN ID message ID of the specified channel.

Syntax
```
:CHANnel<x>:RMATh:CANId:
MID {<String>}
:CHANnel<x>:RMATh:CANId:MID?
```
<x> = 1 to 16
- When MFormat is set to Standard
  <String> = “0” to “7FF”
- When MFormat is set to Extended
  <String> = “0” to “1FFFFFFF”

Example
```
:CHANNEL:RMATH:CANID:MID "7FF"
:CHANNEL:RMATH:CANID:MID?
-> :CHANNEL:RMATH:CANID:MID "7FF"
```

Description This command is valid on models with the /G3 or /G5 option.

:CHANnel<x>:RMATh:CANId:SOURce

Function Sets or queries the CAN ID detection source waveform of the specified channel.

Syntax
```
:CHANnel<x>:RMATh:CANId:
SOURce {<NRf>}
:CHANnel<x>:RMATh:CANId:SOURce?
```
<x> = 1 to 16
<NRf> = 1 to 16

Example
```
:CHANNEL:RMATH:CANID:SOURCE 1
:CHANNEL:RMATH:CANID:SOURCE?
-> :CHANNEL:RMATH:CANID:SOURCE 1
```

Description This command is valid on models with the /G3 or /G5 option.

:CHANnel<x>:RMATh:CVALue

Function Sets or queries coefficient C of the currently specified real time math operation.

Syntax `:CHANnel<x>:RMATh:CVALue {<NRf>}`
`:CHANnel<x>:RMATh:CVALue?`
<x> = 1 to 16
<NRf> = –9.9999E+30 to +9.9999E+30

Example `CHANNEL1:RMATH:CVALUE +1.0000E+30`
`CHANNEL1:RMATH:CVALUE?`
`-> CHANNEL1:RMATH:CVALUE +1.0000E+30`

Description This command is valid on models with the /G3 or /G5 option.

:CHANnel<x>:RMATh:DA?

Function Queries all logic signal to analog waveform conversion settings.

Syntax `:CHANnel<x>:RMATh:DA?`

Description
- This command is valid on models with the /G3 or /G5 option.
- An execution error will occur if you specify a channel other than that of a logic input module.

:CHANnel<x>:RMATh:DA:BLENgth (Bit Length)

Function Sets or queries the logic signal to analog waveform conversion bit length.

Syntax `:CHANnel<x>:RMATh:DA:BLENgth {<NRf>}`
`:CHANnel<x>:RMATh:DA:BLENgth?`
<x> = 2 to 16
<NRf> = 1 to 16

Example `:CHANNEL1:RMATH:DA:BLENGTH 16`
`:CHANNEL1:RMATH:DA:BLENGTH?`
`-> :CHANNEL1:RMATH:DA:BLENGTH 16`

Description
- This command is valid on models with the /G3 or /G5 option.
- An execution error will occur if you specify a channel other than that of a logic input module.

:CHANnel<x1>:RMATh:DA:SOURce<x2>

Function Sets or queries the math source waveform that you want to convert into an analog waveform.

Syntax `:CHANnel<x>:RMATh:DA:SOURce<x2> {<NRf>}`
`:CHANnel<x>:RMATh:DA:SOURce<x2>?`
<x1> = 1 to 16
<x2> = 1, 2

Example `:CHANNEL1:RMATH:DA:SOURCE1 1`
`:CHANNEL1:RMATH:DA:SOURCE1?`
`-> :CHANNEL1:RMATH:DA:SOURCE1 1`

Description
- This command is valid on models with the /G3 or /G5 option.
- You cannot select logic channels of an installed CAN bus monitor module, CAN & LIN bus monitor module, or CAN/CAN FD monitor module.
- An execution error will occur if you specify a channel other than that of a logic input module.

:CHANnel<x>:RMATh:DA:TYPE

Function Sets or queries the logic signal to analog waveform conversion method (type).

Syntax `:CHANnel<x>:RMATh:DA:TYPE {OBINary|SIGNed|UNSigned}`
`:CHANnel<x>:RMATh:DA:TYPE?`
<x> = 1 to 16

Example `:CHANNEL1:RMATH:DA:TYPE OBINARY`
`:CHANNEL1:RMATH:DA:TYPE?`
`-> :CHANNEL1:RMATH:DA:TYPE OBINARY`

Description
- This command is valid on models with the /G3 or /G5 option.
- An execution error will occur if you specify a channel other than that of a logic input module.

:CHANnel<x>:RMATh:DELay

Function Sets or queries the delay of the specified channel.

Syntax `:CHANnel<x>:RMATh:DELay {<Time>}`
`:CHANnel<x>:RMATh:DELay?`
<x> = 1 to 16
<NRf> = 0 s, 0.1 us to 10 ms
Resolution 0.1us to 100.0us: 0.1us
101us to 1ms: 1us
1.01ms to 10ms: 10us

Example `:CHANNEL1:RMATH:DELAY 0`
`:CHANNEL1:RMATH:DELAY?`
`-> :CHANNEL1:RMATH:DELAY 0`

Description
- This command is valid on models with the /G3 or /G5 option.
- You cannot set this setting for the channels of an installed 16-CH voltage input module, 16-CH temperature/voltage input module, logic input module, CAN bus monitor module, CAN & LIN bus monitor module, or CAN/CAN FD monitor module.

:CHANnel<x>:RMATh:DVALue

Function Sets or queries coefficient D of the currently specified real time math operation.

Syntax `:CHANnel<x>:RMATh:DVALue {<NRf>}`
`:CHANnel<x>:RMATh:DVALue?`
<x> = 1 to 16
<NRf> = –9.9999E+30 to +9.9999E+30

Example `CHANNEL1:RMATH:DVALUE +1.0000E+30`
`CHANNEL1:RMATH:DVALUE?`
`-> CHANNEL1:RMATH:DVALUE +1.0000E+30`

Description This command is valid on models with the /G3 or /G5 option.

:CHANnel<x>:RMATh:ECOunt? (Edge Count)

Function Queries all reset condition settings for the specified channel’s edge count operation.

Syntax `:CHANnel<x>:RMATh:ECOunt?`

Description This command is valid on models with the /G3 or /G5 option.

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:CHANnel<x>:RMATh:ECOunt:MRESet:EXECute (Manual Reset)

Function Resets the counter of the specified channel's edge count operation.

Syntax :CHANnel<x>:RMATh:ECOunt:MRESet:EXECute

Example :CHANNEL1:RMATH:ECOUNT:MRESET:EXECUTE

Description This command is valid on models with the /G3 or /G5 option.

:CHANnel<x>:RMATh:ECOunt:OVERange

Function Sets or queries whether the edge count is reset when an over limit occurs for the specified channel's edge count operation.

Syntax :CHANnel<x>:RMATh:ECOunt:OVERange {<Boolean>}
:CHANnel<x>:RMATh:ECOunt:OVERange?
<x> = 1 to 16

Example :CHANNEL1:RMATH:ECOUNT:OVERANGE 1
:CHANNEL1:RMATH:ECOUNT:OVERANGE?
-> :CHANNEL1:RMATH:ECOUNT:OVERANGE 1

Description This command is valid on models with the /G3 or /G5 option.

:CHANnel<x>:RMATh:ECOunt:SRESet (Start Reset)

Function Sets or queries whether the edge count is reset when the edge count operation starts for the specified channel.

Syntax :CHANnel<x>:RMATh:ECOunt:SRESet {<Boolean>}
:CHANnel<x>:RMATh:ECOunt:SRESet?
<x> = 1 to 16

Example :CHANNEL1:RMATH:ECOUNT:SRESET 1
:CHANNEL1:RMATH:ECOUNT:SRESET?
-> :CHANNEL1:RMATH:ECOUNT:SRESET 1

Description This command is valid on models with the /G3 or /G5 option.

:CHANnel<x>:RMATh:EVALue

Function Sets or queries coefficient E of the currently specified real time math operation.

Syntax :CHANnel<x>:RMATh:EVALue {<NRf>}
:CHANnel<x>:RMATh:EVALue?
<x> = 1 to 16
<NRf> = –9.9999E+30 to +9.9999E+30

Example CHANNEL1:RMATH:EVALUE +1.0000E+30
CHANNEL1:RMATH:EVALUE?
-> CHANNEL1:RMATH:EVALUE +1.0000E+30

Description This command is valid on models with the /G3 or /G5 option.

:CHANnel<x>:RMATh:FREQ?

Function Queries all the settings for the specified channel's frequency, period, torque, and edge count (excluding reset) operations.

Syntax :CHANnel<x>:RMATh:FREQ?

Description
- This command is valid on models with the /G3 or /G5 option.
- To set the math settings for the frequency, period, torque, and edge count (excluding reset) operations, use the :CHANnel<x>:RMATh:FREQ command and the commands that are lower in its hierarchy. Before you set any of the settings, use the :CHANnel<x>:RMATh:OPERation command to set the operation type to FREQuency, PERiod, or ECOunt. For details on the commands that have different settings for the various operations, see the conditions that are written in the command descriptions.

:CHANnel<x>:RMATh:FREQ:BIT

Function Sets or queries the math source waveform (the source bit) for the specified channel's frequency, period, torque, and edge count operations (when the source is a logic channel).

Syntax :CHANnel<x>:RMATh:FREQ:BIT {<NRf>}
:CHANnel<x>:RMATh:FREQ:BIT?
<x> = 1 to 16
<NRf> = 1 to 8

Example :CHANNEL1:RMATH:FREQ:BIT 1
:CHANNEL1:RMATH:FREQ:BIT?
-> :CHANNEL1:RMATH:FREQ:BIT 1

Description This command is valid on models with the /G3 or /G5 option.

:CHANnel<x>:RMATh:FREQ:DECeleration

Function Sets or queries whether frequency, period, and torque, computation's deceleration prediction is turned on.

Syntax :CHANnel<x>:RMATh:FREQ:DECeleration {<Boolean>}
:CHANnel<x>:RMATh:FREQ:DECeleration?
<x> = 1 to 16

Example :CHANNEL1:RMATH:FREQ:DECELERATION ON
:CHANNEL1:RMATH:FREQ:DECELERATION? ->
:CHANNEL1:RMATH:FREQ:DECELERATION ON

Description This command is valid on models with the /G3 or /G5 option.

:CHANnel<x>:RMATh:FREQ:HYSTeresis

Function Sets or queries the detection hysteresis for the specified channel's frequency, period, torque, and edge count operations.

Syntax :CHANnel<x>:RMATh:FREQ:HYSTeresis {HIGH|LOW|MIDDLE}
:CHANnel<x>:RMATh:FREQ:HYSTeresis?
<x> = 1 to 16

Example :CHANNEL1:RMATH:FREQ:HYSTERESIS HIGH
:CHANNEL1:RMATH:FREQ:HYSTERESIS?
-> :CHANNEL1:RMATH:FREQ:HYSTERESIS HIGH

Description This command is valid on models with the /G3 or /G5 option.

:CHANnel<x>:RMATh:FREQ:LEVel

Function Sets or queries the detection level for the specified channel's frequency, period, torque, and edge count operations.

Syntax :CHANnel<x>:RMATh:FREQ:LEVel {<Voltage>|<NRf>|<Current>}
:CHANnel<x>:RMATh:FREQ:LEVel?
<x> = 1 to 16

Example :CHANNEL1:RMATH:FREQ:LEVEL 1
:CHANNEL1:RMATH:FREQ:LEVEL?
-> :CHANNEL1:RMATH:FREQ:LEVEL 1.000000E+00

Description This command is valid on models with the /G3 or /G5 option.

:CHANnel<x>:RMATh:FREQ:OFFSet

Function Sets or queries the frequency/period calculation offset.

Syntax :CHANnel<x>:RMATh:FREQ:OFFSet {<NRf>}
:CHANnel<x>:RMATh:FREQ:OFFSet?
<x> = 1 to 16
<NRf> = –9.9999E+30 to +9.9999E+30

Description This command is valid on models with the /G3 or /G5 option.

:CHANnel<x>:RMATh:FREQ:PROTate (Pulse per Rotate)

Function Sets or queries the number of pulses per rotation for the specified channel's frequency operation.

Syntax :CHANnel<x>:RMATh:FREQ:PROTate {<NRf>}
:CHANnel<x>:RMATh:FREQ:PROTate?

Example :CHANNEL1:RMATH:FREQ:PROTATE 180
:CHANNEL1:RMATH:FREQ:PROTATE?
-> :CHANNEL1:RMATH:FREQ:PROTATE 180

:CHANnel<x>:RMATh:FREQ:SCALe

Function Sets or queries the scale of the specified channel's frequency operation.

Syntax :CHANnel<x>:RMATh:FREQ:SCALe {HZ|RPM}
:CHANnel<x>:RMATh:FREQ:SCALe?
<x> = 1 to 16

Example :CHANNEL1:RMATH:FREQ:SCALE HZ
:CHANNEL1:RMATH:FREQ:SCALE?
-> :CHANNEL1:RMATH:FREQ:SCALE HZ

Description This command is valid on models with the /G3 or /G5 option.

:CHANnel<x>:RMATh:FREQ:SLOPe

Function Sets or queries the detection slope for the specified channel's frequency, period, torque, and edge count operations.

Syntax :CHANnel<x>:RMATh:FREQ:SLOPe {RISE|FALL}
:CHANnel<x>:RMATh:FREQ:SLOPe?
<x> = 1 to 16

Example :CHANNEL1:RMATH:FREQ:SLOPE RISE
:CHANNEL1:RMATH:FREQ:SLOPE?
-> :CHANNEL1:RMATH:FREQ:SLOPE RISE

Description This command is valid on models with the /G3 or /G5 option.

:CHANnel<x>:RMATh:FREQ:SOURce

Function Sets or queries the math source waveform for the specified channel's frequency, period, torque, and edge count operations.

Syntax :CHANnel<x>:RMATh:FREQ:SOURce {<NRf>[,<NRf>]}
:CHANnel<x>:RMATh:FREQ:SOURce?
<x> = 1 to 16

Example :CHANNEL1:RMATH:FREQ:SOURCE 1
:CHANNEL1:RMATH:FREQ:SOURCE?
-> :CHANNEL1:RMATH:FREQ:SOURCE 1

Description This command is valid on models with the /G3 or /G5 option.

:CHANnel<x>:RMATh:FREQ:STOPpredict

Function Sets or queries whether frequency, torque, and period computation's stop prediction is turned on.

Syntax :CHANnel<x>:RMATh:FREQ:STOPpredict {<NRf>|OFF}
:CHANnel<x>:RMATh:FREQ:STOPpredict?
<x>=1 to 16
<NRf> = 2, 4, 8, 16

Example :CHANNEL1:RMATH:FREQ:STOPPREDICT OFF
:CHANNEL1:RMATH:FREQ:STOPPREDICT?
-> :CHANNEL1:RMATH:FREQ:STOPPREDICT OFF

Description This command is valid on models with the /G3 or /G5 option.

:CHANnel<x1>:RMATh:IFILter?

Function Queries all IIR filter operation settings.

Syntax `:CHANnel<x1>:RMATh:IFILter?`
<x1> = 1 to 16

Description This command is valid on models with the /G3 or /G5 option.

:CHANnel<x1>:RMATh:IFILter:BAND

Function Sets or queries the band of the IIR filter operation.

Syntax `:CHANnel<x1>:RMATh:IFILter:BAND {BPASs|HPASs|LPASs}`
<x1> = 1 to 16

Example
```
:CHANNEL1:RMATH:IFILTER:BAND BPASS
:CHANNEL1:RMATH:IFILTER:BAND?
-> :CHANNEL1:RMATH:IFILTER:
   BAND BPASS
```

Description This command is valid on models with the /G3 or /G5 option.

:CHANnel<x1>:RMATh:IFILter:CUToff

Function Sets or queries the cutoff frequency of the IIR filter operation.

Syntax `:CHANnel<x1>:RMATh:IFILter:CUToff {<Frequency>}`
<x1> = 1 to 16
<Frequency>:
When BAND is set to LPASs
Range: 0.2 Hz to 3 MHz
Resolution:
0.2 Hz (0.2 Hz to 29.8 Hz)
2 Hz (30 Hz to 298 Hz)
20 Hz (300 Hz to 2.98 kHz)
200 Hz (3 kHz to 29.8 kHz)
2 kHz (30 kHz to 298 kHz)
20 kHz (300 kHz to 3 MHz)
When BAND is set to HPASs
Range: 20 Hz to 3 MHz
Resolution:
20 Hz (20 Hz to 2.98 kHz)
200 Hz (3 kHz to 29.8 kHz)
2 kHz (30 kHz to 298 kHz)
20 kHz (300 kHz to 3 MHz)

Example
```
:CHANNEL1:RMATH:IFILTER:CUTOFF 100Hz
:CHANNEL1:RMATH:IFILTER:CUTOFF?
-> :CHANNEL1:RMATH:IFILTER:
   CUTOFF 100Hz
```

Description This command is valid on models with the /G3 or /G5 option.

:CHANnel<x1>:RMATh:IFILter:CFRequency

Function Sets or queries the center frequency of the bandpass filter of the IIR filter operation.

Syntax `:CHANnel<x1>:RMATh:IFILter:CFRequency {<Frequency>}`
<x1> = 1 to 16
<Frequency>:
Range: 60 Hz to 3 MHz
Resolution:
20 Hz (60 Hz to 1.18 kHz)
200 Hz (1.2 kHz to 11.8 kHz)
2 kHz (12 kHz to 118 kHz)
20 kHz (120 kHz to 3 MHz)

Example
```
:CHANNEL1:RMATH:IFILTER:
CFREQUENCY 100Hz
:CHANNEL1:RMATH:IFILTER:CFREQUENCY?
-> :CHANNEL1:RMATH:IFILTER:
   CFREQUENCY 100Hz
```

Description This command is valid on models with the /G3 or /G5 option.

:CHANnel<x1>:RMATh:IFILter:PBANd

Function Sets or queries the bandwidth of the bandpass filter of the IIR filter operation.

Syntax `:CHANnel<x1>:RMATh:IFILter:PBANd {<Frequency>}`
<x1> = 1 to 16
<Frequency> = 2 MHz, 1.5 MHz, 1 MHz, 500 kHz, 200 kHz, 150 kHz, 100 kHz, 50 kHz, 20 kHz, 15 kHz, 10 kHz, 5 kHz, 2 kHz, 1.5 kHz, 1 kHz, 500 Hz, 200 Hz, 100 Hz

Example
```
:CHANNEL1:RMATH:IFILTER:PBAND 100Hz
:CHANNEL1:RMATH:IFILTER:PBAND?
-> :CHANNEL1:RMATH:IFILTER:
   PBAND 100Hz
```

Description This command is valid on models with the /G3 or /G5 option.

:CHANnel<x1>:RMATh:IFILter:INTerpo

Function Sets or queries whether interpolation is used with the IIR filter operation.

Syntax `:CHANnel<x1>:RMATh:IFILter:INTerpo {<Boolean>}`
<x1> = 1 to 16

Example
```
:CHANNEL1:RMATH:IFILTER:INTERPO ON
:CHANNEL1:RMATH:IFILTER:INTERPO?
-> :CHANNEL1:RMATH:IFILTER:
   INTERPO ON
```

Description This command is valid on models with the /G3 or /G5 option.

:CHANnel<x>:RMATh:INTegral?

Function Queries all integration settings of the specified channel.

Syntax :CHANnel<x>:RMATh:INTegral?
<x> = 1 to 16

Description This command is valid on models with the /G3 or /G5 option.

:CHANnel<x>:RMATh:INTegral:MRESet:EXECute (Manual Reset)

Function Resets the integrated value of the specified channel.

Syntax :CHANnel<x>:RMATh:INTegral:MRESet:EXECute

Example :CHANNEL1:RMATH:INTEGRAL:MRESET:EXECUTE

Description This command is valid on models with the /G3 or /G5 option.

:CHANnel<x>:RMATh:INTegral:OVERange

Function Sets or queries whether the integrated value is reset when an over limit occurs for the specified channel.

Syntax :CHANnel<x>:RMATh:INTegral:OVERange {<Boolean>}
:CHANnel<x>:RMATh:INTegral:OVERange?
<x> = 1 to 16

Example :CHANNEL1:RMATH:INTEGRAL:OVERRANGE 1
:CHANNEL1:RMATH:INTEGRAL:OVERRANGE?
-> :CHANNEL1:RMATH:INTEGRAL:OVERRANGE 1

Description This command is valid on models with the /G3 or /G5 option.

:CHANnel<x>:RMATh:INTegral:SRESet (Start Reset)

Function Sets or queries whether the integrated value is reset when integration starts for the specified channel.

Syntax :CHANnel<x>:RMATh:INTegral:SRESet {<Boolean>}
:CHANnel<x>:RMATh:INTegral:SRESet?
<x> = 1 to 16

Example :CHANNEL1:RMATH:INTEGRAL:SRESET 1
:CHANNEL1:RMATH:INTEGRAL:SRESET?
-> :CHANNEL1:RMATH:INTEGRAL:SRESET 1

Description This command is valid on models with the /G3 or /G5 option.

:CHANnel<x>:RMATh:INTegral:ZRESet?

Function Queries all settings related to the integrated value being reset when the signal crosses zero in integration of the specified channel.

Syntax :CHANnel<x>:RMATh:INTegral:ZRESet?

Description This command is valid on models with the /G3 or /G5 option.

:CHANnel<x>:RMATh:INTegral:ZRESet:HYSTeresis

Function Sets or queries the hysteresis that is used for resetting the integrated value when the signal crosses zero for the specified channel.

Syntax :CHANnel<x>:RMATh:INTegral:ZRESet:HYSTeresis {LOW|HIGH|MIDDle}
:CHANnel<x>:RMATh:INTegral:ZRESet:HYSTeresis?
<x> = 1 to 16

Example :CHANNEL1:RMATH:INTEGRAL:ZRESET LOW
:CHANNEL1:RMATH:INTEGRAL:ZRESET?
-> :CHANNEL1:RMATH:INTEGRAL:ZRESET LOW

Description This command is valid on models with the /G3 or /G5 option.

:CHANnel<x>:RMATh:INTegral:ZRESet:MODE

Function Sets or queries whether the integrated value is reset when the signal crosses zero for the specified channel.

Syntax :CHANnel<x>:RMATh:INTegral:ZRESet:MODE {<Boolean>}
:CHANnel<x>:RMATh:INTegral:ZRESet:MODE?
<x> = 1 to 16

Example :CHANNEL1:RMATH:INTEGRAL:ZRESET:MODE 1
:CHANNEL1:RMATH:INTEGRAL:ZRESET:MODE?
-> :CHANNEL1:RMATH:INTEGRAL:ZRESET:MODE 1

Description This command is valid on models with the /G3 or /G5 option.

:CHANnel<x>:RMATh:INTegral:ZRESet:SLOPe

Function Sets or queries the slope that is used for resetting the integrated value when the signal crosses zero for the specified channel.

Syntax :CHANnel<x>:RMATh:INTegral:ZRESet:SLOPe {FALL|RISE}
:CHANnel<x>:RMATh:INTegral:ZRESet:SLOPe?
<x> = 1 to 16

Example :CHANNEL1:RMATH:INTEGRAL:ZRESET:SLOPE FALL
:CHANNEL1:RMATH:INTEGRAL:ZRESET:SLOPE?
-> :CHANNEL1:RMATH:INTEGRAL:ZRESET:SLOPE FALL

Description This command is valid on models with the /G3 or /G5 option.

:CHANnel<x>:RMATh:KNOCkflt?

Function Queries all knocking filter settings of the specified channel.

Syntax `:CHANnel<x>:RMATh:KNOCkflt?`

Description This command is valid on DL850EVs with the /G3 or /G5 option.

:CHANnel<x>:RMATh:KNOCkflt:DIFFerential

Function Sets or queries the differentiation on/off status of the specified channel's knocking filter.

Syntax
```
:CHANnel<x>:RMATh:KNOCkflt:DIFFerential {<Boolean>}
:CHANnel<x>:RMATh:KNOCkflt:DIFFerential?
```
<x> = 1 to 16

Example
```
:CHANNEL1:RMATH:KNOCKFLT:DIFFERENTIAL 1
:CHANNEL1:RMATH:KNOCKFLT:DIFFERENTIAL?
-> :CHANNEL1:RMATH:KNOCKFLT:
   DIFFERENTIAL 1
```

Description This command is valid on DL850EVs with the /G3 or /G5 option.

:CHANnel<x>:RMATh:KNOCkflt:ELEVel

Function Sets or queries the elimination level of the specified channel's knocking filter.

Syntax
```
:CHANnel<x>:RMATh:KNOCkflt:ELEVel {<Voltage>|<Current>|<NRf>}
:CHANnel<x>:RMATh:KNOCkfltinaiton:ELEVel?
```
<x> = 1 to 16

Example
```
:CHANNEL1:RMATH:KNOCKFLT:ELEVEL 1
:CHANNEL1:RMATH:KNOCKFLT:ELEVEL?
-> :CHANNEL1:RMATH:KNOCKFLT:
   ELEVEL 1.000000E+00
```

Description This command is valid on DL850EVs with the /G3 or /G5 option.

:CHANnel<x>:RMATh:LABel

Function Sets or queries the label of the specified RMath channel (the specified channel when real time math is turned on).

Syntax
```
:CHANnel<x>:RMATh:LABel {<String>}
```
<x> = 1 to 16
<String> = Up to 16 characters

Example
```
:CHANNEL1:RMATH:LABEL "TRACE3"
:CHANNEL1:RMATH:LABEL?
-> :CHANNEL1:RMATH:LABEL "TRACE3"
```

Description This command is valid on models with the /G3 or /G5 option.

:CHANnel<x>:RMATh:MAVG (Moving Average)

Function Sets or queries the on/off status of the mean of the specified RMath channel (the specified channel when real time math is turned on).

Syntax
```
:CHANnel<x>:RMATh:MAVG {<Boolean>}
```
<x> = 1 to 16

Example
```
:CHANNEL1:RMATH:MAVG 1
:CHANNEL1:RMATH:MAVG?
-> :CHANNEL1:RMATH:MAVG 1
```

Description This command is valid on models with the /G3 or /G5 option.

:CHANnel<x>:RMATh:MODE

Function Sets or queries the real time math on/off status of the specified channel.

Syntax
```
:CHANnel<x>:RMATh:MODE {<Boolean>}
:CHANnel<x>:RMATh:MODE?
```
<x> = 1 to 16

Example
```
:CHANNEL1:RMATH:MODE 1
:CHANNEL1:RMATH:MODE?
-> :CHANNEL1:RMATH:MODE 1
```

Description
- This command is valid on models with the /G3 or /G5 option.
- You cannot set this setting to ON for the channels of an installed 16-CH voltage input module, 16-CH temperature/voltage input module, CAN bus monitor module, CAN & LIN bus monitor module, or CAN/CAN FD monitor module.

:CHANnel<x>:RMATh:OFFSet

Function Sets or queries the offset of the specified RMath channel (the specified channel when real time math is turned on).

Syntax
```
:CHANnel<x>:RMATh:OFFSet {<NRf>}
```
<x> = 1 to 16

Example
```
:CHANNEL1:RMATH:OFFSET 1
:CHANNEL1:RMATH:OFFSET?
-> :CHANNEL1:RMATH:OFFSET 1
```

Description This command is valid on models with the /G3 or /G5 option.

:CHANnel<x>:RMATh:OPERation

Function Sets or queries the operation of the specified real time math channel.

Syntax
```
:CHANnel<x>:RMATh:OPERation {PLUS|
MINus|MULTiple|DIVide|DIFFerential|
FPLus|FMINus|FMULtiple|FDIVide|INT1|
INT2|POLYnomial|SQRT1|SQRT2|LOG1|
LOG2|RANGle|SIN|COS|ATAN|RMS|POWer|
PINTegral|DA|KNOCkflt|ERANGle|PASub|
FREQuency|PERiod|ECOunt|RESolver|
IFILter|PWM|RPOWer|CANId|TORQue|
AMINus|TPResolver}
:CHANnel<x>:RMATh:OPERation?
```
<x> = 1 to 16

Example
```
:CHANNEL1:RMATH:OPERATION PLUS
:CHANNEL1:RMATH:OPERATION?
-> :CHANNEL1:RMATH:OPERATION PLUS
```

Description This command is valid on models with the /G3 or /G5 option.

:CHANnel<x>:RMATh:OPTimize

Function Optimizes the vertical scale of the specified channel that will be used in real time math.

Syntax
```
:CHANnel<x>:RMATh:OPTimize
```
<x> = 1 to 16

Example
```
:CHANNEL1:RMATH:OPTIMIZE
```

Description This command is valid on models with the /G3 or /G5 option.

:CHANnel<x>:RMATh:PASub:SIGN

Function Sets or queries the signs of the sources for the polynomial with a coefficient operation of the specified channel.

Syntax
```
:CHANnel<x>:RMATh:PASub:SIGN
{MINus|PLUS}[,{MINus|PLUS}][,{MINus|
PLUS}][,{MINus|PLUS}]
:CHANnel<x>:RMATh:PASub:SIGN?
```
<x> = 1 to 16

Example
```
:CHANNEL1:RMATH:PASUB:SIGN PLUS
:CHANNEL1:RMATH:PASUB:SIGN?
-> :CHANNEL1:RMATH:PASUB:SIGN PLUS
```

Description This command is valid on models with the /G3 or /G5 option.

:CHANnel<x>:RMATh:PINTegral?

Function Queries all effective power integration settings of the specified channel.

Syntax
```
:CHANnel<x>:RMATh:PINTegral?
```

:CHANnel<x>:RMATh:PINTegral:MRESet:EXECute

Function Resets the effective power integration of the specified channel.

Syntax
```
:CHANnel<x>:RMATh:PINTegral:MRESet:E
XECute
```
<x> = 1 to 16

Example
```
:CHANNEL1:RMATH:PINTEGRAL:MRESET:
EXECUTE
```

Description This command is valid on models with the /G3 or /G5 option.

:CHANnel<x>:RMATh:PINTegral:OVERange

Function Sets or queries whether the integrated power value of the specified channel is reset when an over limit occurs during effective power integration.

Syntax
```
:CHANnel<x>:RMATh:PINTegral:
OVERange {<Boolean>}
:CHANnel<x>:RMATh:PINTegral:OVERan
ge?
```
<x> = 1 to 16

Example
```
:CHANNEL1:RMATH:PINTEGRAL:
OVERRANGE 1
:CHANNEL1:RMATH:PINTEGRAL:OVERRANGE?
-> :CHANNEL1:RMATH:PINTEGRAL:
   OVERRANGE 1
```

Description This command is valid on models with the /G3 or /G5 option.

:CHANnel<x>:RMATh:PINTegral:SCALe

Function Sets the reference time for the effective power integration of the specified channel.

Syntax
```
:CHANnel<x>:RMATh:PINTegral:
SCALe {HOUR|SECond}
:CHANnel<x>:RMATh:PINTegral:SCALe?
```
<x> = 1 to 16

Example
```
:CHANNEL1:RMATH:PINTEGRAL:SCALE HOUR
:CHANNEL1:RMATH:PINTEGRAL:SCALE
-> :CHANNEL1:RMATH:PINTEGRAL:
   SCALE HOUR
```

Description This command is valid on models with the /G3 or /G5 option.

:CHANnel<x>:RMATh:PINTegral:SRESet

Function: Sets or queries whether the integrated value is reset when the effective power integration starts for the specified channel.

Syntax:
```
:CHANnel<x>:RMATh:PINTegral:
SRESet {<Boolean>}
:CHANnel<x>:RMATh:PINTegral:SRESet?
```
<x> = 1 to 16

Example:
```
:CHANNEL1:RMATH:PINTEGRAL:SRESET 1
:CHANNEL1:RMATH:PINTEGRAL:SRESET?
-> :CHANNEL1:RMATH:PINTEGRAL:
   SRESET 1
```

Description: This command is valid on models with the /G3 or /G5 option.

:CHANnel<x>:RMATh:POSition

Function: Sets or queries the vertical position of the specified RMath channel (the specified channel when real time math is turned on).

Syntax:
```
:CHANnel<x>:RMATh:POSition {<NRf>}
:CHANnel<x>:RMATh:POSition?
```
<x> = 1 to 16
<NRf> = –5.00 to +5.00 (div; in steps of 0.01 div)

Example:
```
:CHANNEL1:RMATH:POSITION 2.00
:CHANNEL1:RMATH:POSITION?
-> :CHANNEL1:RMATH:POSITION 2.00
```

Description: This command is valid on models with the /G3 or /G5 option.

:CHANnel<x>:RMATh:POWer?

Function: Queries all effective power calculation period settings of the specified channel.

Syntax:
```
:CHANnel<x>:RMATh:POWer?
```

Description: This command is valid on models with the /G3 or /G5 option.

:CHANnel<x>:RMATh:POWer:TERM:EBIT

Function: Sets or queries the effective power calculation period's edge detection math source waveform (detection bit) of the specified channel (when a logic channel is being used as the edge detection channel).

Syntax:
```
:CHANnel<x>:RMATh:POWer:TERM:
EBIT {<NRf>}
:CHANnel<x>:RMATh:POWer:TERM:EBIT?
```
<x> = 1 to 16
<NRf> = 1 to 8

Example:
```
:CHANNEL1:RMATH:POWER:TERM:EBIT 1
:CHANNEL1:RMATH:POWER:TERM:EBIT?
-> :CHANNEL1:RMATH:POWER:TERM:EBIT 1
```

Description:
- This command is valid on models with the /G3 or /G5 option.
- This setting is shared with the :CHANnel<x>:RMATh:RMS command.

:CHANnel<x>:RMATh:POWer:TERM:EHYSteresis

Function: Sets or queries the effective power calculation period's detection hysteresis of the specified channel.

Syntax:
```
:CHANnel<x>:RMATh:POWer:TERM:EHYSter
esis {HIGH|LOW|MIDDle}
:CHANnel<x>:RMATh:POWer:TERM:EHYSter
esis?
```
<x> = 1 to 16

Example:
```
:CHANNEL1:RMATH:POWER:TERM:
EHYSTERESIS HIGH
:CHANNEL1:RMATH:POWER:TERM:
EHYSTERESIS?
-> :CHANNEL1:RMATH:POWER:TERM:
   EHYSTERESIS HIGH
```

Description:
- This command is valid on models with the /G3 or /G5 option.
- This setting is shared with the :CHANnel<x>:RMATh:RMS command.

:CHANnel<x>:RMATh:POWer:TERM:ELEVel

Function: Sets or queries the effective power calculation period's detection level of the specified channel.

Syntax:
```
:CHANnel<x>:RMATh:POWer:TERM:
ELEVel {<Voltage>|<NRf>|<Current>}
:CHANnel<x>:RMATh:POWer:TERM:ELEVel?
```
<x> = 1 to 16

Example:
```
:CHANNEL1:RMATH:POWER:TERM:ELEVEL 1
:CHANNEL1:RMATH:POWER:TERM:ELEVEL? ->
:CHANNEL1:RMATH:POWER:TERM:
ELEVEL 1.000000E+00
```

Description:
- This command is valid on models with the /G3 or /G5 option.
- This setting is shared with the :CHANnel<x>:RMATh:RMS command.

:CHANnel<x>:RMATh:POWer:TERM:ESLope

Function: Sets or queries the effective power calculation period's detection slope of the specified channel.

Syntax:
```
:CHANnel<x>:RMATh:POWer:TERM:
ESLope {BISlope|FALL|RISE}
:CHANnel<x>:RMATh:POWer:TERM:ESLope?
```
<x> = 1 to 16

Example:
```
:CHANNEL1:RMATH:POWER:TERM:
ESLOPE FALL
:CHANNEL1:RMATH:POWER:TERM:ESLOPE?
-> :CHANNEL1:RMATH:POWER:TERM:
   ESLOPE FALL
```

Description:
- This command is valid on models with the /G3 or /G5 option.
- This setting is shared with the :CHANnel<x>:RMATh:RMS command.

:CHANnel<x>:RMATh:POWer:TERM:ESOurce

Function Sets or queries the effective power calculation period's edge detection math source waveform of the specified channel.

Syntax
```
:CHANnel<x>:RMATh:POWer:
ESOurce {S1|S2|<NRf>[,<NRf>]}
:CHANnel<x>:RMATh:POWer:ESOurce?
```
<x> = 1 to 16

Example
```
:CHANNEL1:RMATH:POWER:TERM:
ESOURCE S1
:CHANNEL1:RMATH:POWER:TERM:ESOURCE?
-> :CHANNEL1:RMATH:POWER:TERM:
   ESOURCE S1
```

Description
- This command is valid on models with the /G3 or /G5 option.
- This setting is shared with the :CHANnel<x>:RMATh:RMS command.

:CHANnel<x1>:RMATh:PWM:PERiod

Function Sets or queries the period of the PWM operation.

Syntax
```
:CHANnel<x1>:RMATh:PWM:
PERiod {<Time>}
```
<x1> = 1 to 16
<Time> = 0.0000001 to 0.005 s (100 ns to 5 ms)

Example
```
:CHANNEL1:RMATH:PWM:PERIOD 0.01
:CHANNEL1:RMATH:PWM:PERIOD?
-> :CHANNEL1:RMATH:PWM:PERIOD 0.01
```

Description This command is valid on models with the /G3 or /G5 option.

:CHANnel<x>:RMATh:RANGle?

Function Queries all settings related to the angle-of-rotation, electrical angle, sine, and cosine operations of the specified channel.

Syntax
```
:CHANnel<x>:RMATh:RANGle?
```

Description
- This command is valid on models with the /G3 or /G5 option.
- To set the math settings for the angle-of-rotation, electrical angle, sine, and cosine operations, use the :CHANnel<x>:RMATh:RANGle command and the commands that are lower in its hierarchy. Before you set any of the settings, use the :CHANnel<x>:RMATh:OPERation command to set the operation type to RANGle, EANGle, SIN, or COS. For details on the commands that have different settings for the various operations, see the conditions that are written in the command descriptions.

:CHANnel<x>:RMATh:RANGle:BLENgth

Function Sets or queries the bit length when the encoding type is GRAY for the specified channel's angle-of-rotation, electrical angle, sine, and cosine operations.

Syntax
```
:CHANnel<x>:RMATh:RANGle:
BLENgth {<NRf>}
:CHANnel<x>:RMATh:RANGle:BLENgth?
```
<x>=1 to 16
<NRf>=2 to 16

Example
```
:CHANNEL1:RMATH:RANGLE:BLENGTH 16
:CHANNEL1:RMATH:RANGLE:BLENGTH?
-> :CHANNEL1:RMATH:RANGLE:
   BLENGTH 16
```

Description This command is valid on models with the /G3 or /G5 option.

:CHANnel<x>:RMATh:RANGle:CCONdition

Function Sets or queries the resolution for the specified channel's angle-of-rotation, electrical angle, sine, and cosine operations.

Syntax
```
:CHANnel<x>:RMATh:RANGle:
CCONdition {<NRf>}
:CHANnel<x>:RMATh:RANGle:CCONdition?
```
<x> = 1 to 16
<NRf> = 1, 2, 4

Example
```
:CHANNEL1:RMATH:RANGLE:CCONDITION 4
:CHANNEL1:RMATH:RANGLE:CCONDITION?
-> :CHANNEL1:RMATH:RANGLE:
   CCONDITION 4
```

Description This command is valid on models with the /G3 or /G5 option.

:CHANnel<x>:RMATh:RANGle:ETYPe (Edge Type)

Function Sets or queries the encoding type for the specified channel's angle-of-rotation, electrical angle, sine, and cosine operations.

Syntax
```
:CHANnel<x>:RMATh:RANGle:
ETYPe {ABZ|AZ|A8Bit|A16Bit|GRAY|
RESolver}
:CHANnel<x>:RMATh:RANGle:ETYPe?
```
<x> = 1 to 16

Example
```
:CHANNEL1:RMATH:RANGLE:ETYPE ABZ
:CHANNEL1:RMATH:RANGLE:ETYPE?
-> :CHANNEL1:RMATH:RANGLE:ETYPE ABZ
```

Description
- This command is valid on models with the /G3 or /G5 option.
- RESolver is valid when the operation type (CHANnel<x>:RMATh:OPERation command) is set to ERANGe, SIN, or COS and when the operation type of another real time math channel is set to RESolver.

:CHANnel<x1>:RMATh:RANGle:HYSTeresis <x2>

Function Sets or queries the slope for the specified math source waveform for the specified channel's angle-of-rotation, electrical angle, sine, and cosine operations.

Syntax
```
:CHANnel<x>:RMATh:RANGle:HYSTeresis
<x2> {HIGH|LOW|MIDDle}
:CHANnel<x>:RMATh:RANGle:
HYSTeresis <x2>?
```
<x1> = 1 to 16
<x2> = 1 to 3

Example
```
:CHANNEL1:RMATH:RANGLE:
HYSTERESIS HIGH
:CHANNEL1:RMATH:RANGLE:HYSTERESIS? ->
:CHANNEL1:RMATH:RANGLE:
HYSTERESIS HIGH
```

Description This command is valid on models with the /G3 or /G5 option.

:CHANnel<x1>:RMATh:RANGle:LEVel<x2>

Function Sets or queries the detection level for the specified math source waveform for the specified channel's angle-of-rotation, electrical angle, sine, and cosine operations.

Syntax
```
:CHANnel<x>:RMATh:RANGle:
LEVel<x2> {<Voltage>|<NRf>|
<Current>}
:CHANnel<x>:RMATh:RANGle:LEVel<x2>?
```
<x1> = 1 to 16
<x2> = 1 to 3

Example
```
:CHANNEL1:RMATH:RANGLE:LEVEL 1
:CHANNEL1:RMATH:RANGLE:LEVEL?
-> :CHANNEL1:RMATH:RANGLE:
   LEVEL 1.000000E+00
```

Description This command is valid on models with the /G3 or /G5 option.

:CHANnel<x>:RMATh:RANGle:LOGic?

Function Queries all the math source waveform settings for the specified channel's angle-of-rotation, electrical angle, sine, and cosine operations.

Syntax
```
:CHANnel<x>:RMATh:RANGle:LOGic?
```

Description
- This command is valid on models with the /G3 or /G5 option.
- An execution error will occur if you specify a channel other than that of a logic input module.

:CHANnel<x>:RMATh:RANGle:LOGic:MODE

Function Sets or queries the math source waveform mode for the specified channel's angle-of-rotation, electrical angle, sine, and cosine operations.

Syntax
```
:CHANnel<x>:RMATh:RANGle:LOGic:
MODE {<Boolean>}
:CHANnel<x>:RMATh:RANGle:LOGic:MODE?
```
<x> = 1 to 16

Example
```
:CHANNEL1:RMATH:RANGLE:LOGIC:MODE 1
:CHANNEL1:RMATH:RANGLE:LOGIC:MODE?
-> :CHANNEL1:RMATH:RANGLE:LOGIC:
   MODE 1
```

Description
- This command is valid on models with the /G3 or /G5 option.
- An execution error will occur if you specify a channel other than that of a logic input module.

:CHANnel<x1>:RMATh:RANGle:LOGic:SBIT <x2> (Source BIT)

Function Sets or queries the source bit when the math source waveform mode for the specified channel's angle-of-rotation, electrical angle, sine, and cosine operations is logic.

Syntax
```
:CHANnel<x1>:RMATh:RANGle:LOGic:SBIT
<x2> {<NRf>}
:CHANnel<x1>:RMATh:RANGle:LOGic:SBIT
<x2>?
```
<x1> = 1 to 16
<x2> = 1 to 3
1: Phase A setting
2: Phase B setting
3: Phase Z setting
<NRf> = 1 to 8

Example
```
:CHANNEL1:RMATH:RANGLE:LOGIC:SBIT1 1
:CHANNEL1:RMATH:RANGLE:LOGIC:SBIT1?
-> :CHANNEL1:RMATH:RANGLE:LOGIC:
   SBIT1 1
```

Description
- This command is valid on models with the /G3 or /G5 option.
- An execution error will occur if you specify a channel other than that of a logic input module.

:CHANnel<x1>:RMATh:RANGle:LOGic:SOURce<x2>

Function Sets or queries the math source waveform when the math source waveform mode for the specified channel's angle-of-rotation, electrical angle, sine, and cosine operations is logic.

Syntax `:CHANnel<x>:RMATh:RANGle:LOGic:SOURce<x2> {<NRf>}`
`:CHANnel<x>:RMATh:RANGle:LOGic:SOURce<x2>?`
<x1> = 1 to 16, <x2> = 1 to 2
<NRf> = 1 to 16

Example `:CHANNEL1:RMATH:RANGLE:LOGIC:SOURCE1 1`
`:CHANNEL1:RMATH:RANGLE:LOGIC:SOURCE1?`
`-> :CHANNEL1:RMATH:RANGLE:LOGIC:SOURCE1 1`

Description
- This command is valid on models with the /G3 or /G5 option.
- An execution error will occur if you specify a channel other than that of a logic input module.

:CHANnel<x1>:RMATh:RANGle:MRESet:EXECute

Function Resets the angle of the specified channel's angle operations.

Syntax `:CHANnel<x>:RMATh:RANGle:MRESet:EXECute`
<x1> = 1 to 16

Description This command is valid on models with the /G3 or /G5 option.

:CHANnel<x>:RMATh:RANGle:NLOGic (Negative Logic)

Function Sets or queries the on/off status of negative logic in angle operations.

Syntax `:CHANnel<x>:RMATh:RANGle:NLOGic {<Boolean>}`
`:CHANnel<x>:RMATh:RANGle:NLOGic?`
<x> = 1 to 16

Example `:CHANEL1:RMATH:RANGLE:NLOGIC 1`
`:CHANEL1:RMATH:RANGLE:NLOGIC?`
`->:CHANEL1:RMATH:RANGLE:NLOGIC 1`

Description This command is valid on models with the /G3 or /G5 option.

:CHANnel<x>:RMATh:RANGle:PROTate (Pulse per Rotate)

Function Sets or queries the number of pulses per rotation for the specified channel's angle-of-rotation, electrical angle, sine, and cosine operations.

Syntax `:CHANnel<x>:RMATh:RANGle:PROTate {<NRf>}`
`:CHANnel<x>:RMATh:RANGle:PROTate?`
<x> = 1 to 16
<NRf> = 1 to 500000
When the type is absolute 16 bit
Maximum value 65536
When the type is absolute 8 bit
Maximum value 256

Example `:CHANNEL1:RMATH:RANGLE:PROTATE 1`
`:CHANNEL1:RMATH:RANGLE:PROTATE?`
`-> :CHANNEL1:RMATH:RANGLE:PROTATE 1`

Description This command is valid on models with the /G3 or /G5 option.

:CHANnel<x>:RMATh:RANGle:REVerse

Function Sets or queries whether the rotation direction is inverted for the specified channel's angle-of-rotation, electrical angle, sine, and cosine operations.

Syntax `:CHANnel<x>:RMATh:RANGle:REVerse {<Boolean>}`
`:CHANnel<x>:RMATh:RANGle:REVerse?`
<x> = 1 to 16

Example `:CHANNEL1:RMATH:RANGLE:REVERSE 1`
`:CHANNEL1:RMATH:RANGLE:REVERSE? ->`
`:CHANNEL1:RMATH:RANGLE:REVERSE 1`

Description This command is valid on models with the /G3 or /G5 option.

:CHANnel<x1>:RMATh:RANGle:RSOurce (Resolver Source Ch)

Function Sets or queries the math source waveform when the encoding type of the angle-of-rotation, sine, and cosine operations is RESolver.

Syntax `:CHANnel<x1>:RMATh:RANGle:RSOurce {RMATh<x2>}`
<x1> = 1 to 16
<x2> = 1 to 15

Example `:CHANNEL1:RMATH:RANGLE:RSOURCE RMATH1`
`:CHANNEL1:RMATH:RANGLE:RSOURCE?`
`-> :CHANNEL1:RMATH:RANGLE:RSOURCE RMATH1`

Description This command is valid on models with the /G3 or /G5 option.

:CHANnel<x>:RMATh:RANGle:RTIMing (Reset Timing)

Function Sets or queries the timing that will be used to reset the number of rotations for the specified channel's angle-of-rotation, electrical angle, sine, and cosine operations.

Syntax
```
:CHANnel<x>:RMATh:RANGle:
RTIMing {ZTERm|ZARise|ZA1L|ZA2H|
ZA2L}
:CHANnel<x>:RMATh:RANGle:RTIMing?
```
<x> = 1 to 16

Example
```
:CHANNEL1:RMATH:RANGLE:RTIMING ZTERM
:CHANNEL1:RMATH:RANGLE:RTIMING?
-> :CHANNEL1:RMATH:RANGLE:
   RTIMING ZTERM
```

Description This command is valid on models with the /G3 or /G5 option.

:CHANnel<x1>:RMATh:RANGle:SCALe

Function Sets or queries the scale of the specified channel's angle-of-rotation and electrical angle operations.

Syntax
```
:CHANnel<x>:RMATh:RANGle:
SCALe {DEGRee|RADian|USERdefine}
:CHANnel<x>:RMATh:RANGle:SCALe?
```
<x1> = 1 to 16

Example
```
:CHANNEL1:RMATH:RANGLE:SCALE DEGREE
:CHANNEL1:RMATH:RANGLE:SCALE?
-> :CHANNEL1:RMATH:RANGLE:
   SCALE DEGREE
```

Description
- This command is valid on models with the /G3 or /G5 option.
- USERdefine can only be specified when the :CHANnel<x>:RMATh:OPERation command has been used to select RANGle.

:CHANnel<x>:RMATh:RANGle:SLOGic (Source Logic)

Function Sets or queries the math source waveform type for the specified channel's angle-of-rotation, electrical angle, sine, and cosine operations.

Syntax
```
:CHANnel<x>:RMATh:RANGle:
SLOGic {<Boolean>}
:CHANnel<x>:RMATh:RANGle:SLOGic?
```
<x> = 1 to 16

Example
```
:CHANNEL1:RMATH:RANGLE:SLOGIC 1
:CHANNEL1:RMATH:RANGLE:SLOGIC?
-> :CHANNEL1:RMATH:RANGLE:SLOGIC 1
```

Description This command is valid on models with the /G3 or /G5 option.

:CHANnel<x1>:RMATh:RANGle:SOURce<x2>

Function Sets or queries the math source waveform when the math source waveform mode for the specified channel's angle-of-rotation, electrical angle, sine, and cosine operations is not logic.

Syntax
```
:CHANnel<x1>:RMATh:RANGle:
SOURce<x2> {<NRf>[,<NRf>]}
:CHANnel<x1>:RMATh:RANGle:SOURce
<x2>?
```
<x1> = 1 to 16
<x2> = 1 to 3
<NRf> = 1 to 16

Example
```
:CHANNEL1:RMATH:RANGLE:SOURCE1 1
:CHANNEL1:RMATH:RANGLE:SOURCE1?
-> :CHANNEL1:RMATH:RANGLE:SOURCE1 1
```

Description This command is valid on models with the /G3 or /G5 option.

:CHANnel<x1>:RMATh:RANGle:TIMing<x2> (Edge Timing)

Function Sets or queries the edge detection timing for the specified channel's angle-of-rotation, electrical angle, sine, and cosine operations.

Syntax
```
:CHANnel<x>:RMATh:RANGle:
TIMing {ARISe|S1Low|S2High|S2Low}
:CHANnel<x>:RMATh:RANGle:TIMing?
```
<x1> = 1 to 16
<x2> = 1, 2

Example
```
:CHANNEL1:RMATH:RANGLE:TIMING ARISE
:CHANNEL1:RMATH:RANGLE:TIMING?
-> :CHANNEL1:RMATH:RANGLE:
   TIMING ARISE
```

Description This command is valid on models with the /G3 or /G5 option.

:CHANnel<x>:RMATh:RANGle:ZINVert

Function Sets or queries whether the Z phase is inverted for the specified channel's angle-of-rotation, electrical angle, sine, and cosine operations.

Syntax
```
:CHANnel<x>:RMATh:RANGle:
ZINVert {<Boolean>}
:CHANnel<x>:RMATh:RANGle:ZINVert?
```

Example
```
:CHANNEL3:RMATH:RANGLE:ZINVERT ON
:CHANNEL3:RMATH:RANGLE:ZINVERT?
→ :CHANNEL3:RMATH:RANGLE:ZINVERT ON
```

Description This command is valid on models with the /G3 or /G5 option.

:CHANnel<x1>:RMATh:RESolver?

Function Queries all resolver operation settings.

Syntax
```
:CHANnel<x1>:RMATh:RESolver?
```
<x1> = 1 to 16

Description This command is valid on models with the /G3 or /G5 option.

:CHANnel<x1>:RMATh:RESolver:PHASe

Function Sets or queries the angle combination of 3 phase resolver operation.

Syntax
```
:CHANnel<x1>:RMATh:RESolver:
PHASe {P1|P2|P3}
```
<x1> = 1 to 16
P1: 0°-120°, P2: 0°-240°, P3: 120°-240°

Example
```
:CHANNEL2:RMATH:RESOLVER:PHASE P1
:CHANNEL2:RMATH:RESOLVER:PHASE?
-> :CHANNEL2:RMATH:RESOLVER:PHASE P1
```
Description This command is valid on models with the /G3 option.

:CHANnel<x1>:RMATh:RESolver:OFFSet

Function Sets or queries the offset angle of resolver operation.

Syntax
```
:CHANnel<x1>:RMATh:RESolver:OFFSet
{<NRf>}
```
<x1> = 1 to 15
<NRf> = –180 to180
Angle setting in unit of 0.01°

Example
```
:CHANNEL2:RMATH:RESOLVER:OFFSET 60
:CHANNEL2:RMATH:RESOLVER:OFFSET?
-> :CHANNEL2:RMATH:RESOLVER:
   OFFSET 60
```
Description This command is valid on models with the /G3 option.

:CHANnel<x1>:RMATh:RESolver:SOURce<x2>

Function Sets or queries the math source waveform of the resolver operation.

Syntax
```
:CHANnel<x1>:RMATh:RESolver:
SOURce<x2> {<NRf>[,<NRf>]}
```
<x1> = 1 to 16
<x2> = 1 to 3
Resolver operation
- 1: Carrier channel (excitation waveform)
- 2: sinθ channel
- 3: cosθ channel

3-phase resolver operation (0°-120°)
- 1: Carrier channel (excitation waveform)
- 2: sin0° channel
- 3: sin120° channel

3-phase resolver operation (0°-240 °)
- 1: Carrier channel (excitation waveform)
- 2: sin0° channel
- 3: sin240° channel

3-phase resolver operation (120 °-240 °)
- 1: Carrier channel (excitation waveform)
- 2: sin120° channel
- 3: sin240° channel

Example
```
:CHANNEL1:RMATH:RESOLVER:SOURCE1 1
:CHANNEL1:RMATH:RESOLVER:SOURCE1?
-> :CHANNEL1:RMATH:RESOLVER:
   SOURCE1 1
```
Description This command is valid on models with the /G3 option.

:CHANnel<x1>:RMATh:RESolver:SMODe(Sample Mode)

Function Sets or queries the sample mode of the resolver operation.

Syntax
```
:CHANnel<x1>:RMATh:RESolver:
SMODe {AUTO|MANual}
```
<x1> = 1 to 16

Example
```
:CHANNEL1:RMATH:RESOLVER:SMODE AUTO
:CHANNEL1:RMATH:RESOLVER:SMODE?
-> :CHANNEL1:RMATH:RESOLVER:
   SMODE AUTO
```
Description This command is valid on models with the /G3 or /G5 option.

:CHANnel<x1>:RMATh:RESolver:HYSTeresis

Function Sets or queries the hysteresis of the resolver operation when the sample mode is set to AUTO.

Syntax
```
:CHANnel<x1>:RMATh:RESolver:
HYSTeresis {HIGH|LOW|MIDDle}
```
<x1> = 1 to 16

Example
```
:CHANNEL1:RMATH:RESOLVER:
HYSTERESIS LOW
:CHANNEL1:RMATH:RESOLVER:HYSTERESIS?
-> :CHANNEL1:RMATH:RESOLVER:
   HYSTERESIS LOW
```
Description This command is valid on models with the /G3 or /G5 option.

:CHANnel<x1>:RMATh:RESolver:STIMe(Sampling Time)

Function Sets or queries the time from the excitation waveform edge of the resolver operation when the sample mode is set to MANual.

Syntax
```
:CHANnel<x1>:RMATh:RESolver:
STIMe {<Time>}
```
<x1> = 1 to 16
<Time> = 0.0000001 to 0.001 s (100 ns to 1 ms)

Example
```
:CHANNEL1:RMATH:RESOLVER:
STIME 0.0001
:CHANNEL1:RMATH:RESOLVER:STIME?
-> :CHANNEL1:RMATH:RESOLVER:
   STIME 1.0E-3
```
Description This command is valid on models with the /G3 or /G5 option.

:CHANnel<x1>:RMATh:RESolver:TFILter

Function: Sets or queries the tracking filter of the resolver operation.

Syntax: :CHANnel<x1>:RMATh:RESolver:TFILter {OFF|<NRf>}
<x1> = 1 to 16
<NRf> = 100, 250, 1000, 2000

Example: :CHANNEL1:RMATH:RESOLVER:TFILTER 100
:CHANNEL1:RMATH:RESOLVER:TFILTER?
-> :CHANNEL1:RMATH:RESOLVER:TFILTER 100

Description: This command is valid on models with the /G3 or /G5 option.

:CHANnel<x1>:RMATh:RESolver:SCALe

Function: Sets or queries the scale of the resolver operation.

Syntax: :CHANnel<x1>:RMATh:RESolver:SCALe {DEG1|DEG2|RAD1|RAD2}
<x1> = 1 to 16
DEG1: Degrees (–180 to +180)
DEG2: Degrees (0 to +360)
RAD1: Radians (–π to π)
RAD2: Radians (0 to 2π)

Example: :CHANNEL1:RMATH:RESOLVER:SCALE DEG1
:CHANNEL1:RMATH:RESOLVER:SCALE?
-> :CHANNEL1:RMATH:RESOLVER:SCALE DEG1

Description: This command is valid on models with the /G3 or /G5 option.

:CHANnel<x>:RMATh:RMS?

Function: Queries all RMS calculation period settings of the specified channel.

Syntax: :CHANnel<x>:RMATh:RMS?

Description: This command is valid on models with the /G3 or /G5 option.

:CHANnel<x>:RMATh:RMS:TERM:EBIT

Function: Sets or queries the edge detection math source waveform (the detection bit) for when the RMS calculation period of the specified channel is set to edge (when a logic channel is being used as the edge detection channel).

Syntax: :CHANnel<x>:RMATh:RMS:TERM:EBIT {<NRf>}
:CHANnel<x>:RMATh:RMS:TERM:EBIT?
<x> = 1 to 16
<NRf> = 1 to 8

Example: :CHANNEL1:RMATH:RMS:TERM:EBIT 1
:CHANNEL1:RMATH:RMS:TERM:EBIT?
-> :CHANNEL1:RMATH:RMS:TERM:EBIT 1

Description:
- This command is valid on models with the /G3 or /G5 option.
- This setting is shared with the :CHANnel<x>:RMATh:POWer command.

:CHANnel<x>:RMATh:RMS:TERM:EHYSteresis

Function: Sets or queries the detection hysteresis for when the RMS calculation period of the specified channel is set to edge.

Syntax: :CHANnel<x>:RMATh:RMS:TERM:EHYSteresis {HIGH|LOW|MIDDle}
:CHANnel<x>:RMATh:RMS:TERM:EHYSteresis?
<x> = 1 to 16

Example: :CHANNEL1:RMATH:RMS:TERM:EHYSTERESIS HIGH
:CHANNEL1:RMATH:RMS:TERM:EHYSTERESIS?
-> :CHANNEL1:RMATH:RMS:TERM:EHYSTERESIS HIGH

Description:
- This command is valid on models with the /G3 or /G5 option.
- This setting is shared with the :CHANnel<x>:RMATh:POWer command.

:CHANnel<x>:RMATh:RMS:TERM:ELEVel

Function: Sets or queries the detection level for when the RMS calculation period of the specified channel is set to edge.

Syntax: :CHANnel<x>:RMATh:RMS:TERM:ELEVel {<Voltage>|<NRf>|<Current>}
:CHANnel<x>:RMATh:RMS:TERM:ELEVel?
<x> = 1 to 16

Example: :CHANNEL:RMATH:RMS:TERM:ELEVEL 1
:CHANNEL1:RMATH:RMS:TERM:ELEVEL?
-> :CHANNEL1:RMATH:RMS:TERM:ELEVEL 1.000000E+00

Description:
- This command is valid on models with the /G3 or /G5 option.
- This setting is shared with the :CHANnel<x>:RMATh:POWer command.

:CHANnel<x>:RMATh:RMS:TERM:ESLope

Function: Sets or queries the detection slope for when the RMS calculation period of the specified channel is set to edge.

Syntax: :CHANnel<x>:RMATh:RMS:TERM:ESLope {BISLope|FALL|RISE}
:CHANnel<x>:RMATh:RMS:TERM:ESLope?
<x> = 1 to 16

Example: :CHANNEL1:RMATH:RMS:TERM:ESLOPE FALL
:CHANNEL1:RMATH:RMS:TERM:ESLOPE?
-> :CHANNEL1:RMATH:RMS:TERM:ESLOPE FALL

Description:
- This command is valid on models with the /G3 or /G5 option.
- This setting is shared with the :CHANnel<x>:RMATh:POWer command.

:CHANnel<x>:RMATh:RMS:TERM:ESOurce

Function Sets or queries the edge detection math source waveform for when the RMS calculation period of the specified channel is set to edge.

Syntax
```
:CHANnel<x>:RMATh:RMS:TERM:
ESOurce {OWN|<NRf>[,<NRf>]|
RMATh<x2>}
:CHANnel<x>:RMATh:RMS:TERM:ESOurce?
```
<x> = 1 to 16
<x2> = 1 to 15

Example
```
:CHANNEL1:RMATH:RMS:TERM:ESOURCE OWN
:CHANNEL1:RMATH:RMS:TERM:ESOURCE?
-> :CHANNEL1:RMATH:RMS:TERM:
   ESOURCE OWN
```

Description
- This command is valid on models with the /G3 or /G5 option.
- This setting is shared with the :CHANnel<x>:RMATh:POWer command.

:CHANnel<x>:RMATh:RMS:TERM:MODE

Function Sets or queries the RMS calculation period mode of the specified channel.

Syntax
```
:CHANnel<x>:RMATh:RMS:TERM:
MODE {TIME|EDGE}
:CHANnel<x>:RMATh:RMS:TERM:MODE?
```
<x> = 1 to 16

Example
```
:CHANNEL1:RMATH:RMS:TERM:MODE TIME
:CHANNEL1:RMATH:RMS:TERM:MODE?
-> :CHANNEL1:RMATH:RMS:TERM:
   MODE TIME
```

Description This command is valid on models with the /G3 or /G5 option.

:CHANnel<x>:RMATh:RMS:TERM:TIME

Function Sets or queries the interval for when the RMS calculation period of the specified channel is set to time.

Syntax
```
:CHANnel<x>:RMATh:RMS:TERM:
TIME {<Time>}
:CHANnel<x>:RMATh:RMS:TERM:TIME?
```
<x> = 1 to 16
<Time> = 1ms to 500.0ms

Example
```
:CHANNEL1:RMATH:RMS:TERM:TIME 100ms
:CHANNEL1:RMATH:RMS:TERM:TIME?
-> :CHANNEL1:RMATH:RMS:TERM:
   TIME 100ms
```

Description This command is valid on models with the /G3 or /G5 option.

:CHANnel<x>:RMATh:RPOWer:SOURce<x2>

Function Sets or queries the apparent-power, effective-power, voltage, or current channel used to calculate the reactive power of the specified channel.

Syntax
```
:CHANnel<x>:RMATh:RPOWer:
SOURce<x2> {<NRf>[,<NRf>]|RMATh<x3>}
:CHANnel<x>:RMATh:RPOWer:SOURce<x2>?
```
<x> = 1 to 16
<x2> = 1 to 4
1: ApparentPower
2: EffectivePower
3: Voltage
4: Current
<x3> = 1 to 15

Example
```
:CHANNEL:RMATH:RPOWER:SOURCE RMATH1
:CHANNEL:RMATH:RPOWER:SOURCE?
-> :CHANNEL:RMATH:RPOWER:
   SOURCE RMATH1
```

Description
- This command is valid on models with the /G3 or /G5 option.
- You can also use the CHANnel<x>:RMATh:SC<x> command.

:CHANnel<x>:RMATh:RPOWer:VOLTage:HYSTeresis

Function Sets or queries the hysteresis of the voltage channel used to calculate the reactive power of the specified channel.

Syntax
```
:CHANnel<x>:RMATh:RPOWer:VOLTage:
HYSTeresis {HIGH|LOW|MIDDle}
:CHANnel<x>:RMATh:RPOWer:VOLTage:
HYSTeresis?
```
<x> = 1 to 16

Example
```
:CHANNEL:RMATH:RPOWER:VOLTAGE:
HYSTERESIS HIGH
:CHANNEL:RMATH:RPOWER:VOLTAGE:
HYSTERESIS?
-> :CHANNEL:RMATH:RPOWER:VOLTAGE:
   HYSTERESIS HIGH
```

Description This command is valid on models with the /G3 or /G5 option.

5 Commands

:CHANnel<x1>:RMATh:SC<x2>

Function Sets or queries source waveforms 1 to 3 of the currently specified real time math operation.

Syntax
```
:CHANnel<x1>:RMATh:
SC<x2> {<NRf>[,<NRf>]|RMATh<x3>}
:CHANnel<x1>:RMATh:SC<x2>?
```
<x2> = 1 to 3
<x3> = 1 to 15
<NRf> = 1 to 16

Example
```
CHANNEL1:RMATH:SC1 1
CHANNEL1:RMATH:SC1?
-> CHANNEL1:RMATH:SC1 1
```

Description
- This command is valid on models with the /G3 or /G5 option.
- Use the :CHANnel<x1>:RMATh:FREQ:SOURce command to set the frequency, period, and edge count operations.
- To set the target of the electrical angle operation, use this command with parameter <x> set to 3.

:CHANnel<x>:RMATh:SC4

Function Sets or queries source waveform 4 for the polynomial with a coefficient operation of the specified real time math channel.

Syntax
```
:CHANnel<x>:RMATh:
SC4 {Off|<NRf>[,<NRf>]|RMATh<x3>}
:CHANnel<x>:RMATh:SC4?
```
<x3> = 1 to 15
<NRf> = 1 to 16

Example
```
CHANNEL1:RMATH:SC4 1
CHANNEL1:RMATH:SC4?
-> CHANNEL1:RMATH:SC4 1
```

Description This command is valid on models with the /G3 or /G5 option.

:CHANnel<x>:RMATh:SCALe

Function Sets or queries the two ends of the scale of the specified RMath channel (the specified channel when real time math is turned on).

Syntax
```
:CHANnel<x>:RMATh:SCALe {<NRf>,
<NRf>}
:CHANnel<x>:RMATh:SCALe?
```
<x> = 1 to 16
<NRf> = –9.9999E+30 to +9.9999E+30

Example
```
:CHANNEL1:RMATH:
SCALE -1.0000E+10,+1.0000E+10
:CHANNEL1:RMATH:SCALE?
-> :CHANNEL1:RMATH:
   SCALE {-1.0000E+10,+1.0000E+10}
```

Description This command is valid on models with the /G3 or /G5 option.

:CHANnel<x1>:RMATh:SQRT1:SIGN

Function Sets or queries the sign for the specified channel's square root operation.

Syntax
```
:CHANnel<x>:RMATh:SQRT1:
SIGN {MINus|PLUS}
:CHANnel<x>:RMATh:SQRT1:SIGN?
```
<x1> = 1 to 16

Example
```
:CHANNEL1:RMATH:SQRT1:SIGN1 PLUS
:CHANNEL1:RMATH:SQRT1:SIGN1?
-> :CHANNEL1:RMATH:SQRT1:SIGN1 PLUS
```

Description This command is valid on models with the /G3 or /G5 option.

:CHANnel<x>:RMATh:UNIT

Function Sets or queries the unit string of the specified RMath channel (the specified channel when real time math is turned on).

Syntax
```
:CHANnel<x>:RMATh:UNIT {<String>}
:CHANnel<x>:RMATh:UNIT?
```
<x> = 1 to 16
<String> = Up to 4 characters

Example
```
:CHANNEL1:RMATH:UNIT "RPM"
:CHANNEL1:RMATH:UNIT?
-> :CHANNEL1:RMATH:UNIT "RPM"
```

Description This command is valid on models with the /G3 or /G5 option.

:CHANnel<x>:RMATh:VARiable

Function Sets or queries the vertical scale setup method of the specified RMath channel (the specified channel when real time math is turned on).

Syntax
```
:CHANnel<x>:RMATh:
VARiable {<Boolean>}
:CHANnel<x>:RMATh:VARiable?
```
<x> = 1 to 16

Example
```
:CHANNEL1:RMATH:VARIABLE 1
:CHANNEL1:RMATH:VARIABLE?
-> :CHANNEL1:RMATH:VARIABLE 1
```

Description This command is valid on models with the /G3 or /G5 option.

:CHANnel<x>:RMATh:VDIV

Function Sets or queries the value/div setting of the specified RMath channel (the specified channel when real time math is turned on).

Syntax
```
:CHANnel<x>:RMATh:VDIV {<NRf>}
:CHANnel<x>:RMATh:VDIV?
```
<x> = 1 to 16
<NRf> = 1e–20 to 5e20

Example
```
:CHANNEL1:RMATH:VDIV 1E1
:CHANNEL1:RMATH:VDIV?
-> :CHANNEL1:RMATH:VDIV 1E1
```

Description This command is valid on models with the /G3 or /G5 option.

:CHANnel<x>:RMATh:ZOOM

Function Sets or queries the vertical zoom factor of the specified RMath channel (the specified channel when real time math is turned on).

Syntax
```
:CHANnel<x>:RMATh:ZOOM {<NRf>}
:CHANnel<x>:RMATh:ZOOM?
```
<x> = 1 to 16
<NRf> = 0.1, 0.111, 0.125, 0.143, 0.167, 0.2, 0.25, 0.33, 0.4, 0.5, 0.556, 0.625,0.667, 0.714, 0.8, 0.833, 1, 1.11, 1.25, 1.33, 1.43, 1.67, 2, 2.22, 2.5, 3.33, 4, 5,6.67, 8, 10, 12.5, 16.7, 20, 25, 40, 50, 100

Example
```
:CHANNEL1:RMATH:ZOOM 5
:CHANNEL1:RMATH:ZOOM?
-> :CHANNEL1:RMATH:ZOOM 5
```

Description This command is valid on models with the /G3 or /G5 option.

6 Error Messages

Messages

Messages may appear on the screen during operation. This section describes the error messages and how to respond to them. You can display the messages in the language that you specify through the operations explained section 18.5 in user's manual, IM DL850E-02EN.

Execution Errors

Code	Message	Page
722	Cannot execute search because RealTime math mode is changed after acquisition.	—

Setup Errors

Code	Message	Page
886	Cannot set RealTime Math mode to ON due to the following problems. -The slot is installed 720220, 720221, 720240,720241, 720242 or 720243. -There are not any input which can be set to source for RealTime Math.	1-23
887	There are not any modules which can be set to source for this operation.	1-23
888	Cannot set RealTime Math mode to ON while RealTime Math Function is disable.	3-3

Appendix 1 Digital Filter and Real Time Math

Digital Filter Operation Type

The DL850E/DL850EV has the following two digital filter operation types.

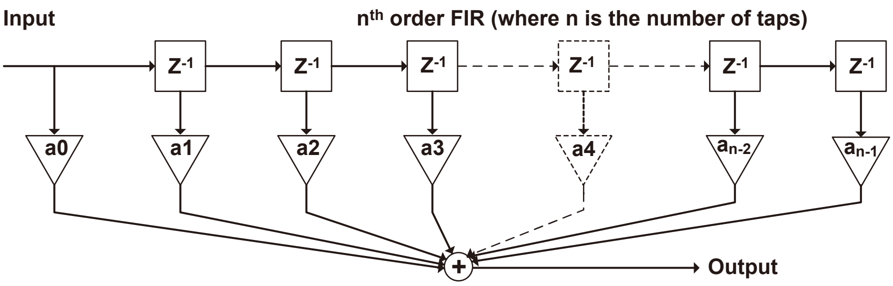
- FIR
- IIR

FIR

The signal block diagram for math that uses an FIR digital filter is shown below. The FIR filter has the following features:

1. A steep, high-order filter can be achieved within the range of the math time.
   However, as the order becomes higher, the math delay becomes longer.
2. Because the filter has linear phase characteristics, it has a constant group delay. Therefore, it has a small amount of phase distortion.
   In real time math, the following filters can be used as FIR filters:
   - Sharp
   - Gauss
   - Mean

Signal Block Diagram of an FIR Filter

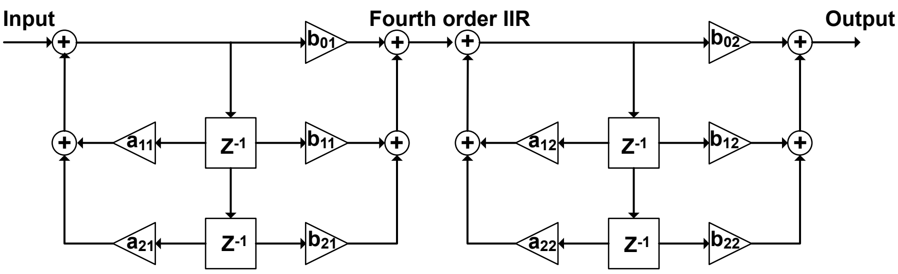


IIR

The signal block diagram for math that uses an IIR digital filter is shown below. The IIR filter has the following features:

1. Even with comparatively low orders, the filter can obtain sufficient cutoff characteristics.
   Therefore, the math delay and group delay are small compared to FIR.
2. The frequency can be set to a lower value than is possible with FIR.
3. Because it has non-linear phase characteristics, the phase distortion of an IIR filter is greater than that of an FIR filter.
   In real time math, a Butterworth filter, which has characteristics similar to an analog filter, can be used as an IIR filter.

Signal Block Diagram of an IIR Filter



App
Appendix

Filter Features

The features of each filter are listed below.

Type	Features	Band	Operation Type
Sharp	Frequency characteristics with a sharp attenuation slope (–40 dB at 1 oct) Linear phase and constant group delay Ripples present in the passband Comb-shaped stopband	Low-Pass High-Pass Band-Pass	FIR
Gauss	Frequency characteristics with a smooth attenuation slope Linear phase and constant group delay No ripples present in the passband No overshoot in the step response Low order and short delay	Low-Pass	FIR
Mean	Comb-shaped frequency characteristics Linear phase and constant group delay No overshoot in the step response	Low-Pass	FIR
IIR (Butterworth)	Attenuation slope steepness between those of the Sharp and Gauss filters Non-linear phase and non-constant group delay No ripples present in the passband and stopband Compared to Sharp and Gauss filters, low cutoff frequency possible Characteristics similar to those of analog filters	Low-Pass High-Pass Band-Pass	IIR
IIR-Lowpass	Frequency characteristics with a smooth attenuation slope Computes at 10 MS/s regardless of the setting. Non-linear phase Characteristics similar to those of analog filters	Low-Pass	IIR

Type	Passband Ripple	Attenuation Slope	Stopband Attenuation	Phase	Selectable Cutoff Range
Sharp	0 dB	–40 dB at 1 oct (Low-Pass)			
		–40 dB at –1 oct (High-Pass)	–40 dB	Linear phase	2 to 30% of the calculation frequency
Gauss	±0.3 dB	$-3.0 \times (f/fc)^2$ dB		Linear phase	2 to 30% of the calculation frequency
Mean	0 dB	See the characteristics graph		Linear phase	—
IIR (Butterworth)	0 dB	–24 dB at 1 oct (Low-Pass)			
		–24 dB at –1 oct (High-Pass)		Non-linear phase	0.2 to 30% of the calculation frequency
IIR-Lowpass	0 dB	–12 dB at –1 oct		Non-linear phase	

About the Group Delay Characteristic

In the filter response characteristics, the delay (in seconds) between the input frequency (sine wave) and the output frequency is known as group delay. The group delay can be normalized by the calculation period (Ts). Group delay is expressed in units of s/Ts. The length of the group delay for each frequency can be determined by the following equation: “group delay of the frequency × calculation period.”

Example

The length of the group delay for the mean can be calculated as shown below (the group delay is constant, regardless of the frequency).

Group delay (in s/Ts) when the mean filter is used = (number of mean points – 1)/2

If there are 16 mean points,

Group delay (in s/Ts) = (16 – 1)/2 = 15/2 = 7.5 s/Ts.

If the calculation frequency (fs) is 100 kHz,

Ts = 1/fs = 1/(100 kHz) = 10 μs.

Therefore,

Length of delay = Group delay × calculation period = 7.5 s/Ts × 10 μs = 75 μs.

About the Calculation Frequency

With the digital filter and IIR filter of real time math, the calculation frequency is automatically set internally depending on the cutoff frequency. Once per calculation period—which is determined from this calculation frequency—simple decimation is performed on the data, and the filter operation is performed, so the filter calculation results are updated once per calculation period.
The calculation frequencies are shown below.

Digital Filter

Cutoff Frequency Range	Calculation Frequency
300 kHz to 30 kHz	1 MHz
29.8 kHz to 3 kHz	100 kHz
2.98 kHz to 300 Hz	10 kHz
298 Hz to 30 Hz	1 kHz
29.8 Hz or less	100 Hz

Real Time Math IIR Filter

Cutoff Frequency Range	Calculation Frequency
3 MHz to 300 kHz	10 MHz
298 kHz to 30 kHz	1 MHz
29.8 kHz to 3 kHz	100 kHz
2.98 kHz to 300 Hz	10 kHz
298 Hz to 30 Hz	1 kHz
29.8 Hz or less	100 Hz

About the Math Delay

The math delay can be calculated from the following equation.

Math delay = 1.4 μs + digital filter delay + math time

If you are not using the digital filter and math features, the delay and math time both become 0.

The digital filter delay varies depending on the filter type and the calculation frequency. For details on the delay, see each filter's math delay explanation.

The math time is different for each function. A table of the math times for each function is shown below.

Function	Math Time (μs)	Notes
S1+S2	0.0	
S1–S2	0.0	
S1*S2	0.0	
S1/S2	0.0	
A(S1)+B(S2)+C	0.0	
A(S1)–B(S2)+C	0.0	
A(S1)*B(S2)+C	0.0	
A(S1)/B(S2)+C	0.0	
Diff	See the filter explanations.	
Integ1	0.2	
Integ2	0.2	
Angle	0.2	
DA	0.2	
Polynomial	0.8	The data is updated once per microsecond.
RMS	0.6	The data is updated once per the specified period.
Power	0.4	The data is updated once per the specified period.
Power Integ	0.2	
Log1	0.4	
Log2	0.2	
Sqrt1	0.2	
Sqrt2	0.0	
Cos	0.2	
Sin	0.2	
Atan	0.3	
Electric Angle	1.1	The data is updated once per the specified period.
Knocking Filter	0.0	
Poly-Add-Sub	0.0	
Frequency	0.2	The data is updated each time that an edge is detected.
Period	0.2	The data is updated each time that an edge is detected.
Edge Count	0.2	The data is updated each time that an edge is detected.
Resolver	0.4	The data is updated once per excitation voltage period.
IIR Filter	See the filter explanations.	
PWM	0.2	
Reactive Power	0.2	
CAN ID	The calculation period is from the last bit sample point of the CAN frame ID to the point of detection. The sample point is approximately at the 70% point of the time span of a bit.	
Torque	0.4	The data is updated each time that an edge is detected.
S1–S2(Angle)	0.0	
3 Phase Resolver	0.4	The data is updated once per excitation voltage period.

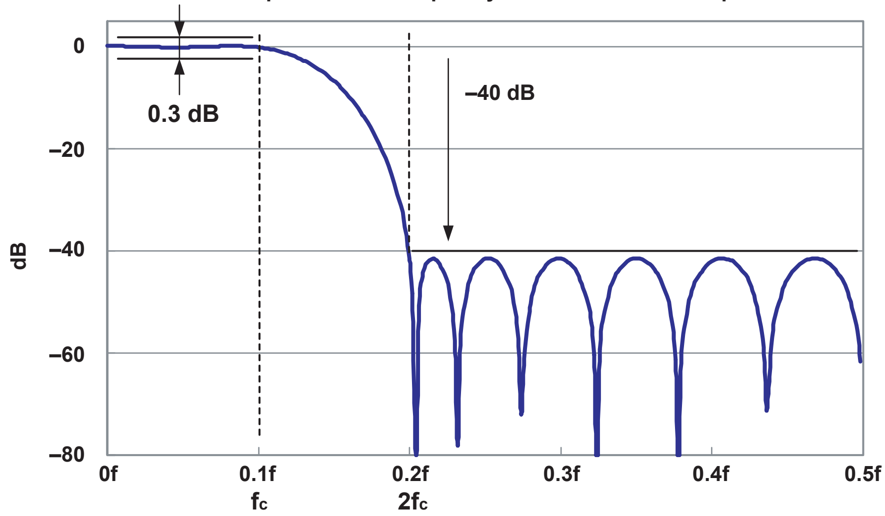
Sharp Filter

Characteristics

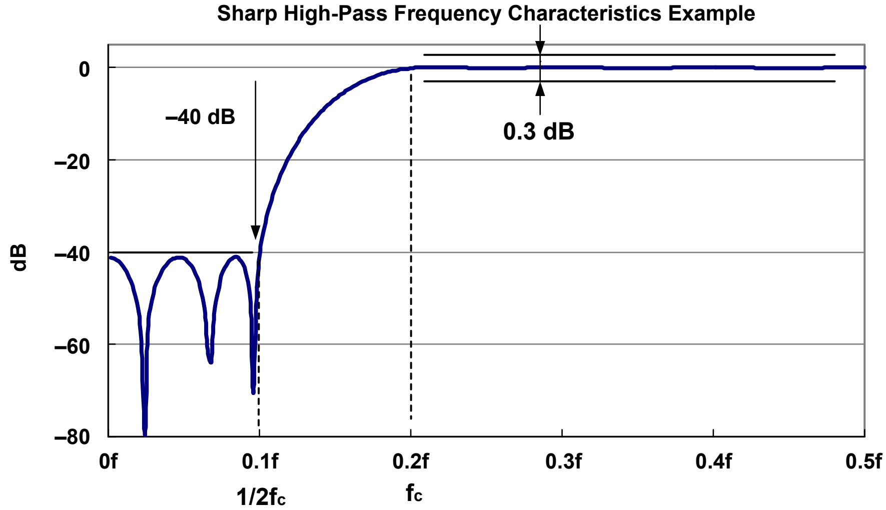
Low-Pass and High-Pass

- The ripple that is present in the passband is within 0.3 dB.
- When the frequency is equal to the cutoff frequency times 2 for low-pass or the cutoff frequency times 0.5 for high-pass, the attenuation is set to –40 dB.
- The stopband attenuation is –40 dB or greater.
- The filter has linear phase and constant group delay.

Sharp Low-Pass Frequency Characteristics Example



Sharp High-Pass Frequency Characteristics Example



(f: Calculation frequency in Hz)

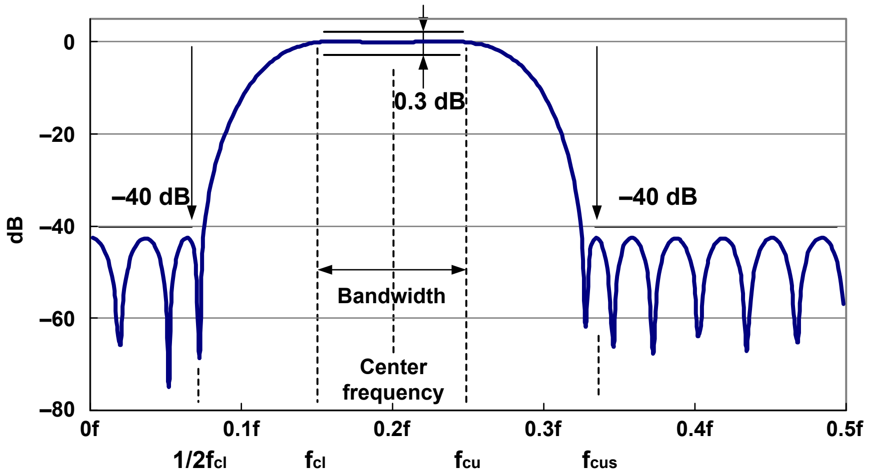
App

Appendix

Band-Pass

- The ripple that is present in the passband is within 0.3 dB.
- In the low frequency band, when the frequency becomes half the frequency that was present at edge fcl of the passband, the attenuation is set to –40 dB.
- In the high frequency band, the width of the transition area, in which the frequency is attenuated –40 dB from the passband edge, is approximately the same as the width of the transition area in the low frequency band.
  (fcl – 1/2fcl = fcus – fcu)
- The stopband attenuation is –40 dB or greater.
- The filter has linear phase and constant group delay.

Sharp Band-Pass Frequency Characteristics Example



In the Sharp band-pass filter, the bandwidth options vary depending on the center frequency.

Sharp Band-Pass Filter Frequency Range

Center Frequency (kHz)	Bandwidth Setting (kHz)	Calculation Frequency (Hz)
300 to 120	200, 150, 100, 50, 20	1 M
118 to 96	150, 100, 50, 20	1 M
94 to 70	100, 50, 20	1 M
68 to 46	50, 20	1 M
44 to 30	20	1 M
29.8 to 12	20, 15, 10, 5, 2	100 k
11.8 to 9.6	15, 10, 5, 2	100 k
9.4 to 7	10, 5, 2	100 k
6.8 to 4.6	5, 2	100 k
4.4 to 3	2	100 k
2.98 to 1.2	2, 1.5, 1, 0.5, 0.2	10 k
1.18 to 0.96	1.5, 1, 0.5, 0.2	10 k
0.94 to 0.7	1, 0.5, 0.2	10 k
0.68 to 0.46	0.5, 0.2	10 k
0.44 to 0.3	0.2	10 k

Order Tables

The orders of each Sharp filter are listed below. The cutoff and center frequency settings are given as percentages of the calculation frequency.

Sharp Low-Pass Filter Orders

Cutoff frequency	2%	3%	4%	5%	6%	7%	8%	9%	10%
Order	94	61	46	37	32	28	24	22	20
Cutoff frequency	11%	12%	13%	14%	15%	16%	17%	18%	19%
Order	17	17	15	14	13	13	11	11	11
Cutoff frequency	20%	21%	22%	23%	24%	25%	26%	27%	28%
Order	10	11	9	9	8	8	8	8	8
Cutoff frequency	29%	30%							
Order	8	8							

Sharp High-Pass Filter Orders

Cutoff frequency	2%	3%	4%	5%	6%	7%	8%	9%	10%
Order	191	127	97	77	65	55	49	45	39
Cutoff frequency	11%	12%	13%	14%	15%	16%	17%	18%	19%
Order	37	33	31	29	27	25	25	23	23
Cutoff frequency	20%	21%	22%	23%	24%	25%	26%	27%	28%
Order	21	21	19	19	19	17	17	17	15
Cutoff frequency	29%	30%							
Order	15	15							

Sharp Band-Pass Filter Orders (Passband width: 2%)

Center frequency	3%	4%	5%	6%	7%	8%	9%	10%	11%
Order	189	142	93	80	69	61	54	49	45
Center frequency	12%	13%	14%	15%	16%	17%	18%	19%	20%
Order	41	37	34	32	27	20	18	18	17
Center frequency	21%	22%	23%	24%	25%	26%	27%	28%	29%
Order	16	16	14	14	14	13	13	12	13
Center frequency	30%								
Order	11								

Sharp Band-Pass Filter Orders (Passband width: 5%)

Center frequency	5%	6%	7%	8%	9%	10%	11%	12%	13%
Order	154	112	93	72	64	58	51	40	37
Center frequency	14%	15%	16%	17%	18%	19%	20%	21%	22%
Order	35	33	31	29	28	26	25	24	23
Center frequency	23%	24%	25%	26%	27%	28%	29%	30%	
Order	22	21	20	19	19	18	17	18	

Sharp Band-Pass Filter Orders (Passband width: 10%)

Center frequency	7%	8%	9%	10%	11%	12%	13%	14%	15%
Order	194	132	97	78	69	57	52	47	39
Center frequency	16%	17%	18%	19%	20%	21%	22%	23%	24%
Order	37	35	33	31	30	28	27	23	23
Center frequency	25%	26%	27%	28%	29%	30%			
Order	20	19	18	18	17	16			

Sharp Band-Pass Filter Orders (Passband width: 15%)

Center frequency	10%	11%	12%	13%	14%	15%	16%	17%	18%
Order	155	110	89	73	62	52	49	41	38
Center frequency	19%	20%	21%	22%	23%	24%	25%	26%	27%
Order	36	34	32	27	26	25	24	23	22
Center frequency	28%	29%	30%						
Order	21	21	21						

Sharp Band-Pass Filter Orders (Passband width: 20%)

Center frequency	12%	13%	14%	15%	16%	17%	18%	19%	20%
Order	191	129	98	78	67	58	49	46	40
Center frequency	21%	22%	23%	24%	25%	26%	27%	28%	29%
Order	38	36	31	29	28	27	26	25	24
Center frequency	30%								
Order	20								

Math Delay

The group delay can be calculated from the following equation. The group delay is constant based on the filter order.

Group delay = (filter order – 1)/2

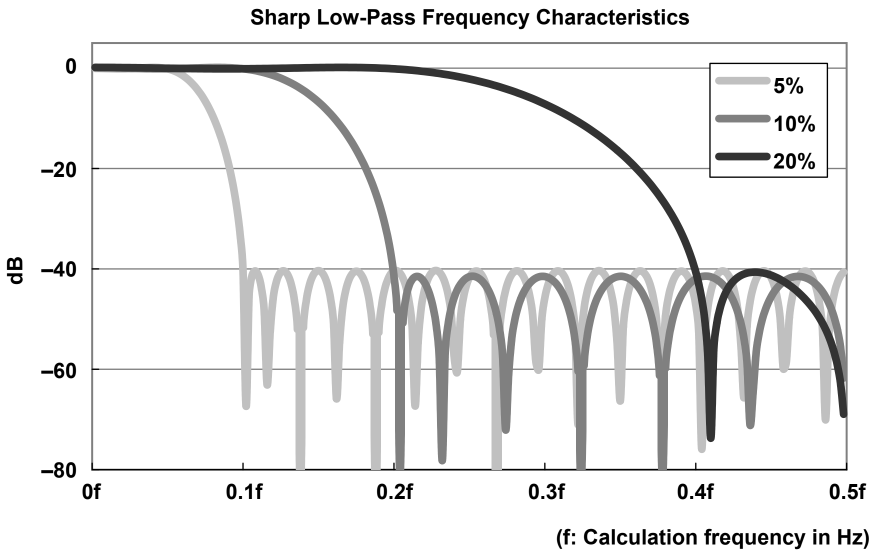
Unit: s/Ts (Ts is the calculation period in seconds)

The math delay can be calculated from the following equation.

Math delay = 1.4 μs + {(filter order – 1)/2} × calculation period

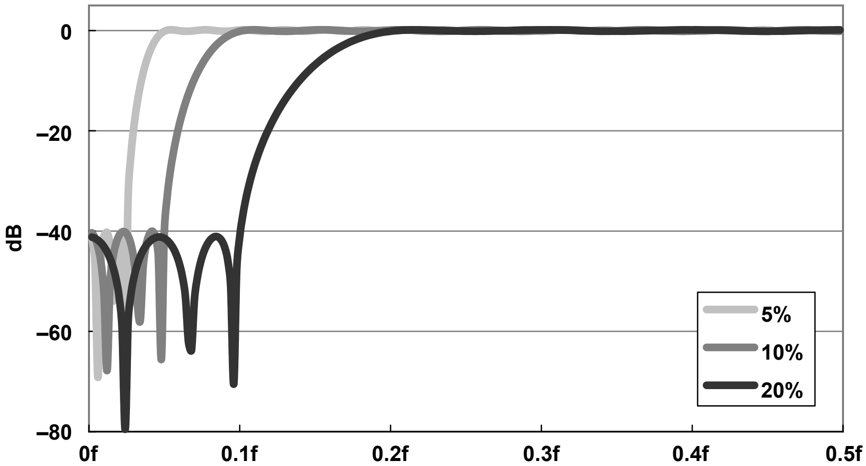
Examples of Characteristics

Sharp Low-Pass



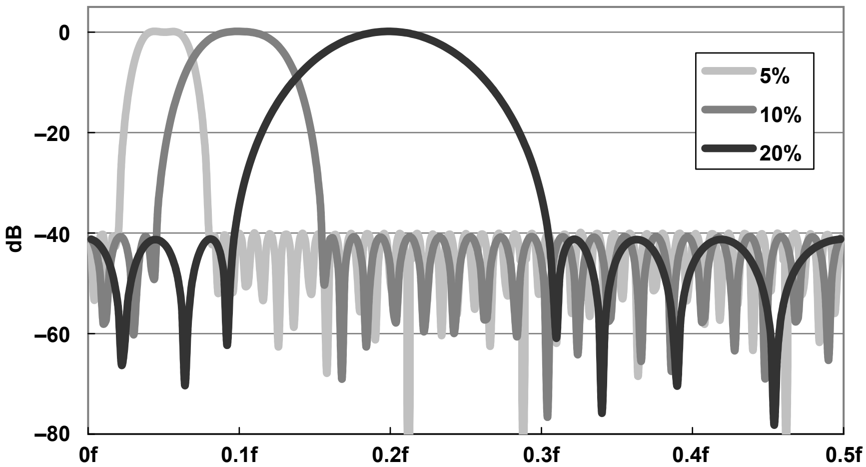
Sharp High-Pass

Sharp High-Pass Frequency Characteristics



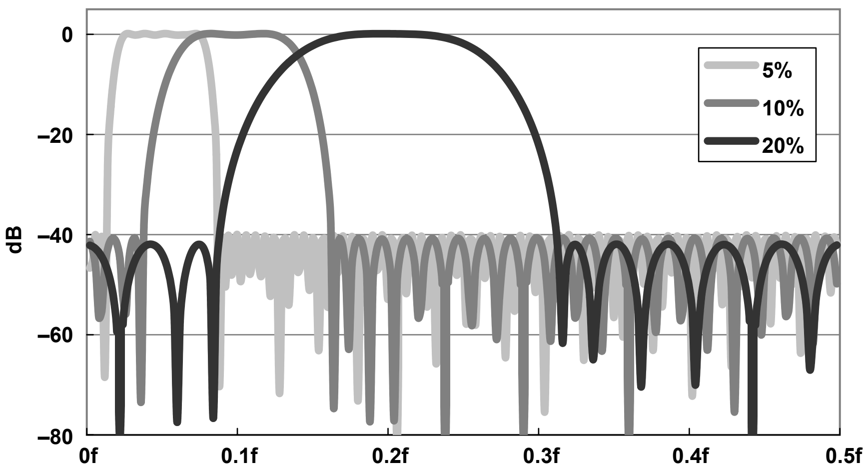
Sharp Band-Pass (Passband width: 2%)

Sharp Band-Pass Frequency Characteristics (Passband width: 2%)



Sharp Band-Pass (Passband width: 5%)

Sharp Band-Pass Frequency Characteristics (Passband width: 5%)



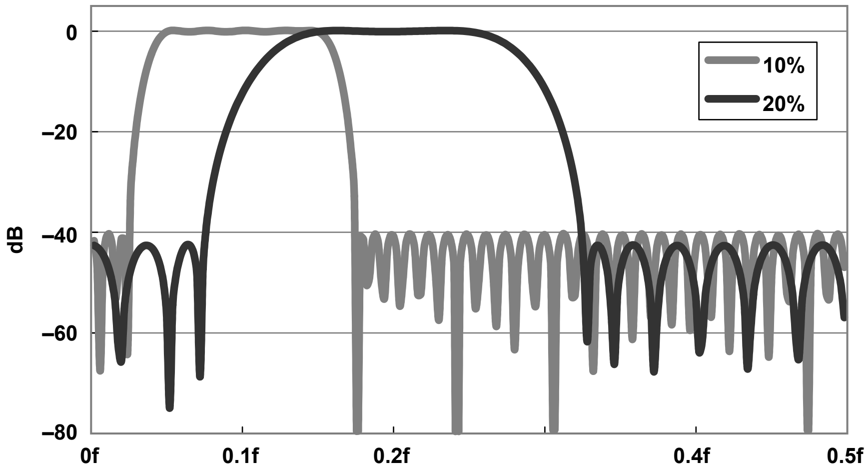
(f: Calculation frequency in Hz)

App

Appendix

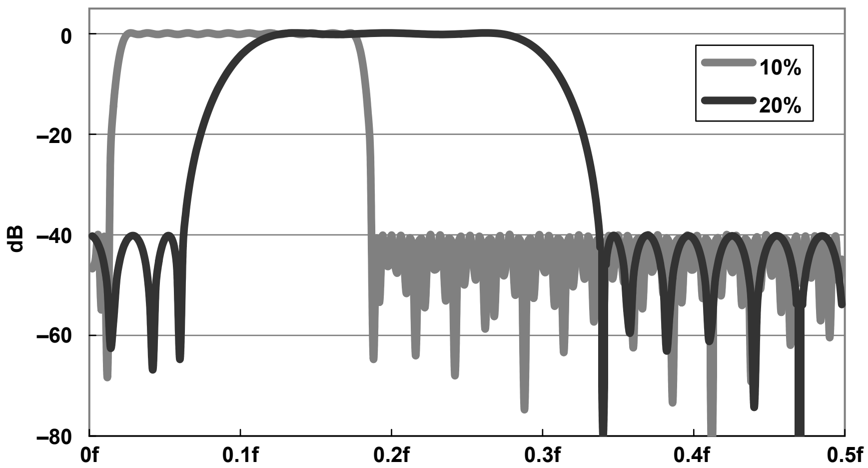
Sharp Band-Pass (Passband width: 10%)

Sharp Band-Pass Frequency Characteristics (Passband width: 10%)



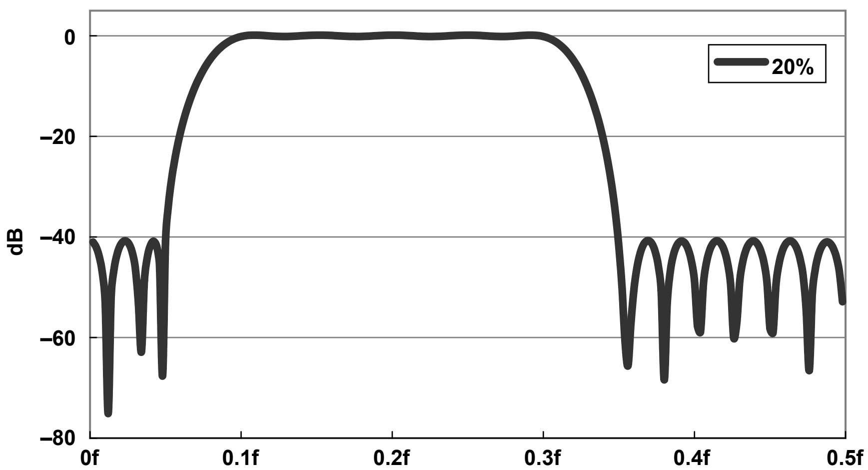
Sharp Band-Pass (Passband width: 15%)

Sharp Band-Pass Frequency Characteristics (Passband width: 15%)



Sharp Band-Pass (Passband width: 20%)

Sharp Band-Pass Frequency Characteristics (Passband width: 20%)



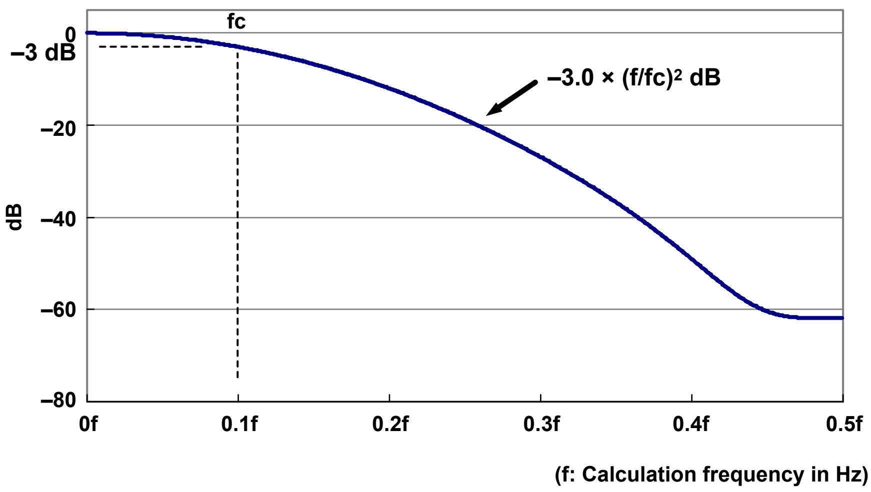
(f: Calculation frequency in Hz)

Gauss Filter

Characteristics

- The passband is flat.
- At the cutoff frequency, the attenuation is –3 dB.
  The damping rate is $-3.0 \times (f/fc)^2$.
- The filter has linear phase and constant group delay.
- The filter can only be set to low-pass.

Gauss Frequency Characteristics Example



Order Table

The orders of the Gauss filter are shown below. The cutoff frequency settings are given as percentages of the calculation frequency.

Gauss Filter Orders

Cutoff frequency	2%	3%	4%	5%	6%	7%	8%	9%	10%
Order	49	33	25	21	17	17	13	13	9
Cutoff frequency	11%	12%	13%	14%	15%	16%	17%	18%	19%
Order	9	9	9	9	9	9	5	5	5
Cutoff frequency	20%	21%	22%	23%	24%	25%	26%	27%	28%
Order	5	5	5	5	5	5	5	5	5
Cutoff frequency	29%	30%							
Order	5	5							

Math Delay

The group delay can be calculated from the following equation. The group delay is constant based on the filter order.

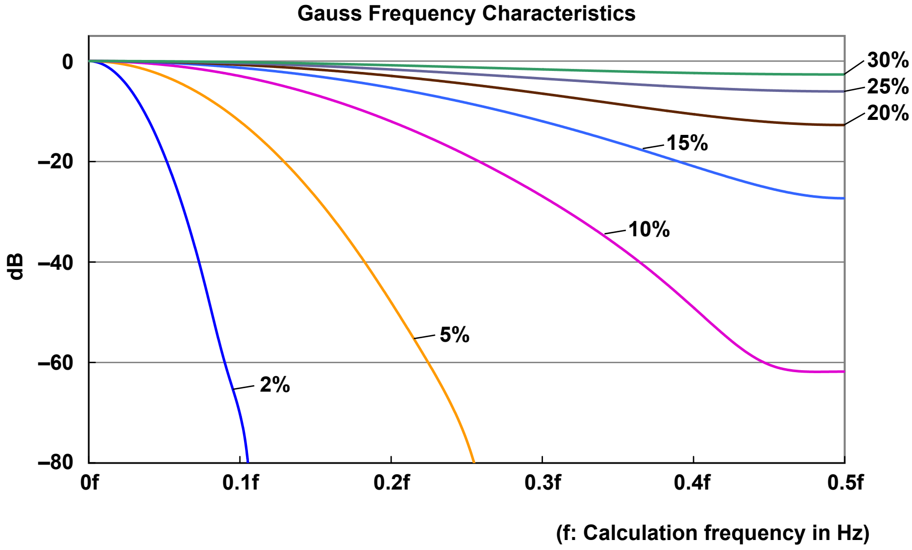
Group delay = (filter order – 1)/2

Unit: s/Ts (Ts is the calculation period in seconds)

The math delay can be calculated from the following equation.

Math delay = 1.4 μs + {(filter order – 1)/2} × calculation period

Example of Characteristics



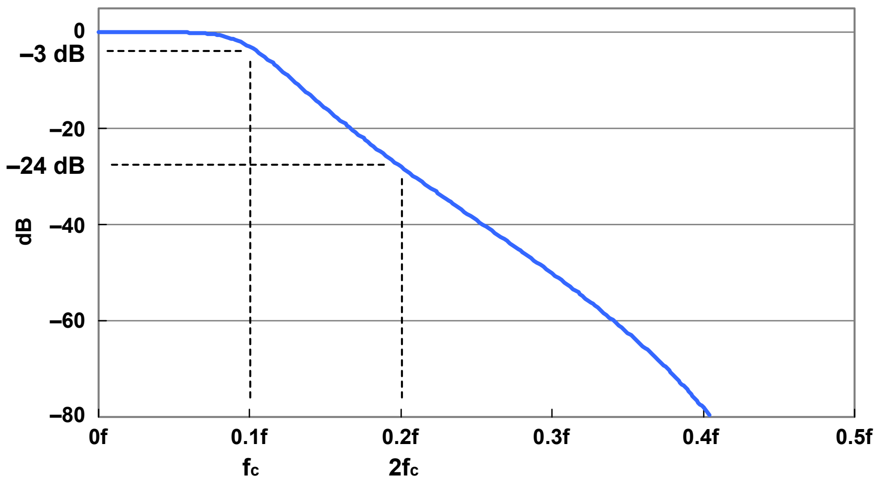
IIR (Butterworth)

Characteristics

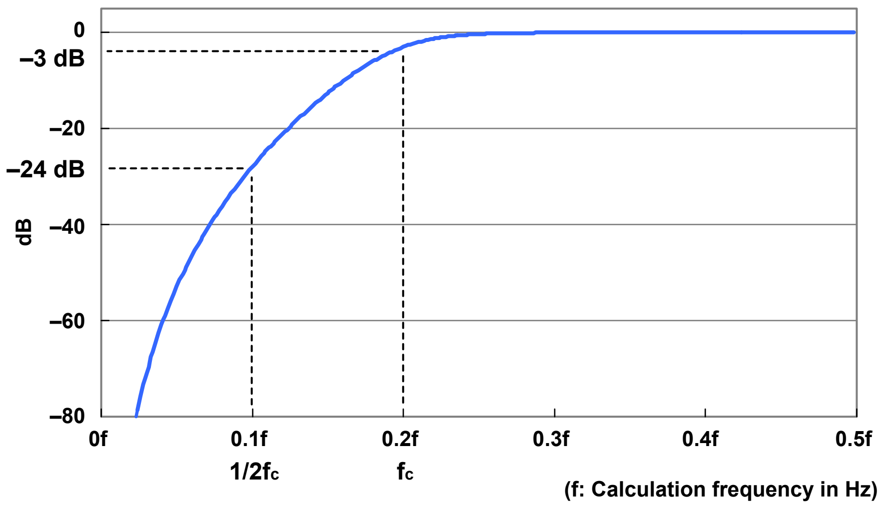
Low-Pass and High-Pass

- This is a fourth order Butterworth filter. The damping rate is approximately –24 dB/oct.
- The passband is flat.
- At the cutoff frequency, the attenuation is –3 dB.
- It has non-linear phase characteristics.
- You can set the frequency lower than other FIR filters.

IIR (Butterworth) Low-Pass Frequency Characteristics Example



IIR (Butterworth) High-Pass Frequency Characteristics Example

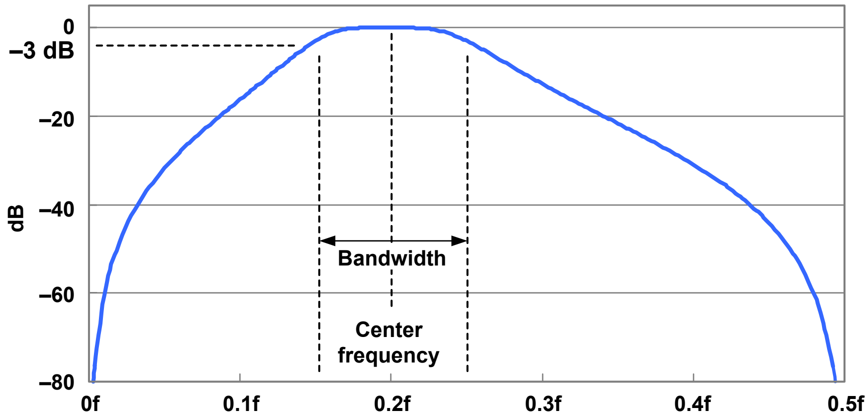


(f: Calculation frequency in Hz)

Band-Pass

- The passband is flat.
- At each end of the passband, the attenuation is –3 dB.
- This is a fourth order Butterworth filter. There are no ripples present in the stopband. For the cutoff characteristic, see “Examples of Characteristics” later in this section.
- It has non-linear phase characteristics.
- You can set the frequency lower than the Sharp filter.

IIR (Butterworth) Band-Pass Frequency Characteristics Example



In the IIR (Butterworth) band-pass filter, the bandwidth options vary depending on the center frequency.

IIR (Butterworth) Band-Pass Filter Frequency Ranges

Center Frequency (kHz)	Bandwidth Setting (kHz)	Calculation Frequency (Hz)
300 to 102	200, 150, 100, 50, 20, 10	1 M
100 to 76	150, 100, 50, 20, 10	1 M
74 to 52	100, 50, 20, 10	1 M
50 to 26	50, 20, 10	1 M
24 to 12	20, 10	1 M
11.8 to 10.2	20, 15, 10, 5, 2, 1	100 k
10 to 7.6	15, 10, 5, 2, 1	100 k
7.4 to 5.2	10, 5, 2, 1	100 k
5 to 2.6	5, 2, 1	100 k
2.4 to 1.2	2, 1	100 k
1.18 to 1.02	2, 1.5, 1, 0.5, 0.2, 0.1	10 k
1 to 0.76	1.5, 1, 0.5, 0.2, 0.1	10 k
0.74 to 0.52	1, 0.5, 0.2, 0.1	10 k
0.5 to 0.26	0.5, 0.2, 0.1	10 k
0.24 to 0.12	0.2, 0.1	10 k
0.1 to 0.06	0.1	10 k

Math Delay

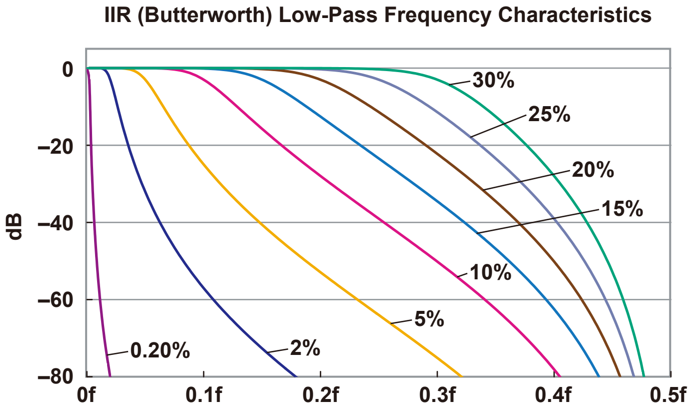
With IIR filters, unlike FIR filters, you cannot define the math delay. This is because the delay varies depending on the input frequency because of the non-linear phase characteristics of IIR filters.
The group delay characteristic indicates the relationship between the frequency of the input signal and the math delay. The math delay can be calculated by adding 1.4 us to the group delay characteristic.

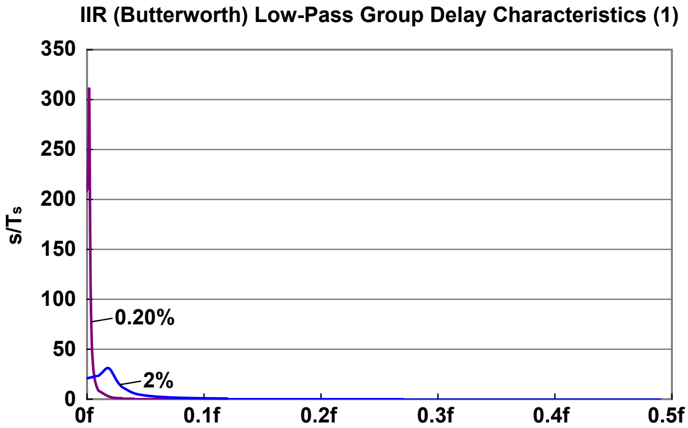
The math delay can be calculated from the following equation.

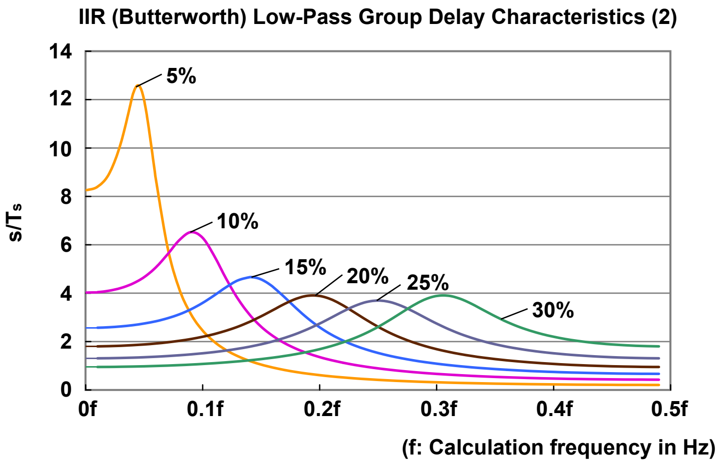
Math delay = (1.4 μs + group delay) × calculation period

Examples of Characteristics

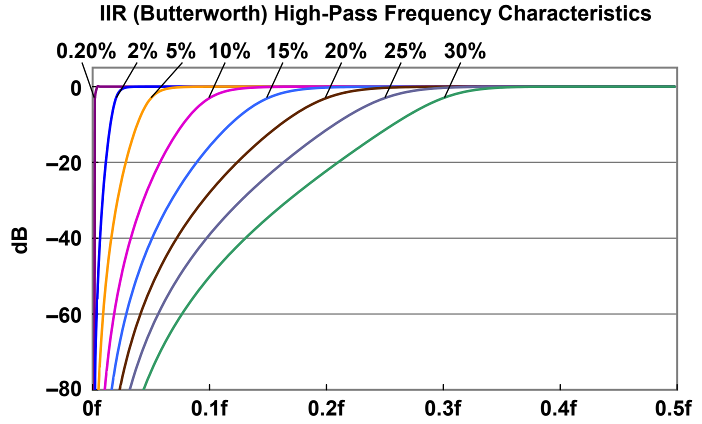
IIR (Butterworth) Low-Pass

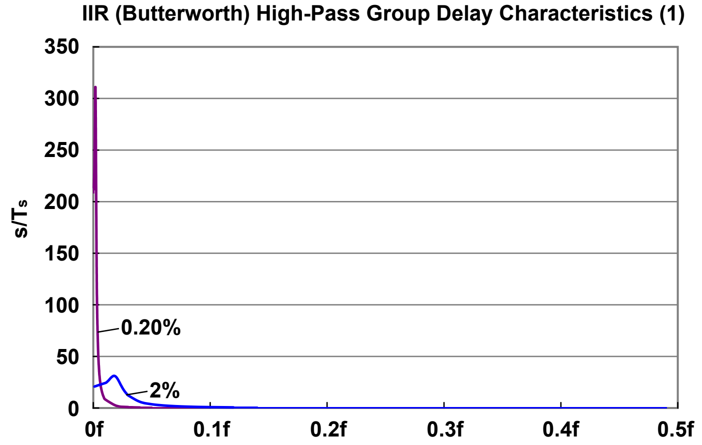


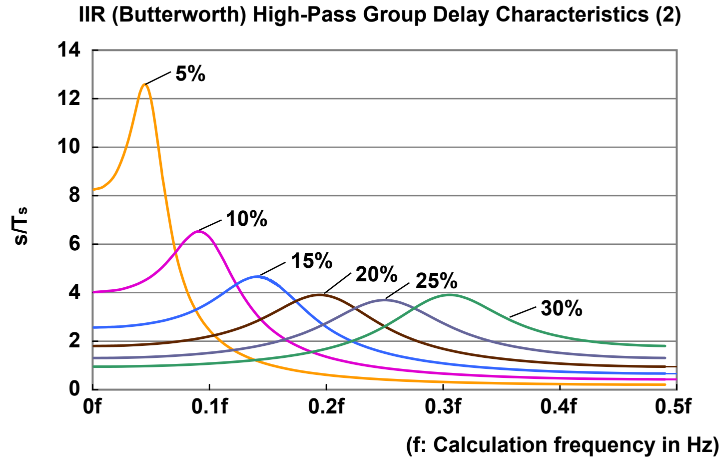




IIR (Butterworth) High-Pass

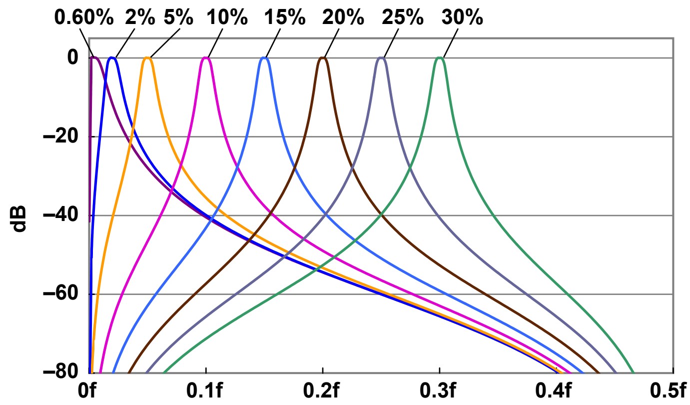




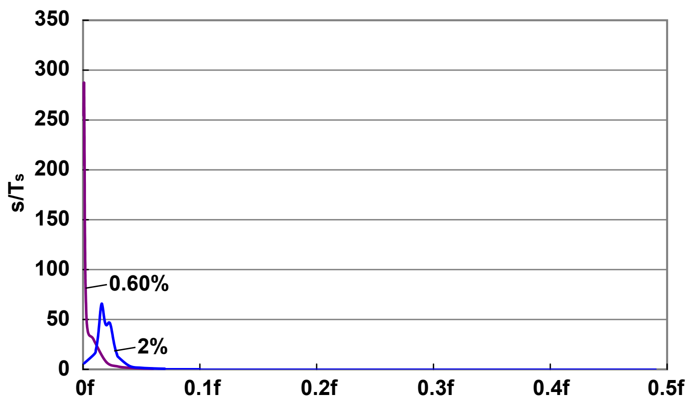


IIR (Butterworth) Band-Pass (Passband width: 1%)

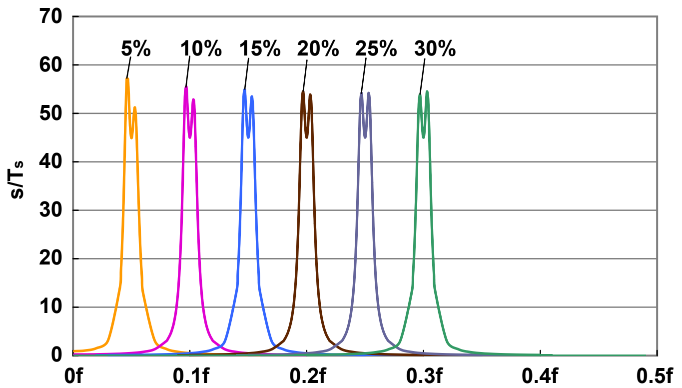
IIR (Butterworth) Band-Pass Frequency Characteristics (Passband width: 1%)



IIR (Butterworth) Band-Pass Group Delay Characteristics (1; passband width: 1%)



IIR (Butterworth) Band-Pass Group Delay Characteristics (2; passband width: 1%)



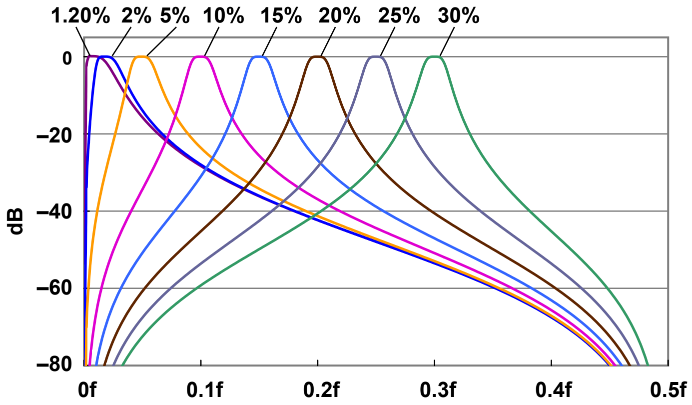
(f: Calculation frequency in Hz)

App

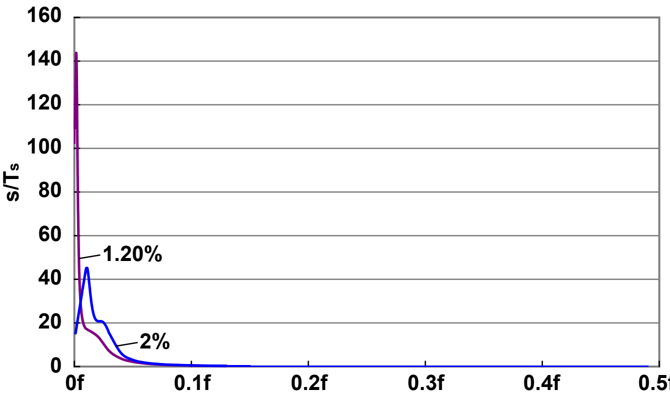
Appendix

IIR (Butterworth) Band-Pass (Passband width: 2%)

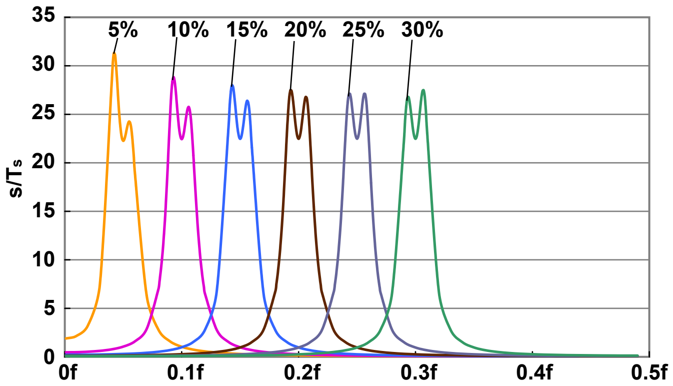
IIR (Butterworth) Band-Pass Frequency Characteristics (Passband width: 2%)



IIR (Butterworth) Band-Pass Group Delay Characteristics (1; passband width: 2%)



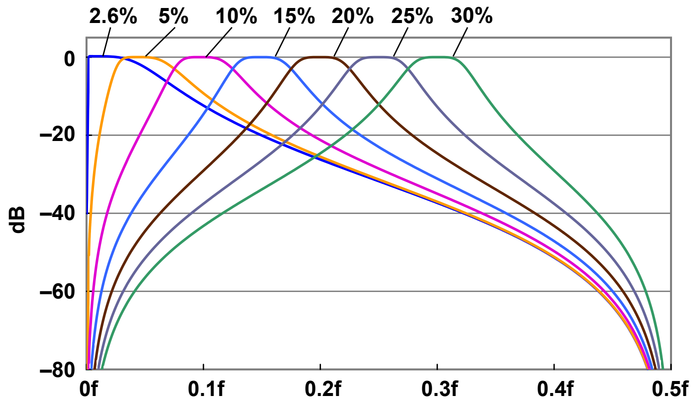
IIR (Butterworth) Band-Pass Group Delay Characteristics (2; passband width: 2%)



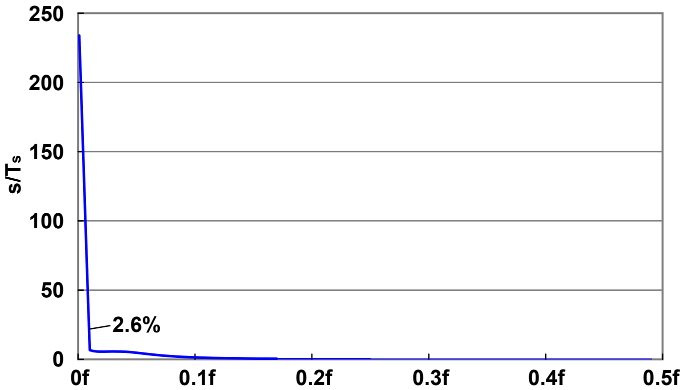
(f: Calculation frequency in Hz)

IIR (Butterworth) Band-Pass (Passband width: 5%)

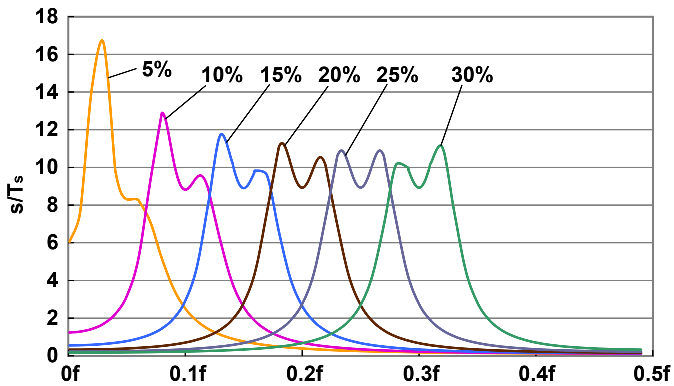
IIR (Butterworth) Band-Pass Frequency Characteristics (Passband width: 5%)



IIR (Butterworth) Band-Pass Group Delay Characteristics (1; passband width: 5%)



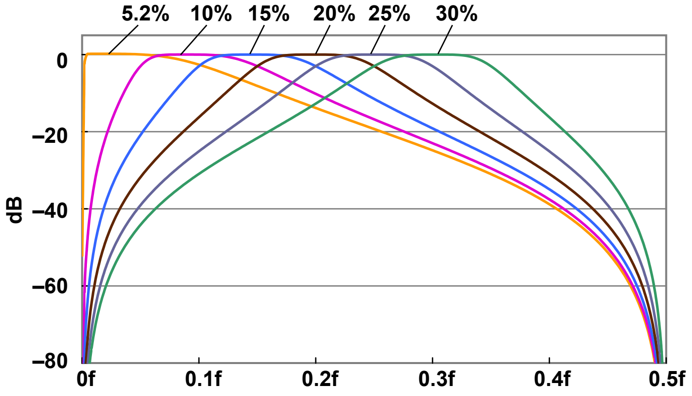
IIR (Butterworth) Band-Pass Group Delay Characteristics (2; passband width: 5%)



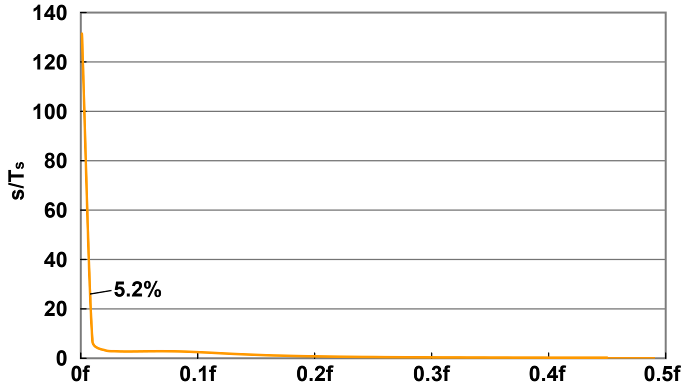
(f: Calculation frequency in Hz)

IIR (Butterworth) Band-Pass (Passband width: 10%)

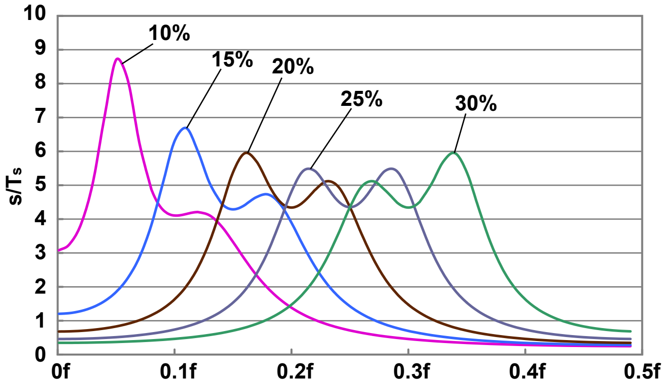
IIR (Butterworth) Band-Pass Frequency Characteristics (Passband width: 10%)



IIR (Butterworth) Band-Pass Group Delay Characteristics (1; passband width: 10%)



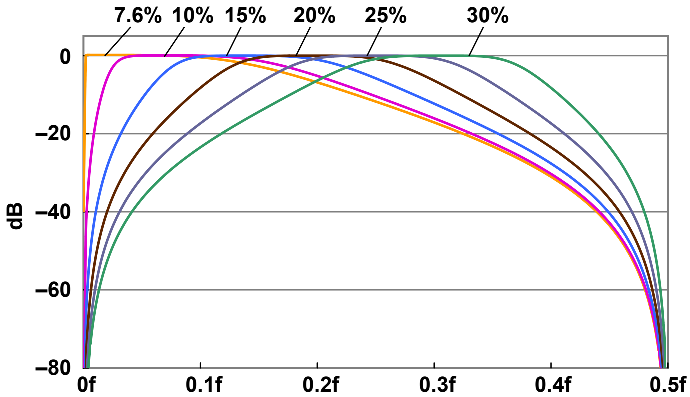
IIR (Butterworth) Band-Pass Group Delay Characteristics (2; passband width: 10%)



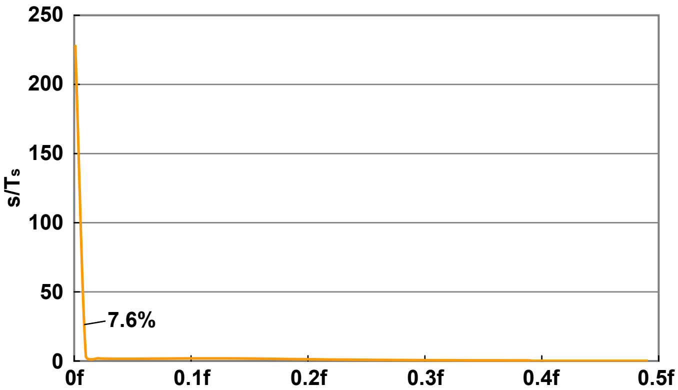
(f: Calculation frequency in Hz)

IIR (Butterworth) Band-Pass (Passband width: 15%)

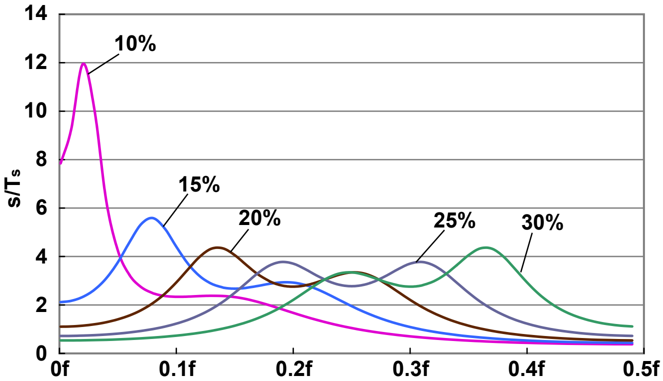
IIR (Butterworth) Band-Pass Frequency Characteristics (Passband width: 15%)



IIR (Butterworth) Band-Pass Group Delay Characteristics (1; passband width: 15%)



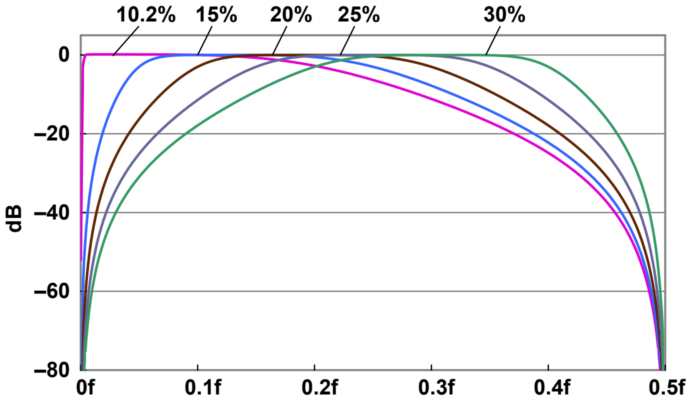
IIR (Butterworth) Band-Pass Group Delay Characteristics (2; passband width: 15%)



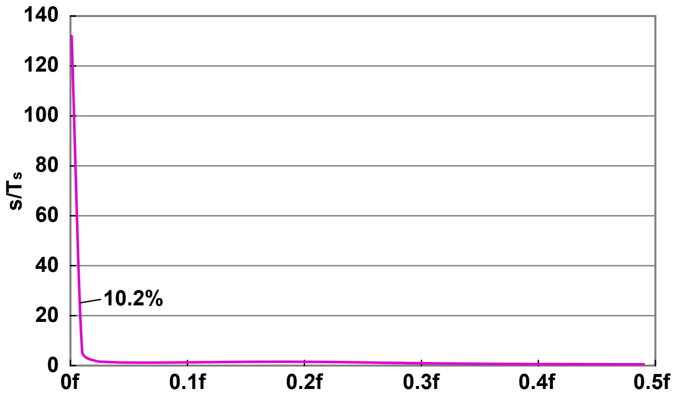
(f: Calculation frequency in Hz)

IIR (Butterworth) Band-Pass (Passband width: 20%)

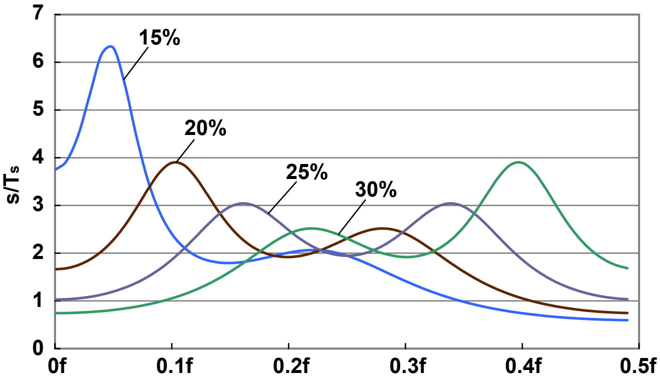
IIR (Butterworth) Band-Pass Frequency Characteristics (Passband width: 20%)



IIR (Butterworth) Band-Pass Group Delay Characteristics (1; passband width: 20%)



IIR (Butterworth) Band-Pass Group Delay Characteristics (2; passband width: 20%)

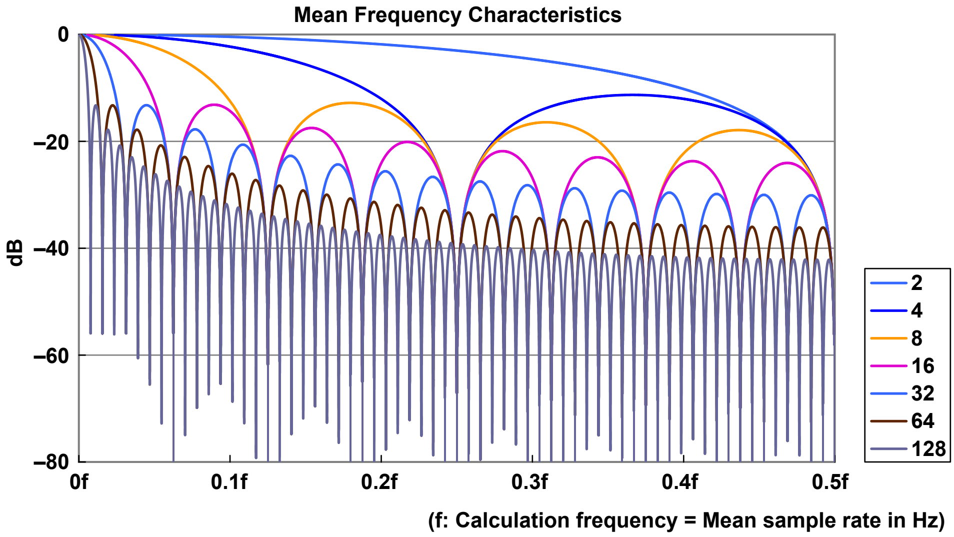


(f: Calculation frequency in Hz)

Mean Filter

Characteristics

- The passband is flat.
- The filter has linear phase and constant group delay.
- The characteristics are those of a low-pass filter.
- The filter has comb-shaped bandwidth characteristics.



Math Delay

The group delay can be calculated from the following equation. The group delay is constant based on the filter order.

Group delay = (number of mean points – 1)/2

Unit: s/Ts (Ts is the calculation period in seconds)

The math delay can be calculated from the following equation.

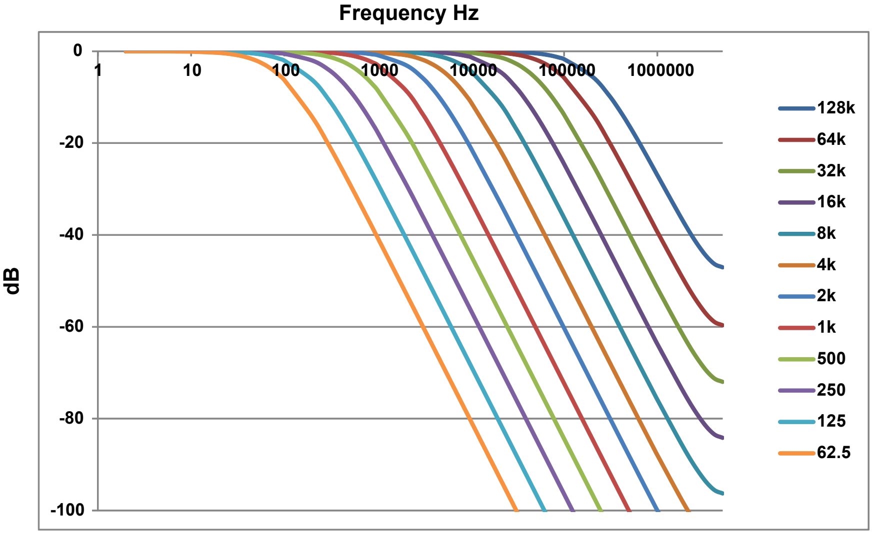
Math delay = 1.4 μs + {(number of mean points – 1)/2} × calculation period

IIR-Lowpass Filter

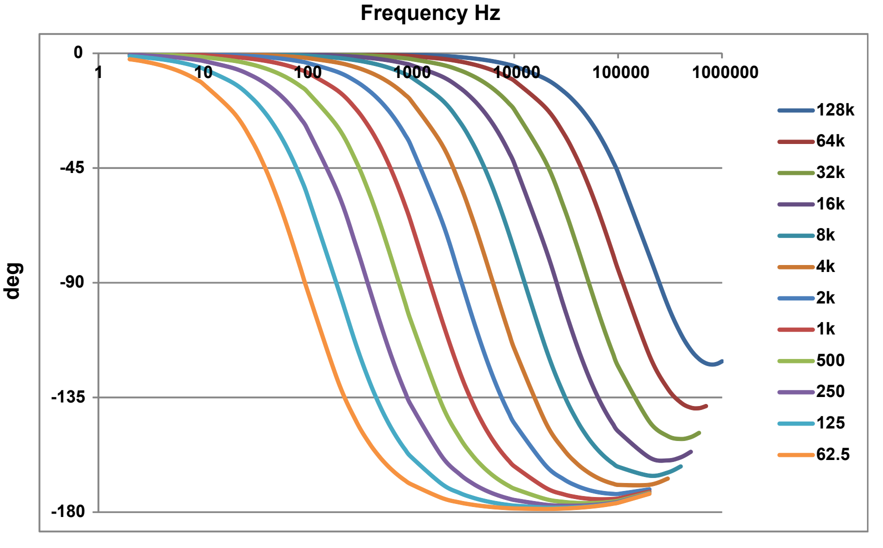
Characteristics

- The passband is flat.
- It has non-linear phase characteristics.

Frequency characteristics



Phase characteristics



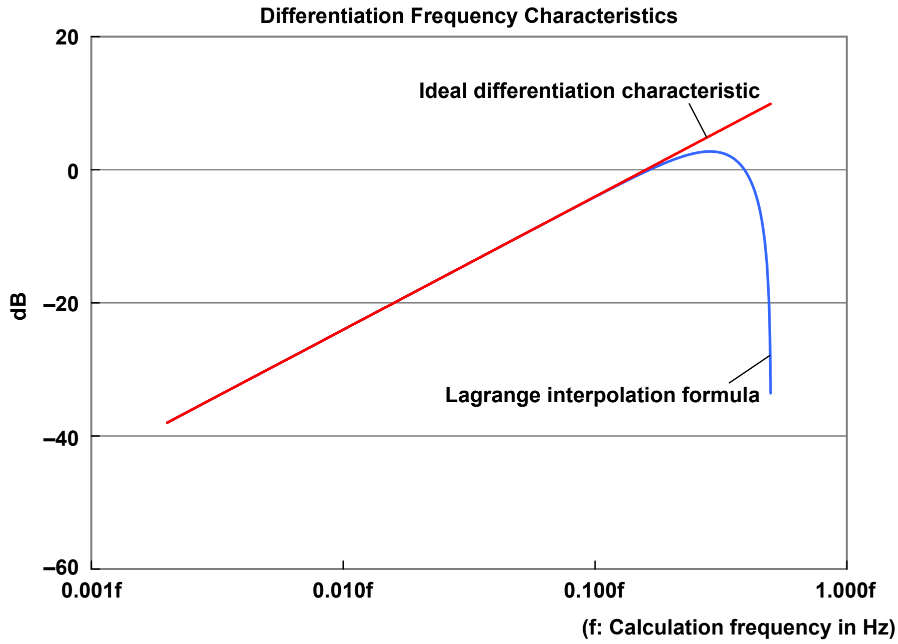
Real Time Math Differentiation

Differentiation Characteristics

The real time math differentiation operation uses a fifth order Lagrange interpolation formula to calculate the differentiated value. The fifth order Lagrange interpolation formula is shown below (see page 5 in the appendix of the *Features Guide*, IM DL850E-01EN).

fn’ = 1/(12Ts){fn-4 – 8fn-3 + 8fn-1 – fn}

The following chart shows the amplitude characteristic in the case where the fifth order Lagrange interpolation formula is used and the ideal differentiation characteristic.



Up to the point where the input frequency is 20% of the calculation period, the differentiation characteristic is almost the same as the ideal differentiation characteristic. At higher frequencies, the high frequency components are restrained by the high-area characteristics of the Lagrange interpolation formula.

Math Delay

The math delay is calculated using the following formula.

Math delay = 1.4 μs + 2 × calculation period*

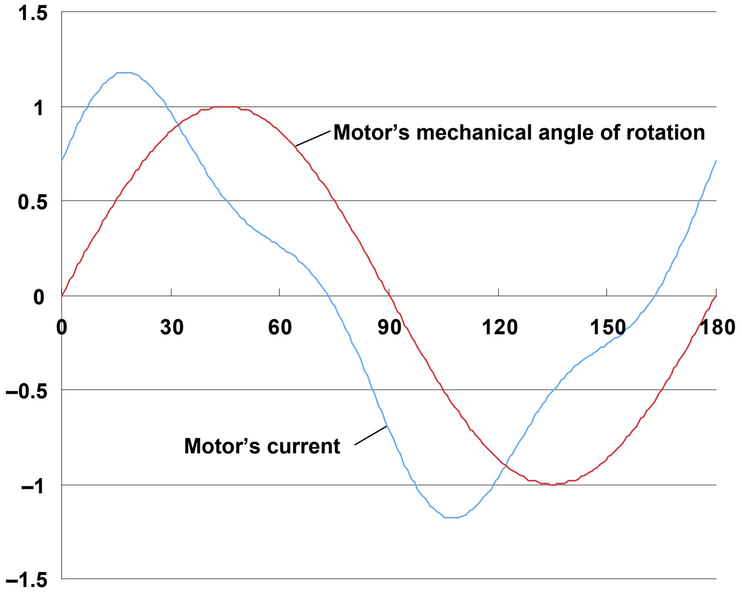
* The “2” in the above formula is the delay due to the Lagrange interpolation formula.

About the Calculation Frequency

Differentiation is calculated at the DL850E/DL850EV sampling frequency. In dual capture mode, it is calculated at the main waveform’s frequency.
However, the upper calculation frequency limit is 10 MHz. If the smaller sample rate exceeds this value, the calculation frequency is set to 10 MHz.
When you are performing external sampling, the calculation frequency is fixed to 10 MHz.

About the Electrical Angle

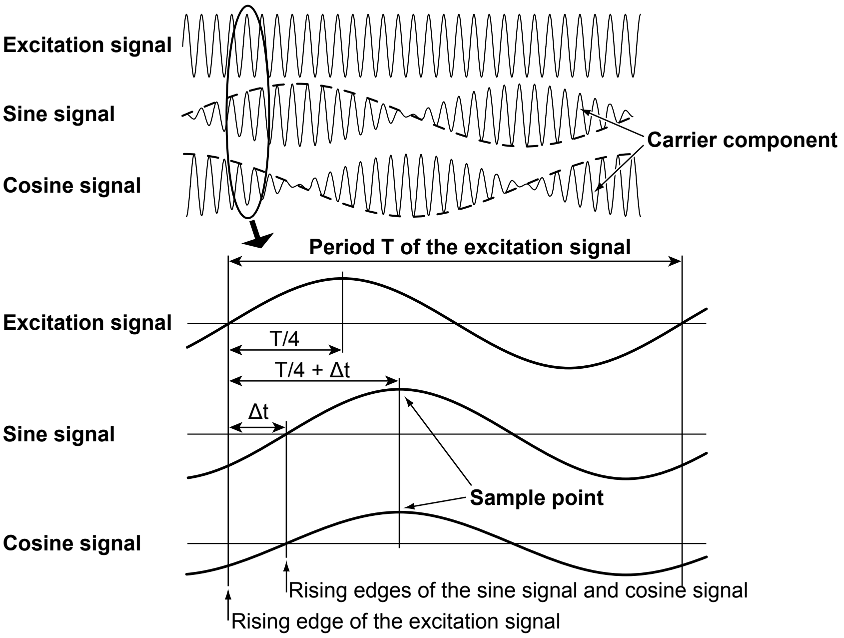
By using the electrical angle math operation, you can calculate the phase difference between the motor's input current and the motor's angle of rotation.
By using an encoder, you can accurately measure the motor's mechanical angle of rotation, but the current waveform using this method is distorted because harmonic components are overlaid on top of it.
In situations such as this, the phase difference between the motor's mechanical angle of rotation and its current cannot be determined in a simple manner.
The real time math feature uses a discrete Fourier transform to determine the fundamental component of the current waveform, and then calculates the phase difference between this fundamental component and the motor's mechanical angle of rotation.



The phase difference is calculated with the motor's mechanical angle of rotation as the reference. If the phase is leading the motor's mechanical angle of rotation, the phase is displayed as a positive value.

Resolver

The angle of rotation is calculated from the excitation signal applied to the resolver and the sine signal and cosine signal that are generated from the detection coils of the resolver. To calculate the angle of rotation precisely, the data of the largest points (the peak values) of the carrier component of the sine and cosine signals are sampled, and the calculation is performed.



When the Sample Mode Is Set to Auto

The rising edge of the excitation signal is detected, and period T of the excitation signal is measured. The rising edges of the sine and cosine signals are also detected, and the time difference Δt between these rising edges and the rising edge of the excitation signal is measured. From period T and time difference Δt, the data at point T/4 + Δt is sampled.

- The Auto setting can be applied when the time difference Δt of the sine and cosine signals in reference to the excitation signal is less than ±90°(T/4).
- Turn the SCALE knob to set the vertical scale (V/div) so that the amplitudes of the excitation, sine, and cosine signals are all ±1.5 div or greater. If the amplitudes are less than ±1.5 div, the Auto function will not operate.

When the Sample Mode Is Set to Manual

The rising edge of the excitation signal is detected, and the data at the point at the specified time after this detected rising edge is sampled.

Tracking Filter

Because the resolver generates discrete signals, the calculation results are also discrete. The DL850E/DL850EV can use a tracking filter to convert the results into a smooth, continuous wave. The tracking filter has a low pass filter. If you set a high cutoff frequency, you can measure a signal that has faster rotations and a higher angular acceleration (change in the number of rotations). On the other hand, the stability and angle resolution in measurements during constant velocity rotations decrease.
The relationship between cutoff frequency and maximum measurable angular acceleration (measurement of the change in the number of rotations) is shown below.

Cutoff Frequency	Maximum Measurable Angular Acceleration
2kHz	140000rps^2
1kHz	54000rps^2
250kHz	1800rps^2
100Hz	180rps^2

When the rotation is fast, if you specify a low cutoff frequency, the DL850E/DL850EV may not be able to calculate the angle correctly. In this situation, set the cutoff frequency to a higher value.

Math Flowchart and Internal Math Expressions of Real Time Math

The math flowchart of real time math is shown below. The real time math I/O is 16-bit binary data (if the input is only 12 bits in length, it is converted to 16 bits).
Internally, real time math is performed on 32-bit floating point data, so I/O data is converted with 1 LSB weight.
Note that 16-bit binary output data is converted with the 1 LSB weight that is determined by value/div. The I/O data is normalized to 2400 LSB/div when displayed on the screen.

Math Input: Conversion of 16-Bit Binary Data to Floating-Point Data

Math source data is acquired into real time math, and at the same time, is converted with 1 LSB weight into floating-point format.
A (float) = A (binary) × (1 LSB weight)
B (float) = B (binary) × (1 LSB weight)

Internal Math

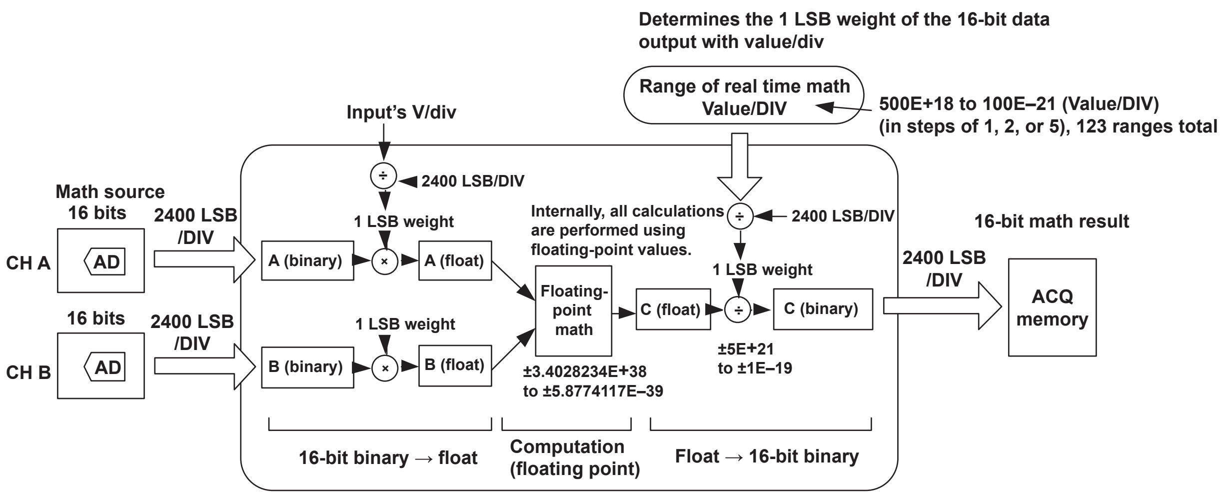
All internal real time math operations are performed using floating-point data.
Example: C (float) = A (float) + B (float)

Calculation of the 1 LSB Weight of the Output

The 1 LSB weight of the output is determined from the real time math range (value/div).
Because 1 div = 2400 LSB,
1 LSB weight of the output = (value/div)/2400.

Math Output: Conversion of Floating-Point Data to 16-Bit Binary Data

The output is converted to 16-bit data through the following formula.
C (binary) = C (float)/(1 LSB weight)



Appendix 2 Equations for Power Analysis and Harmonic Analysis

Power Analysis Equation (For Each Source Channel)

Urms, Irms (True Rms Value, RMS)

These values are the true rms values of the voltage and current. The instantaneous values over one period are squared and averaged. Then, the square root of the value is determined. u(n) is the instantaneous voltage, i(n) is the instantaneous current, n is the nth calculation period based on the synchronization source setting, and T is the number of samples.

$$\mathrm{Urms} = \sqrt{\frac{1}{T}\int_0^T u(n)^2\,dt} \qquad \mathrm{Irms} = \sqrt{\frac{1}{T}\int_0^T i(n)^2\,dt}$$

Umn, Imn (Rectified Mean Value Calibrated to the Rms Value, MEAN)

This function rectifies one period of the voltage or current signal, determines the average, and multiplies the result by a coefficient. The coefficient is a value that when applied to a sinusoidal input signal, gives the true rms value. When the input signal is a distorted or is a DC waveform, these values will differ from the true rms values. u(n) is the instantaneous voltage, i(n) is the instantaneous current, n is the nth calculation period based on the synchronization source setting, and T is the number of samples.

$$\mathrm{Umn} = \frac{\pi}{2\sqrt{2}} \cdot \frac{1}{T}\int_0^T |u(n)|\,dt \qquad \mathrm{Irms} = \frac{\pi}{2\sqrt{2}} \cdot \frac{1}{T}\int_0^T |i(n)|\,dt$$

Note

You can select RMS or MEAN on the DL850E/DL850EV. Regardless of which you select, the values are displayed as Urms and Irms on the DL850E/DL850EV screen.

Udc, Idc (Simple Average, DC)

These are the average values over one period of the voltage and current signals. This function is useful when determining the average value of a DC input signal or a DC component that is superimposed on an AC input signal. u(n) is the instantaneous voltage, i(n) is the instantaneous current, n is the nth calculation period based on the synchronization source setting, and T is the number of samples.

$$\mathrm{Udc} = \frac{1}{T}\int_0^T u(n)\,dt \qquad \mathrm{Idc} = \frac{1}{T}\int_0^T i(n)\,dt$$

Uac, Iac (AC Component, AC)

These are the AC components of the voltage and current. They are the square root values of the difference of the square of the true rms values of the input signal and the square of the DC component.

$$\mathrm{Uac} = \sqrt{\mathrm{Urms}^2 - \mathrm{Udc}^2} \qquad \mathrm{Iac} = \sqrt{\mathrm{Irms}^2 - \mathrm{Idc}^2}$$

P (Active Power)

This value is determined by multiplying together the instantaneous voltages and currents over one period and taking the average. u(n) is the instantaneous voltage, i(n) is the instantaneous current, n is the nth calculation period based on the synchronization source setting, and T is the number of samples.

$$P = \frac{1}{T}\int_0^T u(n) \cdot i(n)\,dt$$

S (Apparent Power)

This value is determined by multiplying together the rms voltages and currents over one period.

$$P = \mathrm{Urms} \cdot \mathrm{Irms}$$

App

Appendix

Q (Reactive Power)

This the square root of the difference of the square of the apparent power and the square of the active power over one period. s is the sign for the lead and lag of each source channel. It is negative when the current leads the voltage. It is positive when the current rags the voltage.

$$Q = s\sqrt{S^2 - P^2}$$

λ (power factor)

This value is determined by dividing the active power by the apparent power over one period.

$$\lambda = \frac{P}{S}$$

φ (Phase Angle)

This is the arc cosine ($\cos^{-1}$) of the value obtained by dividing the active power by the apparent power over one period. It is negative when the current leads the voltage. It is positive when the current rags the voltage.

$$\varphi = \cos^{-1}\left(\frac{P}{S}\right)$$

WP (Integrated Power), WP+ (Positive Integrated Power: Consumed Watt-Hours), WP- (Negative Integrated Power: Watt-Hours Returned to the Power Supply)

These values are determined by multiplying together the instantaneous voltages and currents and integrating them for the number of samples.

$$\text{WP, WP+, or WP-} = \int_0^T u(n) \bullet i(n)\,dt$$

q (Integrated Ampere-Hour), q+ (Positive Integrated Ampere-Hour), q- (Negative Integrated Ampere-Hour)

These values are determined by integrating the currents for the number of samples.

$$q = \int_0^T \text{Irms}\,dt \qquad q+,\ q- = \int_0^T i(n)\,dt$$

WS (Volt-Ampere Hours)

This value is determined by multiplying together the rms voltages and currents over one period and integrating them for the number of samples.

$$WS = \int_0^T \text{Urms} \bullet \text{Irms}\,dt$$

WQ (Var Hours)

This value is determined by taking the square root of the difference of the square of the apparent power and the square of the active power over one period and integrating them for the number of samples.

$$WQ = \int_0^T s\sqrt{S^2 - P^2}\,dt$$

Impedance (Z)

This value is determined by dividing the rms voltages and currents over one period.

$$Z = \frac{Urms}{Irms}$$

Series Resistance (RS)

This value is determined by dividing the active power over one period by the square of the rms current.

$$\frac{P}{Irms^2}$$

Series Reactance (XS)

This value is determined by dividing the reactive power over one period by the square of the rms current.

$$\frac{Q}{Irms^2}$$

Parallel Resistance (RP)

This value is determined by dividing the square of the rms voltage by the active power over one period.

$$\frac{Urms^2}{P}$$

Parallel Reactance (XP)

This value is determined by dividing the square of the rms voltage by the reactive power over one period.

$$\frac{Urms^2}{Q}$$

Three-Phase Unbalance Factor

This is determined by the following equation. The three-phase unbalance factor can be calculated only when the wiring system is set to 3P3W (3V3A), 3P4W, 3P3W→3P3W(3V3A), 3P3W(3V3A)→3P4W, or 3P4W→3P3W(3V3A).

- **Three-Phase Voltage Unbalance Factor**

  With respect to line voltages Urs, Ust, and Utr (rms),

$$\text{Three-phase voltage unbalance factor } K = \frac{U_2}{U_1} \times 100\%$$

where

$$U_1 = \sqrt{(1/6)(Urs^2+Ust^2+Utr^2) + (2/\sqrt{3})\sqrt{Ua(Ua-Urs)(Ua-Ust)(Ua-Utr)}}$$

$$U_2 = \sqrt{(1/6)(Urs^2+Ust^2+Utr^2) - (2/\sqrt{3})\sqrt{Ua(Ua-Urs)(Ua-Ust)(Ua-Utr)}}$$

$$U_a = \frac{(Urs+Ust+Utr)}{2}$$

- **Three-Phase Current Unbalance Factor**

  With respect to currents I1, I2, and I3 (rms),

$$\text{Three-phase voltage unbalance factor } K = \frac{I_2}{I_1} \times 100\%$$

where

$$I_1 = \sqrt{(1/6)(I1^2+I2^2+I3^2) + (2\sqrt{3})\sqrt{(Ia(Ia-I1)(Ia-I2)(Ia-I3)}}$$

$$I_2 = \sqrt{(1/6)(I1^2+I2^2+I3^2) - (2\sqrt{3})\sqrt{(Ia(Ia-I1)(Ia-I2)(Ia-I3)}}$$

$$Ia = \frac{(I1+I2+I3)}{2}$$

The three-phase unbalance factor is calculated by determining the rms values from the following values for each sample for each wiring system.

	3P3W (3V3A)	3P4W	3P3W→ 3P3W (3V3A)	3P3W(3V3A)→ 3P4W	3P4W→ 3P3W (3V3A)
Urs	u1	u1-u2	u1	u1	u1-u2
Ust	u2	u2-u3	u2	u2	u2-u3
Utr	u3	u3-u1	u1-u2	u3	u3-u1
I1	i1	i1	i1	i1	i1
I2	i2	i2	i2	i2	i2
I3	i3	i3	i3	i3	i3

Motor Efficiency

This value is determined by dividing the rotating speed by the total active power.

$$\eta = \frac{Pm}{P\Sigma} \times 100\%$$

Integration Time

This is the time from integration start to integration stop.

Power Analysis Equations (Wiring Unit Σ)

Measurement Function (Σ Function)		Equation: Single-Phase Three-Wire (1P3W)	Three-Phase Three-Wire (3P3W)	Three-Voltage Three-Current Method (3V3A)	Three-Phase Four-Wire (3P4W)
U [V]	Power analysis				
	UrmsΣ	(Urms1 + Urms2) / 2		(Urms1 + Urms2 + Urms3) / 3	
	UmnΣ	(Umn1 + Umn2) / 2		(Umn1 + Umn2 + Umn3) / 3	
	UdcΣ	(Udc1 + Udc2) / 2		(Udc1 + Udc2 + Udc3) / 3	
	UacΣ	(Uac1 + Uac2) / 2		(Uac1 + Uac2 + Uac3) / 3	
	Harmonic analysis				
	UΣ	(U1 + U2) / 2		(U1 + U2 + U3) / 3	
I [A]	Power analysis				
	IrmsΣ	(Irms1 + Irms2) / 2		(Irms1 + Irms2 + Irms3) / 3	
	ImnΣ	(Imn1 + Imn2) / 2		(Imn1 + Imn2 + Imn3) / 3	
	IdcΣ	(Idc1 + Idc2) / 2		(Idc1 + Idc2 + Idc3) / 3	
	IacΣ	(Iac1 + Iac2) / 2		(Iac1 + Iac2 + Iac3) / 3	
	Harmonic analysis				
	IΣ	(I1 + I2) / 2		(I1 + I2 + I3) / 3	
PΣ [W]		P1 + P2			P1 + P2 + P3
SΣ [VA]	Power analysis				
		S1 + S2	$\frac{\sqrt{3}}{2}$(S1 + S2)	$\frac{\sqrt{3}}{3}$(S1 + S2 + S3)	S1 + S2 + S3
	Harmonic analysis				
		$\sqrt{P\Sigma^2 + Q\Sigma^2}$			
QΣ [var]	Power analysis				
		$\sqrt{S\Sigma^2 - P\Sigma^2}$			
	Harmonic analysis	Q1 + Q2			Q1 + Q2 + Q3
λΣ		$\frac{P\Sigma}{S\Sigma}$			
φΣ [°]		$\cos^{-1}\left(\frac{P\Sigma}{S\Sigma}\right)$ (only for power analysis)			
ZΣ [Ω]		$\frac{S\Sigma}{Irms\Sigma^2}$ (only for power analysis)			
RSΣ [Ω]		$\frac{P\Sigma}{Irms\Sigma^2}$ (only for power analysis)			
XSΣ [Ω]		$\frac{Q\Sigma}{Irms\Sigma^2}$ (only for power analysis)			
RPΣ [Ω] (= 1/G)		$\frac{Urms\Sigma^2}{P\Sigma}$ (only for power analysis)			
XPΣ [Ω] (= 1/B)		$\frac{Urms\Sigma^2}{Q\Sigma}$ (only for power analysis)			
η (efficiency 1) [%]		$\frac{P\Sigma B}{P\Sigma A} \cdot 100$ (only for power analysis)			
1/η (efficiency 2) [%]		$\frac{P\Sigma A}{P\Sigma B} \cdot 100$ (only for power analysis)			

Note

- PΣ, QΣ, and λΣ are equations that apply both to power analysis and harmonic analysis.
- Each symbol denotes the measurement function of each source channel that is determined during power analysis or harmonic analysis.
- The letters A and B of ΣA and ΣB denote the combinations of wiring systems.
- A represents Wiring System1, and B represents Wiring System2.

Harmonic Analysis Equations

(Table 1/2)

Measurement Function	Methods of Determination and Equation: Harmonic measurement of measurement function	Methods of Determination and Equation: Total {( ) none }
Voltage Vrms [V]	$U(k) = \sqrt{u_r(k)^2 + u_j(k)^2}$	$U = \sqrt{\sum_{k=1}^{max} U(k)^2}$
Current Irms [A]	$I(k) = \sqrt{i_r(k)^2 + i_j(k)^2}$	$I = \sqrt{\sum_{k=1}^{max} I(k)^2}$
Active power P [W]	$P(k) = u_r(k) \cdot i_r(k) + u_j(k) \cdot i_j(k)$	$P = \sum_{k=1}^{max} P(k)$
Apparent power S [VA]	—	$S = \sqrt{P^2 + Q^2}$
Reactive power Q [var]	$Q(k) = u_r(k) \cdot i_r(k) - u_j(k) \cdot i_j(k)$	$Q = \sum_{k=1}^{max} Q(k)$
Power factor λ	—	$\lambda = \frac{P}{S}$
Phase angle φ [°]	φ(k) = (nth harmonic phase) – (fundamental phase) x k When the source is voltage in Line RMS mode, $\tan^{-1}\left\{\frac{u_r(k)}{u_j(k)}\right\} - \tan^{-1}\left\{\frac{u_r(1)}{u_j(1)}\right\} \times k$ When the source is current in Line RMS mode, $\tan^{-1}\left\{\frac{i_r(k)}{i_j(k)}\right\} - \tan^{-1}\left\{\frac{i_r(1)}{i_j(1)}\right\} \times k$ When Power mode, $\tan^{-1}\left\{\frac{Q_r(k)}{P_j(k)}\right\} - \tan^{-1}\left\{\frac{Q_r(1)}{P_j(1)}\right\} \times k$	—
Harmonic distortion factor (IEC) THDIEC	Calculates the ratio of the total rms value from the 2nd to the 40th harmonic to the fundamental wave. Distortion factor (IEC) = $\sqrt{\frac{\sum_{n=2}^{40} (\text{nth harmonic rms voltage (or current)})^2}{(\text{fundamental rms voltage (or current)})^2}}$	
Harmonic distortion factor (CSA) THDCSA	Calculates the ratio of the total rms value from the 2nd to the 40th harmonic to the total rms value from the fundamental to the 40th harmonic. Distortion factor (CSA) = $\sqrt{\frac{\sum_{n=2}^{40} (\text{nth harmonic rms voltage (or current)})^2}{\sum_{n=1}^{40} (\text{nth harmonic rms voltage (or current)})^2}}$	

Note

- k denotes a harmonic order, r denotes the real part, and j denotes the imaginary part.
- max is 40 when the analysis mode is Line RMS and 35 when it is Power.

(Table 2/2)

<table>
<tr><th rowspan="2">Measurement Function</th><th>Methods of Determination and Equation</th></tr>
<tr><th>Harmonic order of measurement function</th></tr>
<tr><td>Harmonic voltage distortion factor
Uhdf [%]</td><td>$\frac{U(k)}{U(1)} \cdot 100$</td></tr>
<tr><td>Harmonic current distortion factor
Ihdf [%]</td><td>$\frac{I(k)}{I(1)} \cdot 100$</td></tr>
<tr><td>Harmonic active power
distortion factor
Phdf [%]</td><td>$\frac{P(k)}{P(1)} \cdot 100$</td></tr>
</table>

Note

- k denotes a harmonic order.

Power Analysis Equations (Delta Math)

Computed results are determined by substituting all of the sampled data in the table into the equations for voltage U and current I.* The synchronization source used in delta computation is the same source as the source of the first source channel (the input element with the smallest number) in the wiring unit that is subject to delta computation.

<table>
<tr><th rowspan="12">Delta Function</th><th rowspan="2">Delta Math Type φΣ [°]</th><th colspan="2">Substituted Sampled Data</th><th colspan="2" rowspan="2">Data Determined by Delta Math and Examples of Measurement Functions and Symbols</th><th rowspan="2">Notes</th></tr>
<tr><th>u (t)</th><th>i (t)</th></tr>
<tr><td>3P3W→3V3A</td><td>u1− u2</td><td>− i1− i2</td><td>Unmeasured line current calculated in a three-phase three-wire system</td><td>Urms1, Umn1, Udc1, Uac1
Irms1, Imn1, Idc1, Iac1</td><td>Assumption
i1+i2+i3=0</td></tr>
<tr><td rowspan="4">Delta→Star</td><td>$u1-\frac{(u1+u2)}{3}$</td><td>———</td><td rowspan="3">Phase voltage calculated in a three-phase t hree-wire (3V3A) system</td><td>Urms1, Umn1, Udc1, Uac1</td><td rowspan="4">Assumption
Calculated on the assumption that the center of the delta connection is the center of the star connection.</td></tr>
<tr><td>$u2-\frac{(u1+u2)}{3}$</td><td>———</td><td>Urms2, Umn2, Udc2, Uac2</td></tr>
<tr><td>$-\frac{(u1+u2)}{3}$</td><td>———</td><td>Urms3, Umn3, Udc3, Uac3</td></tr>
<tr><td>———</td><td>i1+i2+i3</td><td>Neutral line current</td><td>In</td></tr>
<tr><td rowspan="4">Star→Delta</td><td>u1−u2</td><td>———</td><td rowspan="3">Line voltage calculated in a three-phase four-wire system</td><td>Urms1, Umn1, Udc1, Uac1</td><td rowspan="4">———</td></tr>
<tr><td>u2−u3</td><td>———</td><td>Urms2, Umn2, Udc2, Uac2</td></tr>
<tr><td>u3−u1</td><td>———</td><td>Urms3, Umn3, Udc3, Uac3</td></tr>
<tr><td>———</td><td>i1+i2+i3</td><td>Neutral line current</td><td>In</td></tr>
</table>

* Equations for voltage U and current I for “Power Analysis Equation (For Each Source Channel)”

Note

u1, u2, and u3 represent the sampled voltage data of source channel 1, 2, and 3, respectively. i1, i2, and i3 represent the sampled current data of source channel 1, 2, and 3, respectively.

Power Math Measurement Functions

Power Analysis (Power)

When the Analysis Mode is 1Wiring System

Channels/ Sub channels	Symbol	Math Item	Supported Wiring Systems							
			1P2W	1P3W	3P3W	3P3W (3V3A)	3P4W	3P3W (3P3W->3V3A)	3V3A->3P4W (Delta->Start)	3P4W->3V3A (Start->Delta)
CH13_1	**UrmsΣ**	**Rms voltage**		**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
CH13_2	Urms1	Each rms voltage	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
CH13_3	Urms2	Each rms voltage		Yes	Yes	Yes	Yes	Yes	Yes	Yes
CH13_4	Urms3	Each rms voltage				Yes	Yes	Yes	Yes	Yes
CH13_5	**IrmsΣ**	**Rms current**		**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
CH13_6	Irms1	Each rms current	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
CH13_7	Irms2	Each rms current		Yes	Yes	Yes	Yes	Yes	Yes	Yes
CH13_8	Irms3	Each rms current				Yes	Yes	Yes	Yes	Yes
CH13_9	**UdcΣ**	**Voltage simple average (DC)**		**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
CH13_10	Udc1	Voltage simple average (DC)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
CH13_11	Udc2	Voltage simple average (DC)		Yes	Yes	Yes	Yes	Yes	Yes	Yes
CH13_12	Udc3	Voltage simple average (DC)				Yes	Yes	Yes	Yes	Yes
CH13_13	**IdcΣ**	**Current simple average (DC)**		**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
CH13_14	Idc1	Current simple average (DC)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
CH13_15	Idc2	Current simple average (DC)		Yes	Yes	Yes	Yes	Yes	Yes	Yes
CH13_16	Idc3	Current simple average (DC)				Yes	Yes	Yes	Yes	Yes
CH13_17	**UacΣ**	**Voltage AC component (AC)**		**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
CH13_18	Uac1	Voltage AC component (AC)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
CH13_19	Uac2	Voltage AC component (AC)		Yes	Yes	Yes	Yes	Yes	Yes	Yes
CH13_20	Uac3	Voltage AC component (AC)				Yes	Yes	Yes	Yes	Yes
CH13_21	**IacΣ**	**Current AC component (AC)**		**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
CH13_22	Iac1	Current AC component (AC)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
CH13_23	Iac2	Current AC component (AC)		Yes	Yes	Yes	Yes	Yes	Yes	Yes
CH13_24	Iac3	Current AC component (AC)				Yes	Yes	Yes	Yes	Yes
CH13_25	**PΣ**	**Active power P**		**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
CH13_26	P1	Active power P	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
CH13_27	P2	Active power P		Yes	Yes	Yes	Yes	Yes	Yes	Yes
CH13_28	P3	Active power P				Yes	Yes	Yes	Yes	Yes
CH13_29	**SΣ**	**Apparent power S**		**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
CH13_30	S1	Apparent power S	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
CH13_31	S2	Apparent power S		Yes	Yes	Yes	Yes	Yes	Yes	Yes
CH13_32	S3	Apparent power S				Yes	Yes	Yes	Yes	Yes
CH13_33	**QΣ**	**Reactive power Q**		**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
CH13_34	Q1	Reactive power Q	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
CH13_35	Q2	Reactive power Q		Yes	Yes	Yes	Yes	Yes	Yes	Yes
CH13_36	Q3	Reactive power Q				Yes	Yes	Yes	Yes	Yes

Channels/ Sub channels	Symbol	Math Item	Supported Wiring Systems							
			1P2W	1P3W	3P3W	3P3W (3V3A)	3P4W	3P3W (3P3W->3V3A)	3V3A->3P4W (Delta->Start)	3P4W->3V3A (Start->Delta)
CH13_37	**λΣ**	**Power factor**		**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
CH13_38	λ1	Each power factor	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
CH13_39	λ2	Each power factor		Yes	Yes	Yes	Yes	Yes	Yes	Yes
CH13_40	λ3	Each power factor				Yes	Yes	Yes	Yes	Yes
CH13_41	**ΦΣ**	**Phase angle**		**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
CH13_42	Φ1	Phase angle	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
CH13_43	Φ2	Phase angle		Yes	Yes	Yes	Yes	Yes	Yes	Yes
CH13_44	Φ3	Phase angle				Yes	Yes	Yes	Yes	Yes
CH13_45	fU1	Voltage frequency	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
CH13_46	fU2	Voltage frequency		Yes	Yes	Yes	Yes	Yes	Yes	Yes
CH13_47	fU3	Voltage frequency				Yes	Yes	Yes	Yes	Yes
CH13_48	fI1	Current frequency	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
CH13_49	fI2	Current frequency		Yes	Yes	Yes	Yes	Yes	Yes	Yes
CH13_50	fI3	Current frequency				Yes	Yes	Yes	Yes	Yes
CH13_51	U+pk1	Maximum voltage	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
CH13_52	U-pk1	Minimum voltage	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
CH13_53	U+pk2	Maximum voltage		Yes	Yes	Yes	Yes	Yes	Yes	Yes
CH13_54	U-pk2	Minimum voltage		Yes	Yes	Yes	Yes	Yes	Yes	Yes
CH13_55	U+pk3	Maximum voltage				Yes	Yes	Yes	Yes	Yes
CH13_56	U-pk3	Minimum voltage				Yes	Yes	Yes	Yes	Yes
CH13_57	I+pk1	Maximum current	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
CH13_58	I-pk1	Minimum current	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
CH13_59	I+pk2	Maximum current		Yes	Yes	Yes	Yes	Yes	Yes	Yes
CH13_60	I-pk2	Minimum current		Yes	Yes	Yes	Yes	Yes	Yes	Yes
CH13_61	I+pk3	Maximum current				Yes	Yes	Yes	Yes	Yes
CH13_62	I-pk3	Minimum current				Yes	Yes	Yes	Yes	Yes
CH13_63	P+pk1	Maximum power	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
CH13_64	P-pk1	Minimum power	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
CH14_1	P+pk2	Maximum power		Yes	Yes	Yes	Yes	Yes	Yes	Yes
CH14_2	P-pk2	Minimum power		Yes	Yes	Yes	Yes	Yes	Yes	Yes
CH14_3	P+pk3	Maximum power				Yes	Yes	Yes	Yes	Yes
CH14_4	P-pk3	Minimum power				Yes	Yes	Yes	Yes	Yes
CH14_5	**WPΣ**	**Integrated power**		**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
CH14_6	WP1	Integrated power	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
CH14_7	WP2	Integrated power		Yes	Yes	Yes	Yes	Yes	Yes	Yes
CH14_8	WP3	Integrated power				Yes	Yes	Yes	Yes	Yes
CH14_9	**WP+Σ**	**Integrated power**		**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
CH14_10	WP+1	Integrated power	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
CH14_11	WP+2	Integrated power		Yes	Yes	Yes	Yes	Yes	Yes	Yes
CH14_12	WP+3	Integrated power				Yes	Yes	Yes	Yes	Yes
CH14_13	**WP-Σ**	**Integrated power**		**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
CH14_14	WP-1	Integrated power	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
CH14_15	WP-2	Integrated power		Yes	Yes	Yes	Yes	Yes	Yes	Yes
CH14_16	WP-3	Integrated power				Yes	Yes	Yes	Yes	Yes
CH14_17	**qΣ**	**Integrated ampere-hour**		**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
CH14_18	q1	Integrated ampere-hour	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
CH14_19	q2	Integrated ampere-hour		Yes	Yes	Yes	Yes	Yes	Yes	Yes
CH14_20	q3	Integrated ampere-hour				Yes	Yes	Yes	Yes	Yes

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Appendix

Channels/ Sub channels	Symbol	Math Item	Supported Wiring Systems							
			1P2W	1P3W	3P3W	3P3W (3V3A)	3P4W	3P3W (3P3W->3V3A)	3V3A->3P4W (Delta->Start)	3P4W->3V3A (Start->Delta)
CH14_21	**q+Σ**	**Integrated ampere-hour**		**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
CH14_22	q+1	Integrated ampere-hour	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
CH14_23	q+2	Integrated ampere-hour		Yes	Yes	Yes	Yes	Yes	Yes	Yes
CH14_24	q+3	Integrated ampere-hour				Yes	Yes	Yes	Yes	Yes
CH14_25	**q-Σ**	**Integrated ampere-hour**		**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
CH14_26	q-1	Integrated ampere-hour	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
CH14_27	q-2	Integrated ampere-hour		Yes	Yes	Yes	Yes	Yes	Yes	Yes
CH14_28	q-3	Integrated ampere-hour				Yes	Yes	Yes	Yes	Yes
CH14_29	**WSΣ**	**Volt-ampere hours**		**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
CH14_30	WS1	Volt-ampere hours WS	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
CH14_31	WS2	Volt-ampere hours		Yes	Yes	Yes	Yes	Yes	Yes	Yes
CH14_32	WS3	Volt-ampere hours				Yes	Yes	Yes	Yes	Yes
CH14_33	**WQΣ**	**Var hours**		**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
CH14_34	WQ1	Var hours WQ	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
CH14_35	WQ2	Var hours		Yes	Yes	Yes	Yes	Yes	Yes	Yes
CH14_36	WQ3	Var hours				Yes	Yes	Yes	Yes	Yes
CH14_37	**ZΣ**	**Load circuit impedance**		**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
CH14_38	Z1	Load circuit impedance	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
CH14_39	Z2	Load circuit impedance		Yes	Yes	Yes	Yes	Yes	Yes	Yes
CH14_40	Z3	Load circuit impedance				Yes	Yes	Yes	Yes	Yes
CH14_41	**RSΣ**	**Load circuit series resistance**		**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
CH14_42	RS1	Load circuit series resistance	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
CH14_43	RS2	Load circuit series resistance		Yes	Yes	Yes	Yes	Yes	Yes	Yes
CH14_44	RS3	Load circuit series resistance				Yes	Yes	Yes	Yes	Yes
CH14_45	**XSΣ**	**Load circuit series reactance**		**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
CH14_46	XS1	Load circuit series reactance	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
CH14_47	XS2	Load circuit series reactance		Yes	Yes	Yes	Yes	Yes	Yes	Yes
CH14_48	XS3	Load circuit series reactance				Yes	Yes	Yes	Yes	Yes
CH14_49	**RPΣ**	**Load circuit parallel resistance**		**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
CH14_50	RP1	Load circuit parallel resistance	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
CH14_51	RP2	Load circuit parallel resistance		Yes	Yes	Yes	Yes	Yes	Yes	Yes
CH14_52	RP3	Load circuit parallel resistance				Yes	Yes	Yes	Yes	Yes
CH14_53	**XPΣ**	**Load circuit parallel reactance**		**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**

Channels/ Sub channels	Symbol	Math Item	Supported Wiring Systems							
			1P2W	1P3W	3P3W	3P3W (3V3A)	3P4W	3P3W (3P3W->3V3A)	3V3A->3P4W (Delta->Start)	3P4W->3V3A (Start->Delta)
CH14_54	XP1	Load circuit parallel reactance	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
CH14_55	XP2	Load circuit parallel reactance		Yes	Yes	Yes	Yes	Yes	Yes	Yes
CH14_56	XP3	Load circuit parallel reactance				Yes	Yes	Yes	Yes	Yes
CH14_57	**Pm**	**Motor output (drive efficiency)**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
CH14_58	**η**	**Efficiency**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
CH14_59	**Uubf**	**Three-phase voltage unbalance factor**				**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
CH14_60	**Iubf**	**Three-phase current unbalance factor**				**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
CH14_61	**In**	**Neutral line current**				**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
CH14_62	**Time**	**Integration time**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**

When the Analysis Mode is 2Wiring Systems

Channels/Sub channels		Symbol	Math Item	Supported Wiring Systems							
Wiring System1	Wiring System2			1P2W	1P3W	3P3W	3P3W (3V3A)	3P4W	3P3W (3P3W->3V3A)	3V3A (Delta->Start)	3P4W (Start->Delta)
CH13_1	**CH14_1**	**UrmsΣ**	**Rms voltage**		**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
CH13_1	CH14_1	Urms1	Each rms voltage	Yes							
CH13_2	**CH14_2**	**IrmsΣ**	**Rms current**		**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
CH13_2	CH14_2	Irms1	Each rms current	Yes							
CH13_3	**CH14_3**	**UdcΣ**	**Voltage simple average (DC)**		**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
CH13_3	CH14_3	Udc1	Voltage simple average (DC)	Yes							
CH13_4	**CH14_4**	**IdcΣ**	**Current simple average (DC)**		**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
CH13_4	CH14_4	Idc1	Current simple average (DC)	Yes							
CH13_5	**CH14_5**	**UacΣ**	**Voltage AC component (AC)**		**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
CH13_5	CH14_5	Uac1	Voltage AC component (AC)	Yes							
CH13_6	**CH14_6**	**IacΣ**	**Current AC component (AC)**		**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
CH13_6	CH14_6	Iac1	Current AC component (AC)	Yes							
CH13_7	**CH14_7**	**PΣ**	**Active power P**		**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
CH13_7	CH14_7	P1	Active power P	Yes							
CH13_8	**CH14_8**	**SΣ**	**Apparent power S**		**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
CH13_8	CH14_8	S1	Apparent power S	Yes							
CH13_9	**CH14_9**	**QΣ**	**Reactive power Q**		**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
CH13_9	CH14_9	Q1	Reactive power Q	Yes							
CH13_10	**CH14_10**	**λΣ**	**Power factor**		**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
CH13_10	CH14_10	λ1	Each power factor	Yes							
CH13_11	**CH14_11**	**ΦΣ**	**Phase angle**		**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
CH13_11	CH14_11	Φ1	Phase angle	Yes							
CH13_12	CH14_12	fU1	Voltage frequency	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
CH13_13	CH14_13	fU2	Voltage frequency		Yes	Yes	Yes	Yes	Yes	Yes	Yes
CH13_14	CH14_14	fU3	Voltage frequency				Yes	Yes	Yes	Yes	Yes
CH13_15	CH14_15	fI1	Current frequency	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
CH13_16	CH14_16	fI2	Current frequency		Yes	Yes	Yes	Yes	Yes	Yes	Yes
CH13_17	CH14_17	fI3	Current frequency				Yes	Yes	Yes	Yes	Yes
CH13_18	CH14_18	U+pk1	Maximum voltage	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
CH13_19	CH14_19	U-pk1	Minimum voltage	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
CH13_20	CH14_20	U+pk2	Maximum voltage		Yes	Yes	Yes	Yes	Yes	Yes	Yes
CH13_21	CH14_21	U-pk2	Minimum voltage		Yes	Yes	Yes	Yes	Yes	Yes	Yes
CH13_22	CH14_22	U+pk3	Maximum voltage				Yes	Yes	Yes	Yes	Yes
CH13_23	CH14_23	U-pk3	Minimum voltage				Yes	Yes	Yes	Yes	Yes
CH13_24	CH14_24	I+pk1	Maximum current	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
CH13_25	CH14_25	I-pk1	Minimum current	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
CH13_26	CH14_26	I+pk2	Maximum current		Yes	Yes	Yes	Yes	Yes	Yes	Yes
CH13_27	CH14_27	I-pk2	Minimum current		Yes	Yes	Yes	Yes	Yes	Yes	Yes
CH13_28	CH14_28	I+pk3	Maximum current				Yes	Yes	Yes	Yes	Yes
CH13_29	CH14_29	I-pk3	Minimum current				Yes	Yes	Yes	Yes	Yes
CH13_30	CH14_30	P+pk1	Maximum power	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
CH13_31	CH14_31	P-pk1	Minimum power	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
CH13_32	CH14_32	P+pk2	Maximum power		Yes	Yes	Yes	Yes	Yes	Yes	Yes
CH13_33	CH14_33	P-pk2	Minimum power		Yes	Yes	Yes	Yes	Yes	Yes	Yes

Channels/Sub channels		Symbol	Math Item	Supported Wiring Systems							
Wiring System1	Wiring System2			1P2W	1P3W	3P3W	3P3W (3V3A)	3P4W	3P3W (3P3W->3V3A)	3V3A (Delta->Start)	3P4W (Start->Delta)
CH13_34	CH14_34	P+pk3	Maximum power				Yes	Yes	Yes	Yes	Yes
CH13_35	CH14_35	P-pk3	Minimum power				Yes	Yes	Yes	Yes	Yes
CH13_36	**CH14_36**	**WPΣ**	**Integrated power**		**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
CH13_36	CH14_36	WP1	Integrated power	Yes							
CH13_37	**CH14_37**	**WP+Σ**	**Integrated power**		**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
CH13_37	CH14_37	WP+1	Integrated power	Yes							
CH13_38	**CH14_38**	**WP-Σ**	**Integrated power**		**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
CH13_38	CH14_38	WP-1	Integrated power	Yes							
CH13_39	**CH14_39**	**qΣ**	**Integrated ampere-hour**		**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
CH13_39	CH14_39	q1	Integrated ampere-hour	Yes							
CH13_40	**CH14_40**	**q+Σ**	**Integrated ampere-hour**		**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
CH13_40	CH14_40	q+1	Integrated ampere-hour	Yes							
CH13_41	**CH14_41**	**q-Σ**	**Integrated ampere-hour**		**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
CH13_41	CH14_41	q-1	Integrated ampere-hour	Yes							
CH13_42	**CH14_42**	**WSΣ**	**Volt-ampere hours**		**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
CH13_42	CH14_42	WS1	Volt-ampere hours WS	Yes							
CH13_43	**CH14_43**	**WQΣ**	**Var hours**		**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
CH13_43	CH14_43	WQ1	Var hours WQ	Yes							
CH13_44	**CH14_44**	**ZΣ**	**Load circuit impedance**		**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
CH13_44	CH14_44	Z1	Load circuit impedance	Yes							
CH13_45	**CH14_45**	**RSΣ**	**Load circuit series resistance**		**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
CH13_45	CH14_45	RS1	Load circuit series resistance	Yes							
CH13_46	**CH14_46**	**XSΣ**	**Load circuit series reactance**		**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
CH13_46	CH14_46	XS1	Load circuit series reactance	Yes							
CH13_47	**CH14_47**	**RPΣ**	**Load circuit parallel resistance**		**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
CH13_47	CH14_47	RP1	Load circuit parallel resistance	Yes							
CH13_48	**CH14_48**	**XPΣ**	**Load circuit parallel reactance**		**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
CH13_48	CH14_48	XP1	Load circuit parallel reactance	Yes							
CH13_49	**CH14_49**	**Pm**	**Motor output (drive efficiency)**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
CH13_50	**CH14_50**	**η**	**Efficiency**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
CH13_51	**CH14_51**	**Uubf**	**Three-phase voltage unbalance factor**				**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
CH13_52	**CH14_52**	**Iubf**	**Three-phase current unbalance factor**				**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
CH13_53	**CH14_53**	**In**	**Neutral line current**				**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
CH13_54	**CH14_54**	**Time**	**Integration time**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**

Harmonic Analysis (Harmonics)

When the analysis mode is Line RMS

Channels/Sub channels	Symbol	Math Item
CH15_1 to CH15_40	RMS	Rms value (1st to 40th harmonic)
CH15_41 to CH15_64 CH16_1 to CH16_16	Rhdf(harmonic distortion factor)	Percentage content (1st to 40th harmonic)
CH16_17 to CH16_56	Φ	Phase angle (1st to 40th harmonic)
CH16_57	RMS	Total rms value
CH16_58	THD (IEC)	Distortion factor (IEC)
CH16_59	THD (CSA)	Distortion factor (CSA)

When the Analysis Mode is Power

Channels/ Sub channels	Symbol	Math Item	Supported Wiring Systems							
			1P2W	1P3W	3P3W	3P3W (3V3A)	3P4W	3P3W (3P3W->3V3A)	3V3A (Delta->Start)	3P4W (Start->Delta)
CH15_1 to CH15_35 CH15_36 to CH16_6 CH16_7 to CH16_41	P	Active power (1st to 35th harmonic)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
CH15_41 to CH15_64 CH16_1 to CH16_16	Phdf(harmonic distortion factor)	Active power percentage content (1st to 35th harmonic)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
CH16_7 to CH16_41	Φ	Phase angle (1st to 35th harmonic)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
CH16_42	P	Total active powers	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
CH16_43	S	Total apparent powers	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
CH16_44	Q	Total reactive powers	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
CH16_45	λ	Power factor	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
CH16_46	U1rms	1st harmonic rms voltage	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
CH16_47	I1rms	1st harmonic rms current	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
CH16_48	U2rms	1st harmonic rms voltage		Yes	Yes	Yes	Yes	Yes	Yes	Yes
CH16_49	I2rms	1st harmonic rms current		Yes	Yes	Yes	Yes	Yes	Yes	Yes
CH16_50	U3rms	1st harmonic rms voltage				Yes	Yes	Yes	Yes	Yes
CH16_51	I3rms	1st harmonic rms current				Yes	Yes	Yes	Yes	Yes
CH16_52	ΦU1-U1	1st harmonic voltage phase angle	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
CH16_53	ΦU1-I1	1st harmonic current phase angle	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
CH16_54	ΦU1-U2	1st harmonic voltage phase angle		Yes	Yes	Yes	Yes	Yes	Yes	Yes
CH16_55	ΦU1-I2	1st harmonic current phase angle		Yes	Yes	Yes	Yes	Yes	Yes	Yes
CH16_56	ΦU1-U3	1st harmonic voltage phase angle				Yes	Yes	Yes	Yes	Yes
CH16_57	ΦU1-I3	1st harmonic current phase angle				Yes	Yes	Yes	Yes	Yes

Appendix 3 Power Basics (Power, harmonics, and AC RLC circuits)

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

Power

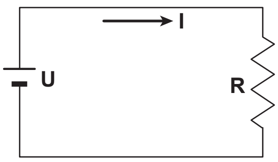
Electrical energy can be converted into other forms of energy and used. For example, it can be converted into the heat in an electric heater, the torque in a motor, or the light in a fluorescent or mercury lamp. In these kinds of examples, the work that electricity performs in a given period of time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

DC Power

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

P = UI [W]

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

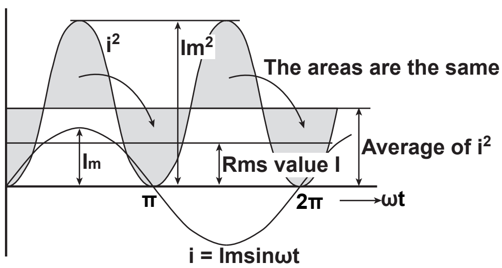


Alternating Current

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

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

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



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

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

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

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

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

These relationships also apply to sinusoidal voltages.

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

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

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

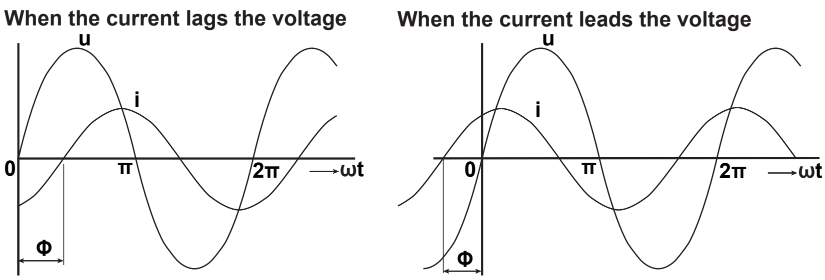
Vector Display of Alternating Current

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

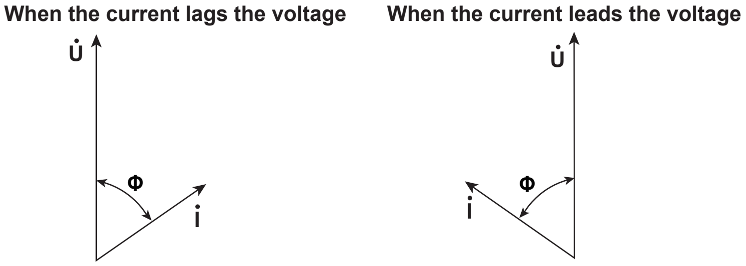
Voltage: u = Umsinωt

Current: i = Imsin(ωt – Φ)

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

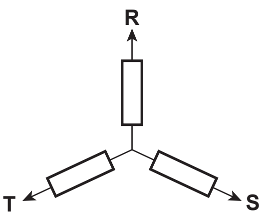


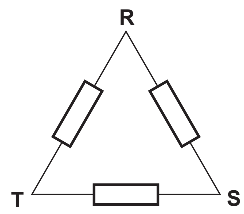
A vector display is used to clearly convey the magnitude and phase relationships between the voltage and current. A positive phase angle is represented by a counterclockwise angle with respect to the vertical axis.
Normally, a dot is placed above the symbol representing a quantity to explicitly indicate that it is a vector. The magnitude of a vector represents the rms value.



Three-Phase AC Wiring

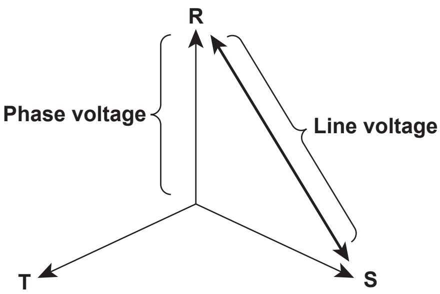
Generally three-phase AC power lines are connected in star wiring configurations or delta wiring configurations.





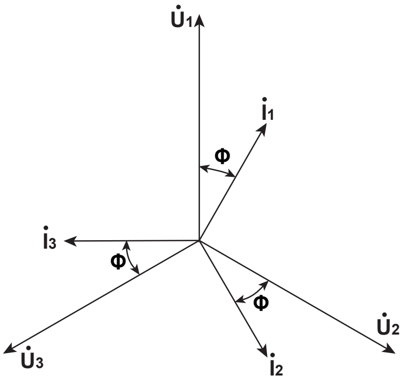
Vector Display of Three-Phase Alternating Current

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



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

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



AC Power

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

If the instantaneous voltage $u = U_m \sin\omega t$ and the instantaneous current $i = I m \sin(\omega t - \Phi)$, the instantaneous AC power p is as follows:

$p = u \times i = U_m \sin\omega t \times I_m \sin(\omega t - \Phi) = UI\cos\Phi - UI\cos(2\omega t - \Phi)$

U and I represent the rms voltage and rms current, respectively.

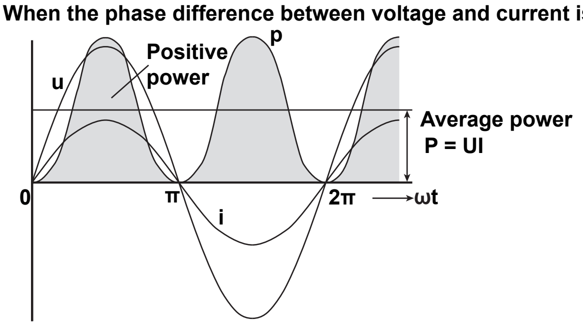
p is the sum of the time-independent term, $UI\cos\Phi$, and the AC component term of the voltage or current at twice the frequency, $-UI\cos(2\omega t - \Phi)$.

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

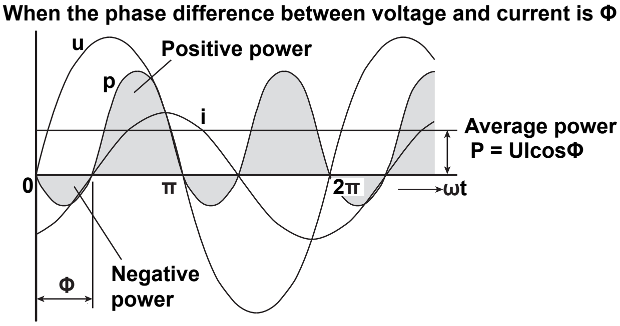
$P = UI\cos\Phi$ [W]

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

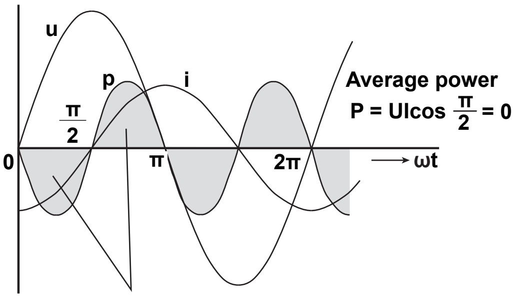
When the phase difference between voltage and current is 0



When the phase difference between voltage and current is Φ



When phase difference between voltage and current is $\frac{\pi}{2}$



The positive and negative powers are the same

Active Power and the Power Factor

In alternating electrical current, not all of the power calculated by the product of voltage and current, UI, is consumed. The product of U and I is called the apparent power. It is expressed as S. The unit of apparent power is the volt-ampere (VA). The apparent power is used to express the electrical capacity of a device that runs on AC electricity.
The true power that a device consumes is called active power (or effective power). It is expressed as P. This power corresponds to the AC power discussed in the previous section.

$S = UI$ [VA]

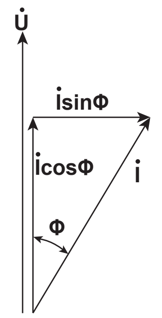
$P = UI\cos\Phi$ [W]

$\cos\Phi$ is called the power factor and is expressed as λ. It indicates the portion of the apparent power that becomes true power.

Reactive Power

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

$Q = UI\sin\Phi$ [var]



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

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

Harmonics

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

Terminology

The terminology related to harmonics is described below.

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

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

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

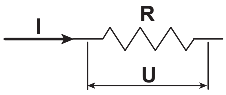
AC RLC Circuits

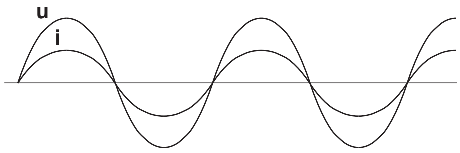
Resistance

The current i when an AC voltage whose instantaneous value $u = U_m \sin\omega t$ is applied to load resistance R [Ω] is expressed by the equation below. I_m denotes the maximum current.

$$i = \frac{U_m}{R}\sin\omega t = I_m \sin\omega t$$

Expressed using rms values, the equation is I = U/R.
There is no phase difference between the current flowing through a resistive circuit and the voltage.



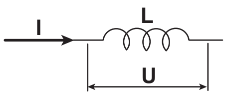


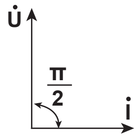
Inductance

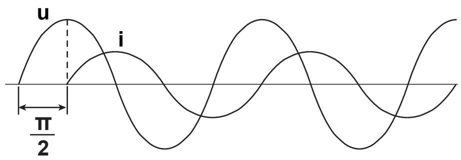
The current i when an AC voltage whose instantaneous value $u = U_m \sin\omega t$ is applied to a coil load of inductance L [H] is expressed by the equation below.

$$i = \frac{U_m}{X_L}\sin\left(\omega t - \frac{\pi}{2}\right) = I_m \sin\left(\omega t - \frac{\pi}{2}\right)$$

Expressed using rms values, the equation is $I = U/X_L$. X_L is called inductive reactance and is defined as $X_L = \omega_L$. The unit of inductive reactance is Ω.
Inductance works to counter current changes (increase or decrease), and causes the current to lag the voltage.





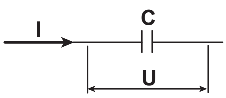


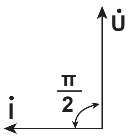
Capacitance

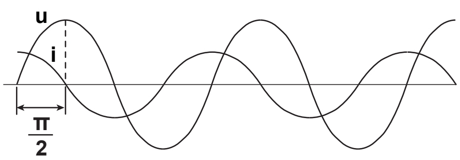
The current i when an AC voltage whose instantaneous value $u = U_m \sin\omega t$ is applied to a capacitive load C [F] is expressed by the equation below.

$$i = \frac{U_m}{X_C}\sin\left(\omega t + \frac{\pi}{2}\right) = I_m \sin\left(\omega t + \frac{\pi}{2}\right)$$

Expressed using rms values, the equation is $I = U/X_C$. X_C is called capacitive reactance and is defined as $X_C = 1/\omega C$. The unit of capacitive reactance is Ω.
When the polarity of the voltage changes, the largest charging current with the same polarity as the voltage flows through the capacitor. When the voltage decreases, discharge current with the opposite polarity of the voltage flows. Thus, the current phase leads the voltage.







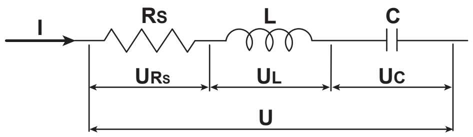
Series RLC Circuits

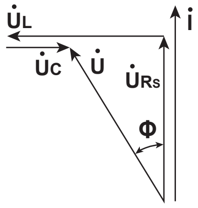
The equations below express the voltage relationships when resistance R_S [Ω], inductance L [H], and capacitance C [F] are connected in series.

$$U = \sqrt{(U_{Rs})^2 + (U_L - U_C)^2} = \sqrt{(IR_S)^2 + (IX_L - IX_C)^2}$$

$$= I\sqrt{(R_S)^2 + (X_L - X_C)^2} = I\sqrt{R_S^2 + X_S^2}$$

$$I = \frac{U}{\sqrt{R_S^2 + X_S^2}}, \quad \Phi = \tan^{-1}\frac{X_S}{R_S}$$





The relationship between resistance R_S, reactance X_S, and impedance Z is expressed by the equations below.

$$X_S = X_L - X_C$$

$$Z = \sqrt{R_S^2 + X_S^2}$$

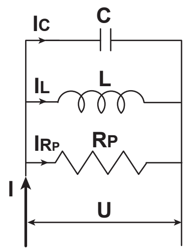
Parallel RLC Circuits

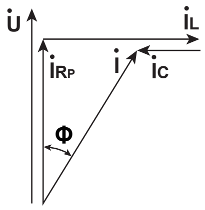
The equations below express the current relationships when resistance R_P [Ω], inductance L [H], and capacitance C [F] are connected in parallel.

$$I = \sqrt{(I_{RP})^2 + (I_L - I_C)^2} = \sqrt{\left(\frac{U}{R_P}\right)^2 + \left(\frac{U}{X_L} - \frac{U}{X_C}\right)^2}$$

$$= U\sqrt{\left(\frac{1}{R_P}\right)^2 + \left(\frac{1}{X_L} - \frac{1}{X_C}\right)^2} = U\sqrt{\left(\frac{1}{R_P}\right)^2 + \left(\frac{1}{X_P}\right)^2}$$

$$U = \frac{IR_PX_P}{\sqrt{R_P^2 + X_P^2}}, \quad \Phi = \tan^{-1}\frac{R_P}{X_P}$$





The relationship between resistance R_P, reactance X_P, and impedance Z is expressed by the equations below.

$$X_P = \frac{X_LX_C}{X_C - X_L}$$

$$Z = \frac{R_PX_P}{\sqrt{R_P^2 + X_P^2}}$$

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