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.

<table>
<thead>
<tr>
<th>Manual Title</th>
<th>Manual No.</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DL850E/DL850EV ScopeCorder Features Guide</td>
<td>IM DL850E-01EN</td>
<td>The supplied CD contains the PDF file of this manual. This manual explains all the DL850E/DL850EV features other than the communication interface features.</td>
</tr>
<tr>
<td>DL850E/DL850EV ScopeCorder Getting Started Guide</td>
<td>IM DL850E-03EN</td>
<td>This guide explains the handling precautions and basic operations of the DL850E/DL850EV.</td>
</tr>
<tr>
<td>DL850E/DL850EV ScopeCorder Communication Interface User’s Manual</td>
<td>IM DL850E-17EN</td>
<td>The supplied CD contains the PDF file of this manual. This manual explains the DL850E/DL850EV communication interface features and how to use them.</td>
</tr>
<tr>
<td>DL850E/DL850EV ScopeCorder Acquisition Software User’s Manual</td>
<td>IM DL850E-61EN</td>
<td>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.</td>
</tr>
<tr>
<td>Precautions Concerning the Modules</td>
<td>IM 701250-04E</td>
<td>The manual explains the precautions concerning the modules. This manual is included if you ordered modules.</td>
</tr>
</tbody>
</table>

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.

<table>
<thead>
<tr>
<th>Document No.</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>PIM 113-01Z2</td>
<td>List of worldwide contacts</td>
</tr>
</tbody>
</table>

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)
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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• Other company and product names are registered trademarks or trademarks of their respective holders.

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.

⚠️ 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

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Denotes</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>k</td>
<td>1000</td>
<td>100 kS/s (sample rate)</td>
</tr>
<tr>
<td>K</td>
<td>1024</td>
<td>720 KB (file size)</td>
</tr>
</tbody>
</table>
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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.
1 Features

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.

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

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.

<table>
<thead>
<tr>
<th>Filter Type</th>
<th>Filter Band</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gauss</td>
<td>Low-Pass</td>
</tr>
<tr>
<td>Sharp</td>
<td>Low-Pass, High-Pass, Band-Pass</td>
</tr>
<tr>
<td>IIR</td>
<td>Low-Pass, High-Pass, Band-Pass</td>
</tr>
</tbody>
</table>

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.

<table>
<thead>
<tr>
<th>Filter Type</th>
<th>Filter Band</th>
<th>Range</th>
<th>Resolution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gauss</td>
<td>Low-Pass</td>
<td>0.002 kHz to 300 kHz</td>
<td>0.0002 kHz (0.002 kHz to 0.0298 kHz range)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0.002 kHz (0.03 kHz to 0.298 kHz range)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0.02 kHz (0.30 kHz to 2.98 kHz range)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0.2 kHz (3.0 kHz to 29.8 kHz range)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2 kHz (30 kHz to 300 kHz range)</td>
</tr>
<tr>
<td>Sharp</td>
<td>Low-Pass</td>
<td>0.002 kHz to 300 kHz</td>
<td>0.0002 kHz (0.002 kHz to 0.0298 kHz range)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0.002 kHz (0.03 kHz to 0.298 kHz range)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0.02 kHz (0.30 kHz to 2.98 kHz range)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0.2 kHz (3.0 kHz to 29.8 kHz range)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2 kHz (30 kHz to 300 kHz range)</td>
</tr>
<tr>
<td></td>
<td>High-Pass</td>
<td>0.20 kHz to 300 kHz</td>
<td>0.02 kHz (0.20 kHz to 2.98 kHz range)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0.2 kHz (3.0 kHz to 29.8 kHz range)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2 kHz (30 kHz to 300 kHz range)</td>
</tr>
<tr>
<td>IIR</td>
<td>Low-Pass</td>
<td>0.002 kHz to 300 kHz</td>
<td>0.0002 kHz (0.002 kHz to 0.0298 kHz range)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0.02 kHz (0.03 kHz to 0.298 kHz range)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0.2 kHz (0.30 kHz to 2.98 kHz range)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2 kHz (30 kHz to 300 kHz range)</td>
</tr>
<tr>
<td></td>
<td>High-Pass</td>
<td>0.02 kHz to 300 kHz</td>
<td>0.02 kHz (0.02 kHz to 2.98 kHz range)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0.2 kHz (0.20 kHz to 2.98 kHz range)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2 kHz (30 kHz to 300 kHz range)</td>
</tr>
</tbody>
</table>
1 Features

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.

<table>
<thead>
<tr>
<th>Filter Type</th>
<th>Range</th>
<th>Resolution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sharp</td>
<td>0.30 kHz to 300 kHz</td>
<td>0.02 kHz (0.30 kHz to 2.98 kHz range)</td>
</tr>
<tr>
<td></td>
<td>Default value: 300 Hz</td>
<td>0.2 kHz (3 kHz to 29.8 kHz range)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 kHz (30 kHz to 300 kHz range)</td>
</tr>
<tr>
<td>IIR</td>
<td>0.06 kHz to 300 kHz</td>
<td>0.02 kHz (60 Hz to 1.18 kHz range)</td>
</tr>
<tr>
<td></td>
<td>Default value: 300 Hz</td>
<td>0.2 kHz (1.2 kHz to 11.8 kHz range)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 kHz (12 kHz to 300 kHz range)</td>
</tr>
</tbody>
</table>

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.

<table>
<thead>
<tr>
<th>Range</th>
<th>Resolution</th>
<th>Data Update Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0 μs to 100 μs</td>
<td>0.1 μs</td>
<td>10 MHz</td>
</tr>
<tr>
<td>101 μs to 1.00 ms</td>
<td>1 μs</td>
<td>1 MHz</td>
</tr>
<tr>
<td>1.01 ms to 10.00 ms</td>
<td>0.01 ms</td>
<td>100 kHz</td>
</tr>
</tbody>
</table>

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.
1 Features

- 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, 3 CAN, 3 LIN, 3 SENT, 3 RMath1 to RMath15

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, the signal level of each signal that you will count as a pulse, and the hysteresis of each signal.
- **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.

\[
A s^4 + B s^3 + C s^2 + D s + E
\]

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.
1 Features

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.
  \[ \sqrt{s_1^2 \pm s_2^2} \]  
  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 \(s_1^2\) and \(s_2^2\) 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.

\[ \text{atan}(s1/s2) \]
\[ s1 \text{ and } s2: \text{Sampling data} \]

**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.
\[ K (s_1 \pm s_2 \pm s_3 \pm s_4) \]
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, the slope (rising or falling), and the hysteresis 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 deceleration 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
1 Features

**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.
1 Features

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.

<table>
<thead>
<tr>
<th>Filter Band</th>
<th>Range</th>
<th>Resolution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low-Pass</td>
<td>0.2 Hz to 3.00 MHz</td>
<td>0.2 Hz (range: 0.2 Hz to 29.8 Hz)</td>
</tr>
<tr>
<td>Default value: 0.30 MHz</td>
<td>2 Hz (range: 30 Hz to 298 Hz)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.02 kHz (range: 0.30 kHz to 2.98 kHz)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.2 kHz (range: 3.0 kHz to 29.8 kHz)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2 kHz (range: 30 kHz to 298 kHz)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.02 MHz (range: 0.30 MHz to 3.00 MHz)</td>
<td></td>
</tr>
<tr>
<td>High-Pass</td>
<td>0.02 kHz to 3.00 MHz</td>
<td>0.02 kHz (range: 0.02 kHz to 2.98 kHz)</td>
</tr>
<tr>
<td>Default value: 0.30 MHz</td>
<td>0.2 kHz (range: 3.0 kHz to 29.8 kHz)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2 kHz (range: 30 kHz to 298 kHz)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.02 MHz (range: 0.30 MHz to 3.00 MHz)</td>
<td></td>
</tr>
</tbody>
</table>

### Center Frequency (Center Frequency)

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

<table>
<thead>
<tr>
<th>Range</th>
<th>Resolution</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.06 kHz to 3.00 MHz</td>
<td>0.02 kHz (range: 0.06 kHz to 1.18 kHz)</td>
</tr>
<tr>
<td>Default value: 0.30kHz</td>
<td>0.2 kHz (range: 1.2 kHz to 11.8 kHz)</td>
</tr>
<tr>
<td></td>
<td>2 kHz (range: 12 kHz to 118 kHz)</td>
</tr>
<tr>
<td></td>
<td>0.02 MHz (range: 0.12 MHz to 3.00 MHz)</td>
</tr>
</tbody>
</table>

### 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.

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, RMath1 to RMath2
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 0x1ffffffff

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 level1, the slope (rising or falling), and the hysteresis2 of the edges that are used to detect the periods.
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), 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).
1 Features

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 $\Sigma$. Measurement functions for wiring units are called $\Sigma$ functions.

For example, $U_{\text{rms}}\Sigma$ represents the true rms value of the average of the voltages measured on the input source channels assigned to wiring unit $\Sigma$.

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

  ![Wiring System and Wiring Unit Diagram]

  Source Channel 1
  - CH1
  - CH2

  Source Channel 2
  - CH3
  - CH4

  Source Channel 3
  - CH5
  - CH6

  Wiring system: Three-phase three-wire
  - Wiring unit: $\Sigma$

  Example: 720210 (HS100M12)

**Delta Math**

Measurement function $\Delta U$ and $\Delta I$ 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).

  ![Star-Delta Diagram]

**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.

  ![Delta-Star Diagram]
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)
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)

* 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.

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)

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

<table>
<thead>
<tr>
<th>Input power</th>
<th>Output power</th>
</tr>
</thead>
<tbody>
<tr>
<td>PΣ of Wiring System 1</td>
<td>PΣ of Wiring System 2</td>
</tr>
</tbody>
</table>

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. \(U_{rs}\) and \(I_t\) 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. \(U_r, U_s, U_t\), and \(I_n\) 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.

![Delta-Star Transformation Diagram](image)

• **Star-Delta Transformation (3P4W → 3V3A)**

Six channels that receive three pairs of voltage and current signals can be wired. \(U_{rs}, U_{st}, U_{tr}\), and \(I_n\) can be determined using delta math.

![Star-Delta Transformation Diagram](image)

**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.
1 Features

- **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
  ![Graph](image1)

 When Reset on Start is ON
  ![Graph](image2)

When Integration Condition is set to In Acquisition

 When Reset on Start is OFF
  ![Graph](image3)

 When Reset on Start is ON
  ![Graph](image4)

- **Scaling (Scaling)**
  Select the integral time unit.
  Second: Second
  Hour: Hour
Efficiency Setting (Efficiency Setting)
Select the measurement function efficiency $\eta$ 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), $\phi$ (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), $\phi$ (active power phases of the 1st to the 35th harmonic), P (all active powers), S (all apparent powers), Q (all reactive powers), $\lambda$ (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), $\varphi$U1-U1 (phase angle), $\varphi$U1-I1 (phase angle), $\varphi$U1-U2 (phase angle), $\varphi$U1-I2 (phase angle), $\varphi$U1-U3 (phase angle), $\varphi$U1-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.
1 Features

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

![Graph display example image]
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)
1 Features

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.

<table>
<thead>
<tr>
<th>Operators and Functions</th>
<th>Input Module Model</th>
<th>RMath (Real Time Math Channel)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>701250, 720250, 701251, 701255, 701267, 720268, 701261, 701262, 701265, 720266, 701270, 701271, 701275, 720210, 720211, 720221, 720220, 720254</td>
<td>720240, 1, 2 720241, 1, 2 720242, 1, 2 720243, 1, 2 (Only usable on the DL850EV)</td>
</tr>
</tbody>
</table>

- **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

- **DA**
  - No
  - No
  - Yes
  - No
  - No

- **Polynomial**
  - Yes
  - Yes
  - No
  - Yes
  - Yes

- **RMS, Power**
  - Math source: Yes
  - No
  - No
  - Yes
  - Yes

- **Edge source**
  - Yes
  - No
  - Yes
  - 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
  - No
  - Yes
  - Yes
  - No

- **Atan**
  - Yes
  - Yes
  - No
  - Yes
  - Yes

- **Electrical Angle**
  - Math source: No
  - No
  - Yes
  - No
  - No

- **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
  - 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
  - Yes

- **CAN ID**
  - Yes
  - No
  - Yes
  - Yes
  - Yes

- **Torque**
  - Yes
  - No
  - Yes
  - Yes
  - Yes

- **S1–S2 (Angle)**
  - Yes
  - 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 Features

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 cannot 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

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

Select Digital.
Select Gauss.
Set the filter band (Low-Pass).
Set the cutoff frequency (using the jog shuttle).
Turns interpolation on and off
Set the delay (using the jog shuttle).

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
2 Configuring Digital Filter Settings

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.

When you have selected the input channel of a frequency module

- Select Digital.
- Select Sharp.
- Set the filter band (Low-Pass, High-Pass, Band-Pass).
- Set the cutoff frequency (using the jog shuttle).
- Turns interpolation on and off
- Set the delay (using the jog shuttle).

When Filter Band Is Set to Band-Pass

- Set the center frequency (using the jog shuttle).
- Set the bandwidth (using the jog shuttle).

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.

When you have selected the input channel of a frequency module

- Select Digital.
- Select IIR.
- Set the filter band (Low-Pass, High-Pass, Band-Pass).
- Set the cutoff frequency (using the jog shuttle).
- Turns interpolation on and off
- Set the delay (using the jog shuttle).

When Filter Band Is Set to Band-Pass

- Set the center frequency (using the jog shuttle).
- Set the bandwidth (using the jog shuttle).

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
2 Configuring Digital Filter Settings

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.

![Filter/Delay Setup Menu]

- Select Digital.
- Select Mean.
- Set the number of taps (using the jog shuttle).
- Set the mean sample (using the jog shuttle).
- Turns interpolation on and off
- Set the delay (using the jog shuttle).

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.

   Select ON.

   Select IIR-Lowpass.

   Set the cutoff frequency (128kHz, 64kHz, 32kHz, 16kHz, 8kHz, 4kHz, 2kHz, 1kHz, 500Hz, 250Hz, 125Hz, 62.5Hz).

   Set the delay (using the jog shuttle).

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.

- Turn real time math on.
- Configure real time math settings.
- Turns the mean on and off
- Optimizes value/div

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

When OFF is Selected
- Display OFF
- RealTime Math OFF

When ON is Selected
- Display OFF
- RealTime Math OFF

The colors are inverted.

• 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

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).

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

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

**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.

Configure real time math settings.

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.

The displayed contents vary depending on the real time math operation that has been specified for the channel at the cursor position.

Use the jog shuttle to move the cursor to the item that you want to set.
3 Configuring Real Time Math Settings

Basic Arithmetic (S1+S2, S1−S2, S1*S2, and S1/S2)
The following screen appears when you select a basic arithmetic operation.

<table>
<thead>
<tr>
<th>Operation</th>
<th>Source1</th>
<th>Source2</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1+S2</td>
<td>Q1</td>
<td>Q2</td>
</tr>
</tbody>
</table>

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.

<table>
<thead>
<tr>
<th>Operation</th>
<th>Source1</th>
<th>Source2</th>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>A(S1)+B(S2)+C</td>
<td>Q1</td>
<td>Q2</td>
<td>1.0000</td>
<td>0.0000</td>
<td>0.0000</td>
</tr>
</tbody>
</table>

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.

<table>
<thead>
<tr>
<th>Operation</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diff(S1)</td>
<td>Q1</td>
</tr>
</tbody>
</table>

Select the function.  
Select the math source waveform.

Integration (Integ1(S1) and Integ2(S2))
The following screen appears when you select an integration function.

<table>
<thead>
<tr>
<th>Operation</th>
<th>Source</th>
<th>Reset Condition</th>
<th>Manual Reset</th>
</tr>
</thead>
<tbody>
<tr>
<td>Integ1(S1)</td>
<td>Q1</td>
<td></td>
<td>Execute</td>
</tr>
</tbody>
</table>

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.
3 Configuring Real Time Math Settings

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).
3 Configuring Real Time Math Settings

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

<Diagram>

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

<Diagram>

- When the Encoding Type Is Absolute 8bit

<Diagram>

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

<Diagram>

* When the bit length of Gray Code is 8 or less, the Source2 setting is ignored.
3 Configuring Real Time Math Settings

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, f, A, B, f, B).
- Select the edge to count pulses on (A, f, A, B, f, B).
- This is displayed when Count Condition is set to x2 or x1.
- This is displayed when Count Condition is set to x2.
- Select the edge that you want to use to trigger a reset operation (A, f, A, B, f, 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 conversion method (Unsigned, Signed, Offset Binary).
- Select the math source logic signal (least significant 8 bits).
- The channels of installed logic modules are displayed.
- The channels of installed logic modules are displayed.
- Select the math source logic signal (most significant 8 bits).
- Select the math source logic signal (least significant 8 bits).
- 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).
RMS Value (RMS)

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

- **If the Calculation Period Is Edge**

  - Select the function.
  - Select the math source waveform.
  - Set the calculation period to Edge.
  - Select the edge detection source (Own, CH1 to CH161, RMath1 to RMath152).
  - Set the level (using the jog shuttle).
  - Set the edge detection condition (, , ).
  - Set the hysteresis (, , ).

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 (Power)**

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

- **If the Calculation Period Is Time**

  - Select the function.
  - Select the math source waveform.
  - Set the calculation period to Time.
  - Set the time (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.
Effective Power Integration (Power Integ)

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

- **Operation**: Select the function.
- **Source1** and **Source2**: Select the math source waveforms.
- **Reset Condition**: Reset conditions for the integration result
  - When waveform acquisition starts
  - When “Value/Div” exceeds +10 div or falls below –10 div
- **Manual Reset**: Resets the integration result
- **Scaling**: Select the scale (Second, Hour).

Common Logarithm (Log1 and Log2)

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

  - **Operation**: Select the function.
  - **Source1** and **Source2**: Select the math source waveforms.
  - **K**: Set the coefficient (using the jog shuttle).

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

  - **Operation**: Select the function.
  - **Source**: Select the math source waveform.
  - **K**: Set the coefficient (using the jog shuttle).

Square Root (Sqrt1 and Sqrt2)

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

  - **Operation**: Select the function.
  - **Source1** and **Source2**: Select the math source waveforms.
  - **Sign**: Select the sign (+, –).

  **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).

  - **Operation**: Select the function.
  - **Source**: Select the math source waveform.
3 Configuring Real Time Math Settings

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 (\(\mathcal{A}, \mathcal{B}, \mathcal{C}\)).
  - 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 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).
  - 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).
  
  Set the encoding conditions.
  
  You can set the conditions when the encoding type is ABZ or AZ.
  
  Select the target (CH1 to CH161, RMath1 to RMath152).

- **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 CH161, RMath1 to RMath152).

- **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 channel2.
  
  The channels that have been defined with the resolver function are displayed.
  
  Select the scale (Radian, Degree).
  
  Select the target (CH1 to CH161, RMath1 to RMath152).

---

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.
3 Configuring Real Time Math Settings

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

- When the Encoding Type is Incremental ABZ or Incremental AZ

<table>
<thead>
<tr>
<th>Source Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Logic Source</td>
</tr>
<tr>
<td>Source</td>
</tr>
<tr>
<td>Phase A</td>
</tr>
<tr>
<td>Phase B</td>
</tr>
<tr>
<td>Phase Z</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Source Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Logic Source</td>
</tr>
<tr>
<td>Source</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Source Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Logic Source</td>
</tr>
<tr>
<td>Source1</td>
</tr>
<tr>
<td>Source2</td>
</tr>
</tbody>
</table>

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.

<table>
<thead>
<tr>
<th>Encode Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Count Condition</td>
</tr>
<tr>
<td>Timing1</td>
</tr>
<tr>
<td>Timing2</td>
</tr>
<tr>
<td>Reset Timing</td>
</tr>
<tr>
<td>Reverse</td>
</tr>
</tbody>
</table>

Set the count condition (x4, x2, x1).
Select the edge to count pulses on (A, A, B, B).
Select the edge to count pulses on (A, A, B, B).
Select the edge 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.

<table>
<thead>
<tr>
<th>Operation</th>
<th>Knock Filter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Source</td>
<td>CH1</td>
</tr>
<tr>
<td>Elimination Level</td>
<td>Off</td>
</tr>
<tr>
<td>Differential</td>
<td>OFF, ON</td>
</tr>
</tbody>
</table>

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.

<table>
<thead>
<tr>
<th>Operation</th>
<th>Poly-Add-Sub</th>
</tr>
</thead>
<tbody>
<tr>
<td>Source1</td>
<td>+ CH1</td>
</tr>
<tr>
<td>Source2</td>
<td>+ CH2</td>
</tr>
<tr>
<td>Source3</td>
<td>+ CH1</td>
</tr>
<tr>
<td>Source4</td>
<td>+ CH1</td>
</tr>
<tr>
<td>K</td>
<td>1.0000</td>
</tr>
</tbody>
</table>

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.

<table>
<thead>
<tr>
<th>Operation</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Source</td>
<td>CH1</td>
</tr>
<tr>
<td>Slope</td>
<td></td>
</tr>
<tr>
<td>Level</td>
<td>0.0000</td>
</tr>
<tr>
<td>Hysteresis</td>
<td></td>
</tr>
<tr>
<td>Scaling</td>
<td></td>
</tr>
<tr>
<td>Deceleration Prediction</td>
<td>OFF, ON</td>
</tr>
<tr>
<td>Stop Prediction</td>
<td>OFF</td>
</tr>
<tr>
<td>Offset(Hz/Rpm)</td>
<td>0.0000</td>
</tr>
</tbody>
</table>

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).
3 Configuring Real Time Math Settings

**Period (Period)**

The following screen appears when you select the period function.

<table>
<thead>
<tr>
<th>Operation</th>
<th>Period</th>
</tr>
</thead>
<tbody>
<tr>
<td>Source</td>
<td>CH1</td>
</tr>
<tr>
<td>Slope</td>
<td></td>
</tr>
<tr>
<td>Level</td>
<td>0.00V</td>
</tr>
<tr>
<td>Hysteresis</td>
<td></td>
</tr>
</tbody>
</table>

- 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 deceleration prediction (OFF, ON).
- Select the stop prediction (OFF, 2, 4, 8, 16).

**Edge Count (Edge Count)**

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

<table>
<thead>
<tr>
<th>Operation</th>
<th>Edge Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Source</td>
<td>CH1</td>
</tr>
<tr>
<td>Slope</td>
<td></td>
</tr>
<tr>
<td>Level</td>
<td>0.00V</td>
</tr>
<tr>
<td>Hysteresis</td>
<td></td>
</tr>
</tbody>
</table>

- Select the function.
- Select the math source waveform.
- Set the edge detection condition (, ).
- Set the level (using the jog shuttle).
- Set the hysteresis (, , ).
- Edge count result reset conditions
  - When the edge count operation begins
  - When “Value/Div” exceeds +10 div or falls below –10 div
- Resets the edge count result

**Resolver (Resolver)**

The following screen appears when you select the resolver function.

<table>
<thead>
<tr>
<th>Operation</th>
<th>Resolver</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sin Ch</td>
<td>CH1</td>
</tr>
<tr>
<td>Cos Ch</td>
<td>CH1</td>
</tr>
<tr>
<td>Carrier Ch</td>
<td>CH1</td>
</tr>
<tr>
<td>Hysteresis</td>
<td></td>
</tr>
<tr>
<td>Tracking Filter</td>
<td>OFF</td>
</tr>
</tbody>
</table>

- Select the function.
- Select the sine phase signal (CH1 to CH16, RMath1 to RMath15).
- Select the cosine phase signal (CH1 to CH16, RMath1 to RMath15).
- Select the excitation signal (CH1 to CH16, RMath1 to RMath15).
- 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
  - (, , , , , )
- 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

![IIR Filter Setup Screen]

- When Filter Band Is Set to Band-Pass

![IIR Filter Setup Screen]

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.

![PWM Demodulation Screen]

Reactive Power (Reactive Power(Q))

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

![Reactive Power Setup Screen]
3 Configuring Real Time Math Settings

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

<table>
<thead>
<tr>
<th>Operation</th>
<th>CAN ID</th>
</tr>
</thead>
<tbody>
<tr>
<td>Source</td>
<td>CH1</td>
</tr>
<tr>
<td>Bit Rate</td>
<td>500kbps</td>
</tr>
<tr>
<td>Message Format</td>
<td>XTD</td>
</tr>
<tr>
<td>ID (Hex)</td>
<td>0x0000</td>
</tr>
</tbody>
</table>

- Select the function.
- Select the detection source waveform.
- Select the bit rate (10k, 20k, 33.3k, 50k, 62.5k, 66.7k, 83.3k, 100k, 125k, 200k, 250k, 400k, 500k, 800k, 1Mbps).
- Select the message format (STD, XTD).
- Set the message ID.

Torque (Torque)
The following screen appears when you select the torque function.

<table>
<thead>
<tr>
<th>Operation</th>
<th>Torque</th>
</tr>
</thead>
<tbody>
<tr>
<td>Source</td>
<td>CH1</td>
</tr>
<tr>
<td>Slope</td>
<td></td>
</tr>
<tr>
<td>Level</td>
<td>0.8V</td>
</tr>
<tr>
<td>Hysteresis</td>
<td></td>
</tr>
<tr>
<td>Deceleration Prediction</td>
<td>OFF</td>
</tr>
<tr>
<td>Stop Prediction</td>
<td>OFF</td>
</tr>
<tr>
<td>A</td>
<td>1.0000</td>
</tr>
<tr>
<td>C</td>
<td>0.0000</td>
</tr>
</tbody>
</table>

- Select the function.
- Select the detection source waveform.
- Set the edge detection condition (f, f).
- Set the level (using the jog shuttle).
- Set the hysteresis (f, f, f).
- Select the deceleration prediction (OFF, ON).
- Select the stop prediction (OFF, 2, 4, 8, 16).
- Set the coefficient (using the jog shuttle).
- Set the coefficient (using the jog shuttle).

Angle Difference (S1−S2(Angle))
The following screen appears when you select the angle difference function.

<table>
<thead>
<tr>
<th>Operation</th>
<th>S1−S2(Angle)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Source1</td>
<td>CH1</td>
</tr>
<tr>
<td>Source2</td>
<td>CH2</td>
</tr>
<tr>
<td>Scaling</td>
<td>Degree</td>
</tr>
</tbody>
</table>

- Select the function.
- Select the math source waveforms.
- Select the scale (Radian, Degree).
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, RMath1 to RMath15).**
- **Select the excitation signal (CH1 to CH16, RMath1 to RMath15).**
- **Set the hysteresis ( ).**
- **Select the tracking filter (OFF, 2kHz, 1kHz, 250Hz, 100Hz).**

**Detail Setting**

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

Select the math source waveform.
Set the wiring system (1P2W, 1P3W, 3P3W, 3V3A, 3P4W, 3P3W→3V3A, 3V3A→3P4W, 3P4W→3V3A)
Set the analysis mode (OFF, 1 Wiring System, 2 Wiring System).

Detail settings

Detail Setting (Detail)
Press Setup... to display the following screen.

- When the calculation period type is set to Edge

Select the calculation period type.
Select the edge detection source* (U1, I1, Other Channel, Own U, Own I).
Set the hysteresis ( , , ).
Set the edge source filter (OFF, 128kHz, 64kHz, 32kHz, 16kHz, 8kHz, 4kHz, 2kHz, 1kHz, 500Hz, 250Hz, 125Hz, 62.5Hz).

* 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.
4 Configuring the Power Math Feature

- When the calculation period type is set to Auto Timer

Select the calculation period type.

Set the update time (using the jog shuttle).

- When the calculation period type is set to AC

Select the calculation period type.

Select the edge detection source* (U1, I1, U2, I2, U3, I3, Other Channel).

Set the hysteresis (, , ).

Set the edge source filter (OFF, 128kHz, 64kHz, 32kHz, 16kHz, 8kHz, 4kHz, 2kHz, 1kHz, 500Hz, 250Hz, 125Hz, 62.5Hz).

Set the stop prediction (2, 4, 8, 16).

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

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

Select the calculation period type.

Select the edge detection source* (U1, I1, U2, I2, U3, I3, Other Channel).

Set the hysteresis (, , ).

Set the edge source filter (OFF, 128kHz, 64kHz, 32kHz, 16kHz, 8kHz, 4kHz, 2kHz, 1kHz, 500Hz, 250Hz, 125Hz, 62.5Hz).

Set the stop prediction (2, 4, 8, 16).

Set the update time (using the jog shuttle).

* 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**

- **When the efficiency mode is set to 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

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.

- Manually resets power integration

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

- Resets Wiring System 1
- Resets Wiring System 2
  Not displayed when the analysis mode is set to Wiring1
- Resets Wiring System 1 and 2
  Not displayed when the analysis mode is set to Wiring1
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
  - Set the edge source filter (OFF, 128kHz, 64kHz, 32kHz, 16kHz, 8kHz, 4kHz, 2kHz, 1kHz, 500Hz, 250Hz, 125kHz, 62.5kHz).
  - Set the hysteresis (, , , ).
  - Select the math source waveform.
  - Set the analysis mode (OFF, Line RMS, Power).
  - Select the harmonic analysis items.
  - Select the ϕ scale.

- When Analysis Mode is set to Power
  - Set the wiring system (1P2W, 1P3W, 3P3W, 3V3A, 3P4W, 3P3W→3V3A, 3V3A→3P4W, 3P4W→3V3A)
  - Set the analysis mode (OFF, Line RMS, Power).
  - Select the harmonic analysis items.
  - Detail settings
4 Configuring the Power Math Feature

Detail Setting (Detail)
Press Setup... to display the following screen.

- Select the edge detection source (U1, I1, Other Channel).
- Set the hysteresis (YES, YES, YES).
- Set the edge source filter (OFF, 128kHz, 64kHz, 32kHz, 16kHz, 8kHz, 4kHz, 2kHz, 1kHz, 500Hz, 250Hz, 125Hz, 62.5Hz).
- Set the \( \phi \) scale (Radian, Degree).

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

<table>
<thead>
<tr>
<th>Output items</th>
<th>Harmonic Analysis Items</th>
<th>Analysis Items</th>
</tr>
</thead>
<tbody>
<tr>
<td>( P(1) )</td>
<td>( P(2) )</td>
<td>( P(3) )</td>
</tr>
</tbody>
</table>

- Set all output items to OFF (clear the check boxes).
- Set P(1 to 35) to OFF.
- Set Phdf(1 to 35) to OFF.
- Set \( \phi \) (1 to 35) to OFF.
- Set all output items to ON (select the check boxes).
- Set P(1 to 35) to ON.
- Set Phdf(1 to 35) to ON.
- Set \( \phi \) (1 to 35) to ON.
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.

- Select the graph window (OFF, Bar, List, Vector).
- Set the display item (\(P\), hdf, \(\varphi\)).
- Set the maximum harmonic to display (using the jog shuttle).
- Select the vertical scale (Linear, Log).
- Set the graph position (using the jog shuttle).

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).
4 Configuring the Power Math Feature

**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.

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

Use the jog shuttle to move the cursor to the item you want to set.
• Setup screen for harmonic analysis

![Diagram of harmonic analysis setup screen]

- 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.

![Diagram showing items set to ON]

- Displays the items that have been set to ON
- Optimizes the Value/Div settings of all items
# 5 Commands

## List of Commands

<table>
<thead>
<tr>
<th>Command</th>
<th>Function</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ANALysis Group</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>:ANALysis&lt;x&gt;:?</td>
<td>Queries all power math (power analysis or harmonic analysis) settings.</td>
<td>5-9</td>
</tr>
<tr>
<td>:ANALysis&lt;x&gt;:HARMonic?</td>
<td>Queries harmonic analysis setting of the power math feature.</td>
<td>5-9</td>
</tr>
<tr>
<td>:ANALysis&lt;x&gt;:HARMonic:GRAPH?</td>
<td>Queries all settings related to the harmonic analysis result display.</td>
<td>5-9</td>
</tr>
<tr>
<td>:ANALysis&lt;x&gt;:HARMonic:GRAPH:DIT em?</td>
<td>Queries all analysis items settings of the harmonic analysis result display.</td>
<td>5-9</td>
</tr>
<tr>
<td>:ANALysis&lt;x&gt;:HARMonic:GRAPH:DIT em:HDF</td>
<td>Sets or queries whether percentage content (HDF) is displayed in the harmonic analysis result display.</td>
<td>5-9</td>
</tr>
<tr>
<td>:ANALysis&lt;x&gt;:HARMonic:GRAPH:DIT em:P</td>
<td>Sets or queries whether active power (P) is displayed in the harmonic analysis result display.</td>
<td>5-9</td>
</tr>
<tr>
<td>:ANALysis&lt;x&gt;:HARMonic:GRAPH:DIT em:PHI</td>
<td>Sets or queries whether phase angle (φ) is displayed in the harmonic analysis result display.</td>
<td>5-9</td>
</tr>
<tr>
<td>:ANALysis&lt;x&gt;:HARMonic:GRAPH:DIT em:RMS</td>
<td>Sets or queries whether rms values (RMS) is displayed in the harmonic analysis result display.</td>
<td>5-9</td>
</tr>
<tr>
<td>:ANALysis&lt;x&gt;:HARMonic:GRAPH:LISTart</td>
<td>Sets or queries whether list starting harmonic is displayed in the harmonic analysis result display (window settings).</td>
<td>5-10</td>
</tr>
<tr>
<td>:ANALysis&lt;x&gt;:HARMonic:GRAPH:MAX order</td>
<td>Sets or queries the maximum displayed harmonic in the harmonic analysis result display (window settings).</td>
<td>5-10</td>
</tr>
<tr>
<td>:ANALysis&lt;x&gt;:HARMonic:GRAPH:MO DE</td>
<td>Sets or queries the graph mode in the harmonic analysis result display (window settings).</td>
<td>5-10</td>
</tr>
<tr>
<td>:ANALysis&lt;x&gt;:HARMonic:GRAPH:NUM eric</td>
<td>Sets or queries whether numeric string is displayed when the graph mode is set to Vector in the harmonic analysis result display (window settings).</td>
<td>5-10</td>
</tr>
<tr>
<td>:ANALysis&lt;x&gt;:HARMonic:GRAPH:POS ition</td>
<td>Sets or queries the graph position in the harmonic analysis result display (window settings).</td>
<td>5-10</td>
</tr>
<tr>
<td>:ANALysis&lt;x&gt;:HARMonic:GRAPH:SCAL e</td>
<td>Sets or queries the vertical scale when the graph mode is set to Bar in the harmonic analysis result display (window settings).</td>
<td>5-10</td>
</tr>
<tr>
<td>:ANALysis&lt;x&gt;:HARMonic:GRAPH:IZO om</td>
<td>Sets or queries the current zoom when the graph mode is set to Vector in the harmonic analysis result display (window settings).</td>
<td>5-10</td>
</tr>
<tr>
<td>:ANALysis&lt;x&gt;:HARMonic:GRAPH:UZO om</td>
<td>Sets or queries the voltage zoom when the graph mode is set to Vector in the harmonic analysis result display (window settings).</td>
<td>5-11</td>
</tr>
<tr>
<td>:ANALysis&lt;x&gt;:HARMonic:MODE</td>
<td>Sets or queries the analysis mode in harmonic analysis settings.</td>
<td>5-11</td>
</tr>
<tr>
<td>:ANALysis&lt;x&gt;:HARMonic:POWER:&lt;Pa rameter 1&gt;:LABEL</td>
<td>Sets or queries the label of an analysis item in harmonic analysis (for Power mode).</td>
<td>5-11</td>
</tr>
<tr>
<td>:ANALysis&lt;x&gt;:HARMonic:POWER:&lt;Pa rameter 1&gt;:OFFSet</td>
<td>Sets or queries the offset of an analysis item in harmonic analysis (for Power mode).</td>
<td>5-11</td>
</tr>
<tr>
<td>:ANALysis&lt;x&gt;:HARMonic:POWER:&lt;Pa rameter 1&gt;:POSition</td>
<td>Sets or queries the position of an analysis item in harmonic analysis (for Power mode).</td>
<td>5-12</td>
</tr>
<tr>
<td>:ANALysis&lt;x&gt;:HARMonic:POWER:&lt;Pa rameter 1&gt;:SCALE</td>
<td>Sets or queries the scale boundaries (upper and lower) of an analysis item in harmonic analysis (for Power mode).</td>
<td>5-12</td>
</tr>
<tr>
<td>:ANALysis&lt;x&gt;:HARMonic:POWER:&lt;Pa rameter 1&gt;:STATE</td>
<td>Sets or queries the on/off status of an analysis item in harmonic analysis (for Power mode).</td>
<td>5-12</td>
</tr>
<tr>
<td>:ANALysis&lt;x&gt;:HARMonic:POWER:&lt;Pa rameter 1&gt;:VARIABLE</td>
<td>Sets or queries the DIV/Scale setting of an analysis item in harmonic analysis (for Power mode).</td>
<td>5-12</td>
</tr>
<tr>
<td>:ANALysis&lt;x&gt;:HARMonic:POWER:&lt;Pa rameter 1&gt;:VDIV</td>
<td>Sets or queries the V/DIV setting of an analysis item in harmonic analysis (for Power mode).</td>
<td>5-12</td>
</tr>
<tr>
<td>:ANALysis&lt;x&gt;:HARMonic:POWER:&lt;Pa rameter 1&gt;:ZOOM</td>
<td>Sets or queries the vertical zoom (V Zoom) of an analysis item in harmonic analysis (for Power mode).</td>
<td>5-13</td>
</tr>
<tr>
<td>:ANALysis&lt;x&gt;:HARMonic:POWER:&lt;Pa rameter 2&gt;:OFFSet</td>
<td>Sets or queries the offset of an analysis item (P, Phdf, and φ of all harmonics) in harmonic analysis (for Power mode).</td>
<td>5-13</td>
</tr>
<tr>
<td>:ANALysis&lt;x&gt;:HARMonic:POWER:&lt;Pa rameter 2&gt;:POSition</td>
<td>Sets the position of an analysis item (P, Phdf, and φ of all harmonics) in harmonic analysis (for Power mode).</td>
<td>5-13</td>
</tr>
<tr>
<td>:ANALysis&lt;x&gt;:HARMonic:POWER:&lt;Pa rameter 2&gt;:SCALE</td>
<td>Sets the scale boundaries (upper and lower) of an analysis item (P, Phdf, and φ of all harmonics) in harmonic analysis (for Power mode).</td>
<td>5-13</td>
</tr>
</tbody>
</table>
## List of Commands

<table>
<thead>
<tr>
<th>Command</th>
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</tr>
</thead>
<tbody>
<tr>
<td>:ANALyst&lt;&lt;:HARMonic:POWER:&lt;Parameter 2&gt;:VARIable</td>
<td>Sets the DIV/Scale setting of an analysis item (P, Phdf, and φ of all harmonics) in harmonic analysis (for Power mode).</td>
<td>5-13</td>
</tr>
<tr>
<td>:ANALyst&lt;&lt;:HARMonic:POWER:ST:ate</td>
<td>Sets the vertical zoom (V Zoom) of an analysis item (P, Phdf, and φ of all harmonics) in harmonic analysis (for Power mode).</td>
<td>5-14</td>
</tr>
<tr>
<td>:ANALyst&lt;&lt;:HARMonic:POWER:SOUR Rce:11</td>
<td>Sets or queries source channel I1 in harmonic analysis (for Power mode).</td>
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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?
<x> = 2
Description This command is valid on models with the /G5 option.

:ANALysis<x>?:HARMonic:GRAPh:DITem:H
DF
Function Sets or queries whether percentage content (HDF) is displayed in the harmonic analysis result display.
Syntax :ANALysis<x>?:HARMonic:GRAPh:DITem:H
DF {<Boolean>}
ANALysis<x>?:HARMonic:GRAPh:DITem:H
DF?
<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
HI
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:R
MS
Function Sets or queries whether rms values (RMS) is displayed in the harmonic analysis result display.
Syntax :ANALysis<x>:HARMonic:GRAPh:DITem:R
MS {<Boolean>}
ANALysis<x>:HARMonic:GRAPh:DITem:R
MS?
<x> = 2
Example :ANALYSIS2:HARMONIC:GRAPH:DITEM:R
MS 1
ANALYSIS2:HARMONIC:GRAPH:DITEM:R
MS?
-> :ANALYSIS2:HARMONIC:GRAPH:
DITEM:R
MS 1
Description This command is valid on models with the /G5 option.
**ANALysis Group**

: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:MAXorder?
<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:MAXORDER 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**
:ANALYSIS2:HARMONIC:GRAPH:NUMERIC
:ANALYSIS2:HARMONIC:GRAPH:NUMERIC?
-> :ANALYSIS2:HARMONIC:GRAPH:NUMERIC

**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, 0.566, 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: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:POSition?
<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:POSITION –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 Group

: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
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
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:<Parameter 1>:LABel {<String>}
:ANALysis<x>:HARMonic:POWer:<Parameter 1>:LABel?
<x> = 2
<String> = Up to 16 characters
Example  
:ANALYSIS2:HARMONIC:POWER:PHDFK5:LABEL "Phdf(5)"
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>:OFFSet
Function  Sets or queries the offset of an analysis item in harmonic analysis (for Power mode).
Syntax  
:ANALysis<x>:HARMonic:POWer:<Parameter 1>:OFFSet {<NRf>}
:ANALysis<x>:HARMonic:POWer:<Parameter 1>:OFFSet?
<x> = 2
<NRf> = -5.00 to 5.00 (in 0.01 steps)
Example  
:ANALYSIS2:HARMONIC:POWER:PK1:OFFSET -50
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:<Parameter 1>:OPTimize
<x> = 2
Example  
:ANALYSIS2:HARMONIC:POWER:PK1:OPTIMIZE
Description  
• For the analysis items, see “Parameter 1 list.”
• This command is valid on models with the /G5 option.
**ANALysis Group**

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

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

**Syntax**
:ANALysis<x>:HARMonic:POWer:<Parameter 1>:POSition {<NRf>}
:ANALysis<x>:HARMonic:POWer:<Parameter 1>:POSition?

**Example**
:ANALYSIS2:HARMONIC:POWER:PK1:POSITION 1

**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>: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:<Parameter 1>:SCALe {<NRf>,<NRf>}
:ANALysis<x>:HARMonic:POWer:<Parameter 1>:SCALe?

**Example**
:ANALYSIS2:HARMONIC:POWER:PK1:SCALE 400,0
:ANALYSIS2:HARMONIC:POWER:PK1:SCALE? -> :ANALYSIS2:HARMONIC:POWER:PK1:SCALE 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:<Parameter 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:<Parameter 1>:STATe {<Boolean>}
:ANALysis<x>:HARMonic:POWer:<Parameter 1>:STATe?

**Example**
:ANALYSIS2:HARMONIC:POWER:PK1:STATE 1

**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>:VARiable

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

**Syntax**
:ANALysis<x>:HARMonic:POWer:<Parameter 1>:VARiable {<Boolean>}
:ANALysis<x>:HARMonic:POWer:<Parameter 1>:VARiable?

**Example**
: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:<Parameter 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:<Parameter 1>:VDIV {<NRf>}
:ANALysis<x>:HARMonic:POWer:<Parameter 1>:VDIV?

**Example**
:ANALYSIS2:HARMONIC:POWER:PK1:VDIV 100

**Description**
• For the analysis items, see "Parameter 1 list."
• This command is valid on models with the /G5 option.
### ANALysis Group

**: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?`  

**Example**

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

**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>}`  

**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.

**: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>}`  

**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>}`  

**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>}`  

**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>}`  

**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.

### Parameter List

- **PALL**: Active power of all harmonics
- **PHDFALL**: Active power percentage content of all harmonics
- **PHIALL**: Phase angle of all harmonics
**ANALysis Group**

**: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

**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: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

**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

**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

**Description**
- This command is valid on models with the /G5 option.
### ANALysis Group

**Function**
Sets or queries source channel U2 in harmonic analysis (for Power mode).

**Syntax**
:ANALysis<x>:HARMonics:POWER:SOURCE:U2 <NRf>
:ANALysis<x>:HARMonics: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.

**Function**
Sets or queries source channel U3 in harmonic analysis (for Power mode).

**Syntax**
:ANALysis<x>:HARMonics:POWER:SOURCE:U3 <NRf>
:ANALysis<x>:HARMonics: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>:HARMonics:POWER:TERM?
**Function**
Queries all calculation period settings in harmonic analysis (for Power mode).

**Syntax**
:ANALysis<x>:HARMonics:POWER:TERM?

**Example**
:ANALYSIS2:HARMONIC:POWER:TERM?

- `->` :ANALYSIS2:HARMONIC:POWER:TERM?

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

#### :ANALysis<x>:HARMonics:POWER:TERM:ESFILTER
**Function**
Sets or queries the edge source filter for the calculation period in harmonic analysis (for Power mode).

**Syntax**
:ANALysis<x>:HARMonics:POWER:TERM:ESFILTER {OFF|<Frequency>}

- `<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>:HARMonics:POWER:TERM:HYSTeresis
**Function**
Sets or queries the hysteresis for the calculation period in harmonic analysis (for Power mode).

**Syntax**
:ANALysis<x>:HARMonics:POWER:TERM:HYSTeresis {HIGH|LOW|MIDDle}

- `<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>:HARMonics:POWER:TERM:ESOuRce
**Function**
Sets or queries the edge detection source for the calculation period in harmonic analysis (for Power mode).

**Syntax**
:ANALysis<x>:HARMonics:POWER:TERM:ESOuRce {U1|U2|U3|I1|I2|I3}

- `<x>` = 2

**Example**
:ANALYSIS2:HARMONIC:POWER:TERM:ESOuRce U1
:ANALYSIS2:HARMONIC:POWER:TERM:ESOuRce I1
:ANALYSIS2:HARMONIC:POWER:TERM:ESOuRce?

- `->` :ANALYSIS2:HARMONIC:POWER:TERM:ESOuRce U1

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

:ANALysis<<:HARMonic:POWer:WIRing
Function Sets or queries the wiring system in harmonic analysis (for Power mode).
Syntax :ANALysis<<:HARMonic:POWer:WIRing
{(P1W2|P1W3|P3W3|V3A3|P3W4),(OFF|P3W3|V3A3|DT_ST|ST_DT)}
<< = 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<<:HARMonic:PScale
Function Sets or queries the φ (phase difference) scale in harmonic analysis (for Power mode).
Syntax :ANALysis<<:HARMonic:PScale
{DEGRee|RADian}
:ANALysis<<:HARMonic:PScale?
<< = 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<<:HARMonic:LRMS?
Function Queries all settings related to the harmonic analysis (for Line RMS mode).
Syntax :ANALysis<<:HARMonic:LRMS?
<< = 2
Example :ANALYSIS2:HARMONIC:LRMS?
-> :ANALYSIS2:HARMONIC:LRMS?
Description • For the analysis items, see “Parameter 1 list.”
• This command is valid when DIV/Scale is set to DIV.

:ANALysis<<:HARMonic:LRMS:<Parameter 1>:LABel
Function Sets or queries the label of an analysis item in harmonic analysis (for Line RMS mode).
Syntax :ANALysis<<:HARMonic:LRMS:<Parameter 1>:LABel {<String>}
:ANALysis<<:HARMonic:LRMS:<Parameter 1>:LABel?
<< = 2
<string> = Up to 16 characters
Example :ANALYSIS2:HARMONIC:LRMS:RMSK3:LABEL "AAA"
:ANALYSIS2:HARMONIC:LRMS:RMSK3:LABEL?
-> :ANALYSIS2:HARMONIC:LRMS:RMSK3:LABEL "AAA"
Description • For the analysis items, see “Parameter 1 list.”
• This command is valid on models with the /G5 option.

:ANALysis<<:HARMonic:LRMS:<Parameter 1>:OPTimize
Function Optimizes Value/Div of an analysis item in harmonic analysis (for Line RMS mode).
Syntax :ANALysis<<:HARMonic:LRMS:<Parameter 1>:OPTimize
<< = 2
Example :ANALYSIS2:HARMONIC:LRMS:RMSK3:OPTimize
1.0
:ANALYSIS2:HARMONIC:LRMS:RMSK3:OPTimize?
-> :ANALYSIS2:HARMONIC:LRMS:RMSK3:OPTimize
1.00000E+00
Description • For the analysis items, see “Parameter 1 list.”
• This command is valid on models with the /G5 option.

:ANALysis<<:HARMonic:LRMS:<Parameter 1>:OFFSet
Function Sets or queries the offset of an analysis item in harmonic analysis (for Line RMS mode).
Syntax :ANALysis<<:HARMonic:LRMS:<Parameter 1>:OFFSet {<NRf>}
:ANALysis<<:HARMonic:LRMS:<Parameter 1>:OFFSet?
<< = 2
Example :ANALYSIS2:HARMONIC:LRMS:RMSK3:OFFSET 1.0
:ANALYSIS2:HARMONIC:LRMS:RMSK3:OFFSET?
-> :ANALYSIS2:HARMONIC:LRMS:RMSK3: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<<:HARMonic:LRMS:<Parameter 1>:POSition
Function Sets or queries the position of an analysis item in harmonic analysis (for Line RMS mode).
Syntax :ANALysis<<:HARMonic:LRMS:<Parameter 1>:POSition {<NRf>}
:ANALysis<<:HARMonic:LRMS:<Parameter 1>:POSition?
<< = 2
Example :ANALYSIS2:HARMONIC:LRMS:RMSK3:POSITION -1.2
:ANALYSIS2:HARMONIC:LRMS:RMSK3:POSITION?
-> :ANALYSIS2:HARMONIC:LRMS:RMSK3: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.

Parameter 1 list
When the analysis mode is Line RMS

<table>
<thead>
<tr>
<th>Parameter 1</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>RMSK&lt;&lt;</td>
<td>RMS Value (RMS)</td>
</tr>
<tr>
<td>RHD FK&lt;&lt;</td>
<td>RMS percentage content</td>
</tr>
<tr>
<td>PHIK&lt;&lt;</td>
<td>Phase angle</td>
</tr>
<tr>
<td>RMS</td>
<td></td>
</tr>
<tr>
<td>THD lec</td>
<td>(Firmware version 3.2 and later)</td>
</tr>
<tr>
<td>THD Csa</td>
<td>(Firmware version 3.2 and later)</td>
</tr>
<tr>
<td>HDF lec</td>
<td>Same as THD lec</td>
</tr>
<tr>
<td>HDF Csa</td>
<td>Same as THD Csa</td>
</tr>
</tbody>
</table>
: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>}

Example
:ANALYSIS2:HARMONIC:LRMS:RMSK3:SCALE 4,0

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:<Parameter 1>:STATE {<Boolean>}

Example
:ANALYSIS2:HARMONIC:LRMS:RMSK3: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:<Parameter 1>:VARIABLE {<Boolean>}

Example
: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:<Parameter 1>:VDIV {<NRf>}

Example
:ANALYSIS2:HARMONIC:LRMS:RMSK3:VDIV 2

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:<Parameter 1>:ZOOM {<NRf>}

Example
:ANALYSIS2:HARMONIC:LRMS:RMSK3: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 Group

: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>}
<xy> = 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>}
<xy> = 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>}
<xy> = 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>}
<xy> = 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>}
<xy> = 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>}
<xy> = 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>}
<xy> = 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?

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?

Example :ANALYSIS2:HARMONIC:LRMS:TERM?

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

:ANALysis<x>:HARMonic:LRMS:TERM:ESFi
lter
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, 1kHz, 2kHz, 4kHz, 8kHz, 16kHz, 32kHz, 64kHz, 128kHz

Example :ANALYSIS2:HARMONIC:LRMS:TERM:ESFILTER 128KHZ
          :ANALYSIS2:HARMONIC:LRMS:TERM:ESFILTER?

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:HYSTERESIS HIGH
          :ANALYSIS2:HARMONIC:LRMS:TERM:HYSTERESIS?

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?

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: All analysis items of power analysis are optimized.
        When <x2> = 2: All analysis items of harmonic analysis are optimized.

Example :ANALYSIS1:POWer1
          :ANALYSIS1:POWer2?

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

Example :ANALYSIS1:POWer1:EFFiciency
          :ANALYSIS1:POWer2:EFFiciency?

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

:ANALysis<x1>:POWer<x2>:EFFiciency:MODE Function
Sets or queries the efficiency mode of power analysis.
Syntax
:ANALysis<x1>:POWer<x2>:EFFiciency:MODE {OFF|POWer|MOTor}
:ANALysis<x1>:POWer<x2>:EFFiciency:MODE?
<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:MOTor {RANGle|SPEed}
:ANALysis<x1>:POWer<x2>:EFFiciency:MOTor?
<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:RANgle {RANGle|SPEed}
:ANALysis<x1>:POWer<x2>:EFFiciency:RANgle?
<x1> = 1  <x2> = 1 or 2  <x3> = 1 to 16
RANGle: Rotation angle
Example
:ANALYSIS1:POWER1:EFFICIENCY:RANgle RANGLE
:ANALYSIS1:POWER1:EFFICIENCY:RANgle?
-> :ANALYSIS1:POWER1:EFFICIENCY:RANgle RANGLE
Description
This command is valid on models with the /G5 option.

:ANALysis<x1>:POWer<x2>:EFFiciency:SCLaling Function
Sets or queries the scaling for the motor efficiency calculation (rotation angle mode) of power analysis.
Syntax
:ANALysis<x1>:POWer<x2>:EFFiciency:SCLaling {<NRf>}
:ANALysis<x1>:POWer<x2>:EFFiciency:SCLaling?
<x1> = 1  <x2> = 1 or 2  <x3> = -9.999E+30 to +9.9999E+30
Example
:ANALYSIS1:POWER1:EFFICIENCY:SCLaling 3.5
:ANALYSIS1:POWER1:EFFICIENCY:SCLaling?
-> :ANALYSIS1:POWER1:EFFICIENCY:SCLaling 3.50000E+00
Description
This command is valid on models with the /G5 option.

: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:SPEed {<NRf>|RANgle|SPEed}
:ANALysis<x1>:POWer<x2>:EFFiciency:SPEed?
<x1> = 1  <x2> = 1 or 2  <x3> = 1 to 16
Example
:ANALYSIS1:POWER1:EFFICIENCY:SPEed 1
:ANALYSIS1:POWER1:EFFICIENCY:SPEed?
-> :ANALYSIS1:POWER1:EFFICIENCY:SPEed 1
Description
This command is valid on models with the /G5 option.

:ANALysis<x1>:POWer<x2>:EFFiciency:SSCALE Function
Sets or queries the scaling for the motor efficiency calculation (rotation speed mode) of power analysis.
Syntax
:ANALysis<x1>:POWer<x2>:EFFiciency:SSCALE {RPS|RPM}
:ANALysis<x1>:POWer<x2>:EFFiciency:SSCALE?
<x1> = 1  <x2> = 1 or 2
Example
:ANALYSIS1:POWER1:EFFICIENCY:SSCALE RPM
:ANALYSIS1:POWER1:EFFICIENCY:SSCALE?
-> :ANALYSIS1:POWER1:EFFICIENCY:SSCALE RPM
Description
This command is valid on models with the /G5 option.
:ANALysis<x1>:POWer<x2>:EFFiciency:T
ORQue
Function Sets or queries the torque source for the motor
efficiency calculation of power analysis.
Syntax :ANALysis<x1>:POWer<x2>:EFFiciency:T
ORQue {<NRf>|RMATH<x3>}
:ANALysis<x1>:POWer<x2>:EFFiciency:T
ORQue?
<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:TORQ
UE 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
Example :ANALYSIS1:POWER1:INTEGRATION:
CALExecute
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:
CONDition
Function Sets or queries whether the integrated value is
reset when the power analysis integration starts.
Syntax :ANALysis<x1>:POWer<x2>:INTEGRation:
CONDition {<Boolean>}
:ANALysis<x1>:POWer<x2>:INTEGRation:
CONDition?
<x1> = 1  <x2> = 1 or 2
Example :ANALYSIS1:POWER1:INTEGRATION:RCONDI
TION 1
:ANALYSIS1:POWER1:INTEGRATION:RCONDIT
ION? -> :ANALYSIS1:POWER1:INTEGRATI
ON: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:SCALI
NG SECOND
:ANALYSIS1:POWER1:INTEGRATION:SCALI
NG? -> :ANALYSIS1:POWER1:INTEGRATION:
:SCALING SECOND
Description This command is valid on models with the /G5
option.
**ANALysis Group**

`:ANALysis<x1>:POWer<x2>:<Parameter>:\n {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>:\n {PH1|PH2|PH3|SIGMa}:LABel\n <x1> = 1 \n <x2> = 1 or 2\n <String> = Up to 16 characters`

**Example**

**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 Systems

- **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**: \{PH1|PH2|PH3|SIGMa\}
- **S**: \{PH1|PH2|PH3|SIGMa\}
- **Q**: \{PH1|PH2|PH3|SIGMa\}
- **LAMBda**: \{PH1|PH2|PH3|SIGMa\}
- **PHI**: \{PH1|PH2|PH3|SIGMa\}
- **FU**: \{PH1|PH2|PH3\}
- **FI**: \{PH1|PH2|PH3\}
- **UPPK**: \{PH1|PH2|PH3\}
- **UMPK**: \{PH1|PH2|PH3\}
- **IPPK**: \{PH1|PH2|PH3\}
- **IMPK**: \{PH1|PH2|PH3\}
- **PPPK**: \{PH1|PH2|PH3\}
- **PMPK**: \{PH1|PH2|PH3\}
- **WH**: \{PH1|SIGMa\}
- **WHP**: \{PH1|SIGMa\}
- **WHM**: \{PH1|SIGMa\}
- **AH**: \{PH1|SIGMa\}
- **AHP**: \{PH1|SIGMa\}
- **AHM**: \{PH1|SIGMa\}
- **WS**: \{PH1|SIGMa\}
- **WQ**: \{PH1|SIGMa\}
- **Z**: \{PH1|SIGMa\}
- **RS**: \{PH1|PH2|PH3|SIGMa\}
- **XS**: \{PH1|PH2|PH3|SIGMa\}
- **RP**: \{PH1|PH2|PH3|SIGMa\}
- **XP**: \{PH1|PH2|PH3|SIGMa\}
- **PM**: \{PH1|PH2|PH3|SIGMa\}
- **ETA**: \{PH1|PH2|PH3|SIGMa\}
- **UUBF**: \{PH1|PH2|PH3|SIGMa\}
- **IUBF**: \{PH1|PH2|PH3|SIGMa\}
- **IN**: \{PH1|PH2|PH3|SIGMa\}
- **TIME**: \{PH1|PH2|PH3|SIGMa\}

**:ANALysis<x1>:POWer<x2>:<Parameter>:\n {PH1|PH2|PH3|SIGMa}:OFFSet`

**Function**
Sets or queries the offset of an analysis item in power analysis.

**Syntax**
`:ANALysis<x1>:POWer<x2>:<Parameter>:\n {PH1|PH2|PH3|SIGMa}:OFFSet\n <x1> = 1 \n <x2> = 1 or 2\n <NRf> = \{PH1|PH2|PH3\}`

**Example**

**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

<x1> = 1
<x2> = 1 or 2

**Example**
:ANALYSIS1:POWER1:URMS:PH1:POSITION 0.5
:ANALYSIS1:POWER1:URMS:PH1:POSITION?

**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

**Example**
:ANALYSIS1:POWER1:URMS:PH1:SCALE 4.00000E+00,-4.00000E+00
:ANALYSIS1:POWER1:URMS:PH1:SCALE?

**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?

**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}:VARiable**

**Function**
Sets or queries the DIV/Scale setting of an analysis item in power supply analysis.

**Syntax**
:ANALysis<x1>:POWer<x2>:<Parameter>:
{:PH1|PH2|PH3|SIGMa}:VARiable {<Boolean>}
:ANALysis<x1>:POWer<x2>:<Parameter>:
{:PH1|PH2|PH3|SIGMa}:VARiable?

<x1> = 1
<x2> = 1 or 2

**Example**
:ANALYSIS1:POWER1:URMS:PH1:VARIABLE 1
:ANALYSIS1:POWER1:URMS:PH1:VARIABLE?

**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 Group**

`: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>}`

- `<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.

`: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}`

- `<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}`

- `<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|2|3}: <NRf>`

- `<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 invalid when the wiring system is 1P2W.
- 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|3}: <NRf>`

- `<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 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|3V3A}: <NRf>`

- `<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 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|3V3A}: <NRf>`

- `<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 Group

: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?

**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?

**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

**Example**
:ANALYSIS1:POWER1:TERM?

**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?

**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:ESFilter {OFF|<Frequency>}
:ANALysis<x1>:POWer<x2>:TERM:ESFilter? <x1> = 1 <x2> = 1 or 2
<Frequency> = 62.5Hz, 125Hz, 250Hz, 500Hz, 1kHz, 2kHz, 4kHz, 8kHz, 16kHz, 32kHz, 64kHz, 128kHz

**Example**
:ANALYSIS1:POWER1:TERM:ESFILTER 128kHz
:ANALYSIS1:POWER1:TERM:ESFILTER?

**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:HYSTeresis {HIGH|LOW|MIDDle}
:ANALysis<x1>:POWer<x2>:TERM:HYSTeresis? <x1> = 1 <x2> = 1 or 2

**Example**
:ANALYSIS1:POWER1:TERM:HYSTESIS MIDDLE
:ANALYSIS1:POWER1:TERM:HYSTESIS?

**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:ESOurce? <x1> = 1 <x2> = 1 or 2

**Example**
:ANALYSIS1:POWER1:TERM:ESOURCE OWNU
:ANALYSIS1:POWER1:TERM:ESOurce?

**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 Group

: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.
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?
Example :CHANNEL1:RMATH:AMINUS:SCALE DEGREE
Description This command is valid on models with the /G3 or /G5 option.

:CHANnel<x>: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?
Example :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 :CHANNEL1: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?
Example :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?
Example :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?
Example :CHANNEL1:RMATH:BWIDTH:BAND BPASS
Description This command is valid on models with the /G3 or /G5 option.

Notes:
- 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.
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)
2kHz (12kHz to 294kHz)
When TYPE is set to SHARP
300Hz to 300kHz
Resolution 20Hz (300Hz to 2.98kHz)
2kHz (30kHz to 300kHz)

Example
:CHANNEL1:RMATH:BWIDTH:CFREQUENCY 300Hz
:CHANNEL1:RMATH:BWIDTH:CFREQUENCY?

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.

FUNCTION
Sets or queries the cutoff frequency of the specified channel’s digital filter.

SYNTAX
:CHANnel<x>:RMATh:BWIDTH:CUTOff {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 LPAS
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 HPAS
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 LPAS
2Hz to 300kHz
Resolution 2Hz (2Hz to 298Hz)
20Hz (30Hz to 298kHz)
200Hz (3kHz to 29.8kHz)
2kHz (30kHz to 300kHz)
When TYPE is set to IIR and BAND is set to HPAS
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?

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?

Example  :CHANNEL1:RMATH:BWIDTH:INTERPO 1
-> :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?

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: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?

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.
RMATH CHANnel Group

: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 :CHAN1:RMATH:BWIDth:PBANd 200Hz
 :CHAN1:RMATH:BWIDth:PBANd?
 -> :CHAN1: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 {GAUSSs|IIR|SHARp|MEAN}
:CHANnel<x>:RMATH:BWIDth:TYPE?
<x> = 1 to 16
Example :CHAN1:RMATH:BWIDth:TYPE IIR
 :CHAN1:RMATH:BWIDth:TYPE?
 -> :CHAN1: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.
  - 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 :CHAN1:RMATH:BWIDth:TYPE
 :CHAN1:RMATH:BWIDth:PBANd 200Hz
 -> :CHAN1:RMATH:BWIDth:PBANd 200Hz

: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 :CHAN1:RMATH:CANId:BRATe 500000
 :CHAN1:RMATH:CANId:BRATe?
 -> :CHAN1: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 :CHAN1:RMATH:CANId:MFORmat STANDARD
 :CHAN1:RMATH:CANId:MFORmat?
 -> :CHAN1: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 :CHAN1:RMATH:CANId:MID "7FF"
 :CHAN1:RMATH:CANId:MID?
 -> :CHAN1: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
Example :CHAN1:RMATH:CANId:SOURce 1
 :CHAN1:RMATH:CANId:SOURce?
 -> :CHAN1: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>?
<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.
RMATH CHANnel Group


**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?

**Example**
 :CHANNEL1:RMATH:ECOUNT:OVERANGE 1
 :CHANNEL1:RMATH:ECOUNT:OVERANGE?

**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?

**Example**
 :CHANNEL1:RMATH:ECOUNT:SRESET 1
 :CHANNEL1:RMATH:ECOUNT:SRESET?

**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?

**Example**
 :CHANNEL1:RMATH:EVALUE +1.0000E+30
 :CHANNEL1:RMATH:EVALue?

**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.

**:CHANnel<x>:RMATH:FREQ:BIT**

**Function**
 Sets or queries the math source waveform (the source bit) for the specified channel's frequency, period, and torque, computation's deceleration prediction is turned on.

**Syntax**
 :CHANnel<x>:RMATH:FREQ:BIT {<NRf>}
 :CHANnel<x>:RMATH:FREQ:BIT?

**Example**
 :CHANNEL1:RMATH:FREQ:BIT 1
 :CHANNEL1:RMATH:FREQ:BIT?

**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?

**Example**
 :CHANNEL1:RMATH:FREQ:DECELERATION ON
 :CHANNEL1:RMATH:FREQ:DECELERATION?

**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?
Example :CHANNEL1:RMATH:FREQ:HYSTERESIS HIGH
-> :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>}
Example :CHANNEL1:RMATH:FREQ:LEVEL 1
-> :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>}
Example :CHANNEL1:RMATH:FREQ:OFFSET 1
-> :CHANNEL1:RMATH:FREQ:OFFSET 0.000000E+00
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>}
Example :CHANNEL1:RMATH:FREQ:PROTATE 180
-> :CHANNEL1:RMATH:FREQ:PROTATE 180
Description This command is valid on models with the /G3 or /G5 option.

: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}
Example :CHANNEL1:RMATH:FREQ:SCALE HZ
-> :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}
Example :CHANNEL1:RMATH:FREQ:SLOPE RISE
-> :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> ]}
Example :CHANNEL1:RMATH:FREQ:SOURCE 1
-> :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}
Example :CHANNEL1:RMATH:FREQ:STOPPREDICT OFF
-> :CHANNEL1:RMATH:FREQ:STOPPREDICT OFF
Description This command is valid on models with the /G3 or /G5 option.
RMATH CHANnel Group

: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
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 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:IFFILTER:CFREQUENCY 100Hz
-> :CHANNEL1:RMATH:IFFILTER: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>: 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:PBAND 100Hz
-> :CHANNEL1:RMATH:IFFILTER: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:IFFILTER:INTERPO ON
-> :CHANNEL1:RMATH:IFFILTER:INTERPO ON
Description This command is valid on models with the /G3 or /G5 option.
### RMATH CHANnel Group

#### :CHANnel<x>:RMATH:INTEGRal?

**Function:** Queries all integration settings of the specified channel.

**Syntax:**
```
:CHANnel<x>:RMATH:INTEGRal?
```

**Description:** This command is valid on models with the /G3 or /G5 option.


**Function:** Resets the integrated value of the specified channel.

**Syntax:**
```
:CHANnel<x>:RMATH:INTEGRal:MRESet:EXEC
```

**Example:**
```
:CHANNEL1:RMATH:INTEGRAL:MRESET:EXEC
```

**Description:** This command is valid on models with the /G3 or /G5 option.

#### :CHANnel<x>:RMATH:INTEGRal:OVERRange

**Function:** Sets or queries whether the integrated value is reset when an over limit occurs for the specified channel.

**Syntax:**
```
:CHANnel<x>:RMATH:INTEGRal:OVERRange {<Boolean>}
:CHANnel<x>:RMATH:INTEGRal:OVERRange?
```

**Example:**
```
:CHANNEL1:RMATH:INTEGRAL:OVERRANGE 1
:CHANNEL1:RMATH:INTEGRAL:OVERRANGE?
```

**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?
```

**Example:**
```
:CHANNEL1:RMATH:INTEGRAL:SRESET 1
:CHANNEL1:RMATH:INTEGRAL:SRESET?
```

**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?
```

**Example:**
```
:CHANNEL1:RMATH:INTEGRAL:ZRESET LOW
:CHANNEL1:RMATH:INTEGRAL:ZRESET?
```

**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?
```

**Example:**
```
:CHANNEL1:RMATH:INTEGRAL:ZRESET:MODE 1
:CHANNEL1:RMATH:INTEGRAL:ZRESET:MODE?
```

**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?
```

**Example:**
```
:CHANNEL1:RMATH:INTEGRAL:ZRESET:SLOPE FALL
:CHANNEL1:RMATH:INTEGRAL:ZRESET:SLOPE?
```

**Description:** This command is valid on models with the /G3 or /G5 option.
RMATH CHANnel Group

: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:DIFferent ial
Function Sets or queries the differentiation on/off status of the specified channel's knocking filter.
Syntax :CHANnel<x>:RMATH:KNOckflt:DIFferent ial {<Boolean>}
:CHANnel<x>:RMATH:KNOckflt:DIFferent ial?
<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:KNOckflt: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|RANGe|SIN|COS|ATAN|RMS|POWER|PINTegral|DA|KNocklit|ERANGle|PASub|FREQuency|PERiod|ECOunt|RESolver|IFILter|PWM|POWer|CANId|TORque|AMINus|TPResolver}**

**Example**

: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**

**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}]**

**Example**

: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?
### RMATH CHANnel Group

**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

**Description**: This command is valid on models with the /G3 or /G5 option.

**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

**Description**: This command is valid on models with the /G3 or /G5 option.

**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.

**Function**: Sets or queries the effective power calculation period’s edge detection math source waveform (detection bit) of the specified 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

**Description**: This command is valid on models with the /G3 or /G5 option. This setting is shared with the :CHANnel<x>:RMATH:RMS command.

**Function**: Sets or queries the effective power calculation period’s detection hysteresis of the specified channel.

**Syntax**:  
:CHANnel<x>:RMATH:POWer:TERM:EHYSteresis {HIGH|LOW|MIDDle}

  :CHANnel<x>:RMATH:POWer:TERM:EHYSteresis?

  <x> = 1 to 16

**Example**:  
: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.

**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 1.000000E+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.

**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

**Description**: This command is valid on models with the /G3 or /G5 option. This setting is shared with the :CHANnel<x>:RMATH:RMS command.
**RMATH CHANnel Group**

: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?

**Example**
: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>}

**Example**
: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?

**Example**
: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?

**Example**
: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?

**Example**
: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<x1>:RMATH:RANGle:HYSTeresis <x2> {HIGH|LOW|MIDDle}  
:CHANnel<x1>: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<x1>:RMATH:RANGle:LEVel<x2> {<Voltage>|<NRf>|<Current>}  
:CHANnel<x1>: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: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  
<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:RANGE: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:RANGE:LOGic:SOURce<x2> {<NRf>}
:CHANnel<x>:RMATH:RANGE:LOGic:SOURce<x2>?
<x1> = 1 to 16, <x2> = 1 to 2
<NRf> = 1 to 16
Example :CHANNEL1:RMATH:RANGE:LOGIC:SOURCE1 1
:CHANNEL1:RMATH:RANGE:LOGIC:SOURCE1?
-> :CHANNEL1:RMATH:RANGE: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:RANGE: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:RANGE:PROTate {<NRf>}
:CHANnel<x>:RMATH:RANGE: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:RANGE:PROTATE 1
Description This command is valid on models with the /G3 or /G5 option.

:CHANnel<x1>:RMATH:RANGE: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:RANGE:REVerse {<Boolean>}
:CHANnel<x>:RMATH:RANGE:REVerse? <x> = 1 to 16
Example :CHANNEL1:RMATH:RANGE:REVERSE 1
Description This command is valid on models with the /G3 or /G5 option.

:CHANnel<x1>:RMATH:RANGE: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<x>:RMATH:RANGE:RSOurce {RMATH<x2>}
:CHANnel<x>:RMATH:RANGE:RSOurce? <x> = 1 to 16
Example :CHANNEL1:RMATH:RANGE:RSOURCE RMATH1
:CHANNEL1:RMATH:RANGE:RSOURCE?
-> :CHANNEL1:RMATH:RANGE:RSOURCE RMATH1
Description This command is valid on models with the /G3 or /G5 option.
**RMATH CHANnel Group**

:CHANnel<x>:RMATH:RANGle:RTIMing

**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?

**Example**
:CHANNEL1:RMATH:RANGLE:RTIMING ZTERM
:CHANNEL1:RMATH:RANGLE:RTIMING?

**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<x1>:RMATH:RANGle:SCALe {DEGRee|RADian|USERdefine}
:CHANnel<x1>:RMATH:RANGle:SCALe?

**Example**
:CHANNEL1:RMATH:RANGLE:SCALE DEGREE
:CHANNEL1:RMATH:RANGLE:SCALE?

**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

**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?

**Example**
:CHANNEL1:RMATH:RANGLE:SLOGIC 1
:CHANNEL1:RMATH:RANGLE:SLOGIC?

**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>?

**Example**
:CHANNEL1:RMATH:RANGLE:SOURce1 1
:CHANNEL1:RMATH:RANGLE:SOURce1?

**Description**
This command is valid on models with the /G3 or /G5 option.

:CHANnel<x1>:RMATH:RANGle:TIMing<x2>

**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?

**Example**
:CHANNEL1:RMATH:RANGLE:TIMING ARISE
:CHANNEL1:RMATH:RANGLE:TIMING?

**Description**
This command is valid on models with the /G3 or /G5 option.

:CHANnel<x1>: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<x1>:RMATH:RANGle:ZINVert {<Boolean>}
:CHANnel<x1>:RMATH:RANGle:ZINVert?

**Example**
:CHANNEL3:RMATH:RANGLE:ZINVERT ON
:CHANNEL3:RMATH:RANGLE:ZINVERT?

**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?

**Example**
:CHANNEL1:RMATH:RESolver?

**Description**
This command is valid on models with the /G3 or /G5 option.
- **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
- **Example**: `:CHANNEL2:RMATH:RESOLVER:PHASE P1`
- **Description**: This command is valid on models with the /G3 option.

- **Function**: Sets or queries the offset angle of resolver operation.
  - **Syntax**: `:CHANnel<x1>:RMATH:RESolver:OFFSet {<NRf>}
    <x1> = 1 to 16
- **Example**: `:CHANNEL2:RMATH:RESOLVER:OFFSET 60`
- **Description**: This command is valid on models with the /G3 option.

- **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
- **Example**: `:CHANNEL1:RMATH:RESOLVER:SOURCE1 1`
- **Description**: This command is valid on models with the /G3 option.

- **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`
- **Description**: This command is valid on models with the /G3 or /G5 option.

- **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`
- **Description**: This command is valid on models with the /G3 or /G5 option.

- **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`
- **Description**: This command is valid on models with the /G3 or /G5 option.
RMATH CHANnel Group

:CHANnel<x>:RMATH:RESolver:TFILTER
Function Sets or queries the tracking filter of the resolver operation.
Syntax :CHANnel<x>:RMATH:RESolver:TFILTER {OFF|<NRf>}
Example :CHANNE1:RMATH:RESolver:TFILTER 100
-> :CHANNE1:RMATH:RESolver:TFILTER?
Description This command is valid on models with the /G3 or /G5 option.

:CHANnel<x>:RMATH:RESolver:SCALE
Function Sets or queries the scale of the resolver operation.
Syntax :CHANnel<x>:RMATH:RESolver:SCALE {DEG1|DEG2|RAD1|RAD2}
Example :CHANNE1:RMATH:RESolver:SCALE DEG1
-> :CHANNE1:RMATH:RESolver:SCALE?
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?
Example :CHANNE1:RMATH:RMS?
-> :CHANNE1: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.
Syntax :CHANnel<x>:RMATH:RMS:TERM:EBIT {<NRf>}
Example :CHANNE1:RMATH:RMS:TERM:EBIT 1
-> :CHANNE1:RMATH:RMS:TERM:EBIT?
Description This command is valid on models with the /G3 or /G5 option.

: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}
Example :CHANNE1:RMATH:RMS:TERM:EHYSteresis HIGH
-> :CHANNE1:RMATH:RMS:TERM:EHYSteresis?
Description 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>}
Example :CHANNE1:RMATH:RMS:TERM:ELEVEL 1
-> :CHANNE1:RMATH:RMS:TERM:ELEVEL?
Description 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}
Example :CHANNE1:RMATH:RMS:TERM:ESLope FALL
-> :CHANNE1:RMATH:RMS:TERM:ESLope?
Description 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?

\(<x> = 1 \text{ to } 16\)

\(<x2> = 1 \text{ to } 15\)

**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?

\(<x> = 1 \text{ to } 16\)

**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?

\(<x> = 1 \text{ to } 16\)

\(<\text{Time}> = 1 \text{ms to } 500.0\text{ms}\)

**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.
RMATh CHANnel Group

: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
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? <x> = 1 to 16 <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?
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.
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).
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?
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?
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

<table>
<thead>
<tr>
<th>Code</th>
<th>Message</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>722</td>
<td>Cannot execute search because RealTime math mode is changed after acquisition.</td>
<td>—</td>
</tr>
</tbody>
</table>

Setup Errors

<table>
<thead>
<tr>
<th>Code</th>
<th>Message</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>886</td>
<td>Cannot set RealTime Math mode to ON due to the following problems.</td>
<td>1-23</td>
</tr>
<tr>
<td></td>
<td>-The slot is installed 720220, 720221, 720240, 720241, 720242 or 720243.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>-There are not any input which can be set to source for RealTime Math.</td>
<td></td>
</tr>
<tr>
<td>887</td>
<td>There are not any modules which can be set to source for this operation.</td>
<td>1-23</td>
</tr>
<tr>
<td>888</td>
<td>Cannot set RealTime Math mode to ON while RealTime Math Function is disable.</td>
<td>3-3</td>
</tr>
</tbody>
</table>
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
Filter Features

The features of each filter are listed below.

<table>
<thead>
<tr>
<th>Type</th>
<th>Features</th>
<th>Band</th>
<th>Operation Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sharp</td>
<td>Frequency characteristics with a sharp attenuation slope (–40 dB at 1 oct)</td>
<td>Low-Pass</td>
<td>FIR</td>
</tr>
<tr>
<td></td>
<td>Linear phase and constant group delay</td>
<td>High-Pass</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ripples present in the passband</td>
<td>Band-Pass</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Comb-shaped stopband</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gauss</td>
<td>Frequency characteristics with a smooth attenuation slope</td>
<td>Low-Pass</td>
<td>FIR</td>
</tr>
<tr>
<td></td>
<td>Linear phase and constant group delay</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>No ripples present in the passband</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>No overshoot in the step response</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Low order and short delay</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>Combs-shaped frequency characteristics</td>
<td>Low-Pass</td>
<td>FIR</td>
</tr>
<tr>
<td></td>
<td>Linear phase and constant group delay</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>No overshoot in the step response</td>
<td></td>
<td></td>
</tr>
<tr>
<td>IIR</td>
<td>Attenuation slope steepness between those of the Sharp and Gauss filters</td>
<td>Low-Pass</td>
<td>IIR</td>
</tr>
<tr>
<td>(Butterworth)</td>
<td>Non-linear phase and non-constant group delay</td>
<td>High-Pass</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Compared to Sharp and Gauss filters, low cutoff frequency possible</td>
<td>Band-Pass</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Characteristics similar to those of analog filters</td>
<td></td>
<td></td>
</tr>
<tr>
<td>IIR-Lowpass</td>
<td>Frequency characteristics with a smooth attenuation slope</td>
<td>Low-Pass</td>
<td>IIR</td>
</tr>
<tr>
<td></td>
<td>Computes at 10 MS/s regardless of the setting.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Non-linear phase</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Characteristics similar to those of analog filters</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### 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 = \((\text{number of mean points} – 1)/2\)

If there are 16 mean points,

- Group delay (in s/Ts) = \((16 – 1)/2 = 15/2 = 7.5 \text{ s/Ts}\).

If the calculation frequency (fs) is 100 kHz,

\(Ts = 1/\text{fs} = 1/(100 \text{ kHz}) = 10 \mu s\).

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.

<table>
<thead>
<tr>
<th>Digital Filter</th>
<th>Real Time Math IIR Filter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cutoff Frequency Range</td>
<td>Calculation Frequency</td>
</tr>
<tr>
<td>300 kHz to 30 kHz</td>
<td>1 MHz</td>
</tr>
<tr>
<td>29.8 kHz to 3 kHz</td>
<td>100 kHz</td>
</tr>
<tr>
<td>2.98 kHz to 300 Hz</td>
<td>10 kHz</td>
</tr>
<tr>
<td>298 Hz to 30 Hz</td>
<td>1 kHz</td>
</tr>
<tr>
<td>29.8 Hz or less</td>
<td>100 Hz</td>
</tr>
<tr>
<td>29.8 Hz or less</td>
<td>100 Hz</td>
</tr>
</tbody>
</table>
Appendix 1 Digital Filter and Real Time Math

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.

<table>
<thead>
<tr>
<th>Function</th>
<th>Math Time (μs)</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1+S2</td>
<td>0.0</td>
<td></td>
</tr>
<tr>
<td>S1–S2</td>
<td>0.0</td>
<td></td>
</tr>
<tr>
<td>S1*S2</td>
<td>0.0</td>
<td></td>
</tr>
<tr>
<td>S1/S2</td>
<td>0.0</td>
<td></td>
</tr>
<tr>
<td>A(S1)+B(S2)+C</td>
<td>0.0</td>
<td></td>
</tr>
<tr>
<td>A(S1)–B(S2)+C</td>
<td>0.0</td>
<td></td>
</tr>
<tr>
<td>A(S1)*B(S2)+C</td>
<td>0.0</td>
<td></td>
</tr>
<tr>
<td>A(S1)/B(S2)+C</td>
<td>0.0</td>
<td></td>
</tr>
<tr>
<td>Diff</td>
<td>See the filter explanations.</td>
<td></td>
</tr>
<tr>
<td>Integ1</td>
<td>0.2</td>
<td></td>
</tr>
<tr>
<td>Integ2</td>
<td>0.2</td>
<td></td>
</tr>
<tr>
<td>Angle</td>
<td>0.2</td>
<td></td>
</tr>
<tr>
<td>DA</td>
<td>0.2</td>
<td></td>
</tr>
<tr>
<td>Polynomial</td>
<td>0.8</td>
<td>The data is updated once per microsecond.</td>
</tr>
<tr>
<td>RMS</td>
<td>0.6</td>
<td>The data is updated once per the specified period.</td>
</tr>
<tr>
<td>Power</td>
<td>0.4</td>
<td>The data is updated once per the specified period.</td>
</tr>
<tr>
<td>Power Integ</td>
<td>0.2</td>
<td></td>
</tr>
<tr>
<td>Log1</td>
<td>0.4</td>
<td></td>
</tr>
<tr>
<td>Log2</td>
<td>0.2</td>
<td></td>
</tr>
<tr>
<td>Sqrt1</td>
<td>0.2</td>
<td></td>
</tr>
<tr>
<td>Sqrt2</td>
<td>0.0</td>
<td></td>
</tr>
<tr>
<td>Cos</td>
<td>0.2</td>
<td></td>
</tr>
<tr>
<td>Sin</td>
<td>0.2</td>
<td></td>
</tr>
<tr>
<td>Atan</td>
<td>0.3</td>
<td></td>
</tr>
<tr>
<td>Electric Angle</td>
<td>1.1</td>
<td>The data is updated once per the specified period.</td>
</tr>
<tr>
<td>Knocking Filter</td>
<td>0.0</td>
<td></td>
</tr>
<tr>
<td>Poly-Add-Sub</td>
<td>0.0</td>
<td></td>
</tr>
<tr>
<td>Frequency</td>
<td>0.2</td>
<td>The data is updated each time that an edge is detected.</td>
</tr>
<tr>
<td>Period</td>
<td>0.2</td>
<td>The data is updated each time that an edge is detected.</td>
</tr>
<tr>
<td>Edge Count</td>
<td>0.2</td>
<td>The data is updated each time that an edge is detected.</td>
</tr>
<tr>
<td>Resolver</td>
<td>0.4</td>
<td>The data is updated once per excitation voltage period.</td>
</tr>
<tr>
<td>IIR Filter</td>
<td>See the filter explanations.</td>
<td></td>
</tr>
<tr>
<td>PWM</td>
<td>0.2</td>
<td></td>
</tr>
<tr>
<td>Reactive Power</td>
<td>0.2</td>
<td></td>
</tr>
<tr>
<td>CAN ID</td>
<td>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.</td>
<td></td>
</tr>
<tr>
<td>Torque</td>
<td>0.4</td>
<td>The data is updated each time that an edge is detected.</td>
</tr>
<tr>
<td>S1–S2(Angle)</td>
<td>0.0</td>
<td></td>
</tr>
<tr>
<td>3 Phase Resolver</td>
<td>0.4</td>
<td>The data is updated once per excitation voltage period.</td>
</tr>
</tbody>
</table>
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](image1)

![Sharp High-Pass Frequency Characteristics Example](image2)
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 fc1 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.
  \[(f_{cl} - 1/2f_{cl} = f_{cus} - f_cu)\]
- The stopband attenuation is –40 dB or greater.
- The filter has linear phase and constant group delay.

In the Sharp band-pass filter, the bandwidth options vary depending on the center frequency.

### Sharp Band-Pass Filter Frequency Range

<table>
<thead>
<tr>
<th>Center Frequency (kHz)</th>
<th>Bandwidth Setting (kHz)</th>
<th>Calculation Frequency (Hz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>300 to 120</td>
<td>200, 150, 100, 50, 20</td>
<td>1 M</td>
</tr>
<tr>
<td>118 to 96</td>
<td>150, 100, 50, 20</td>
<td>1 M</td>
</tr>
<tr>
<td>94 to 70</td>
<td>100, 50, 20</td>
<td>1 M</td>
</tr>
<tr>
<td>68 to 46</td>
<td>50, 20</td>
<td>1 M</td>
</tr>
<tr>
<td>44 to 30</td>
<td>20</td>
<td>1 M</td>
</tr>
<tr>
<td>29.8 to 12</td>
<td>20, 15, 10, 5, 2</td>
<td>100 k</td>
</tr>
<tr>
<td>11.8 to 9.6</td>
<td>15, 10, 5, 2</td>
<td>100 k</td>
</tr>
<tr>
<td>9.4 to 7</td>
<td>10, 5, 2</td>
<td>100 k</td>
</tr>
<tr>
<td>6.8 to 4.6</td>
<td>5, 2</td>
<td>100 k</td>
</tr>
<tr>
<td>4.4 to 3</td>
<td>2</td>
<td>100 k</td>
</tr>
<tr>
<td>2.98 to 1.2</td>
<td>2, 1.5, 1, 0.5, 0.2</td>
<td>10 k</td>
</tr>
<tr>
<td>1.18 to 0.96</td>
<td>1.5, 1, 0.5, 0.2</td>
<td>10 k</td>
</tr>
<tr>
<td>0.94 to 0.7</td>
<td>1, 0.5, 0.2</td>
<td>10 k</td>
</tr>
<tr>
<td>0.68 to 0.46</td>
<td>0.5, 0.2</td>
<td>10 k</td>
</tr>
<tr>
<td>0.44 to 0.3</td>
<td>0.2</td>
<td>10 k</td>
</tr>
</tbody>
</table>
## 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

<table>
<thead>
<tr>
<th>Cutoff frequency</th>
<th>Order</th>
</tr>
</thead>
<tbody>
<tr>
<td>2%</td>
<td>94</td>
</tr>
<tr>
<td>3%</td>
<td>61</td>
</tr>
<tr>
<td>4%</td>
<td>46</td>
</tr>
<tr>
<td>5%</td>
<td>37</td>
</tr>
<tr>
<td>6%</td>
<td>32</td>
</tr>
<tr>
<td>7%</td>
<td>28</td>
</tr>
<tr>
<td>8%</td>
<td>24</td>
</tr>
<tr>
<td>9%</td>
<td>22</td>
</tr>
<tr>
<td>10%</td>
<td>20</td>
</tr>
<tr>
<td>11%</td>
<td>17</td>
</tr>
<tr>
<td>12%</td>
<td>15</td>
</tr>
<tr>
<td>13%</td>
<td>14</td>
</tr>
<tr>
<td>14%</td>
<td>13</td>
</tr>
<tr>
<td>15%</td>
<td>11</td>
</tr>
<tr>
<td>16%</td>
<td>11</td>
</tr>
<tr>
<td>17%</td>
<td>11</td>
</tr>
<tr>
<td>18%</td>
<td>11</td>
</tr>
<tr>
<td>19%</td>
<td>10</td>
</tr>
<tr>
<td>20%</td>
<td>8</td>
</tr>
<tr>
<td>21%</td>
<td>8</td>
</tr>
<tr>
<td>22%</td>
<td>8</td>
</tr>
<tr>
<td>23%</td>
<td>8</td>
</tr>
<tr>
<td>24%</td>
<td>8</td>
</tr>
<tr>
<td>25%</td>
<td>8</td>
</tr>
<tr>
<td>26%</td>
<td>8</td>
</tr>
<tr>
<td>27%</td>
<td>8</td>
</tr>
<tr>
<td>28%</td>
<td>8</td>
</tr>
</tbody>
</table>

### Sharp High-Pass Filter Orders

<table>
<thead>
<tr>
<th>Cutoff frequency</th>
<th>Order</th>
</tr>
</thead>
<tbody>
<tr>
<td>2%</td>
<td>191</td>
</tr>
<tr>
<td>3%</td>
<td>127</td>
</tr>
<tr>
<td>4%</td>
<td>97</td>
</tr>
<tr>
<td>5%</td>
<td>77</td>
</tr>
<tr>
<td>6%</td>
<td>65</td>
</tr>
<tr>
<td>7%</td>
<td>55</td>
</tr>
<tr>
<td>8%</td>
<td>49</td>
</tr>
<tr>
<td>9%</td>
<td>45</td>
</tr>
<tr>
<td>10%</td>
<td>45</td>
</tr>
<tr>
<td>11%</td>
<td>37</td>
</tr>
<tr>
<td>12%</td>
<td>33</td>
</tr>
<tr>
<td>13%</td>
<td>31</td>
</tr>
<tr>
<td>14%</td>
<td>29</td>
</tr>
<tr>
<td>15%</td>
<td>27</td>
</tr>
<tr>
<td>16%</td>
<td>25</td>
</tr>
<tr>
<td>17%</td>
<td>25</td>
</tr>
<tr>
<td>18%</td>
<td>23</td>
</tr>
<tr>
<td>19%</td>
<td>23</td>
</tr>
<tr>
<td>20%</td>
<td>23</td>
</tr>
<tr>
<td>21%</td>
<td>19</td>
</tr>
<tr>
<td>22%</td>
<td>19</td>
</tr>
<tr>
<td>23%</td>
<td>19</td>
</tr>
<tr>
<td>24%</td>
<td>17</td>
</tr>
<tr>
<td>25%</td>
<td>17</td>
</tr>
<tr>
<td>26%</td>
<td>17</td>
</tr>
<tr>
<td>27%</td>
<td>17</td>
</tr>
<tr>
<td>28%</td>
<td>17</td>
</tr>
<tr>
<td>29%</td>
<td>17</td>
</tr>
</tbody>
</table>

### Sharp Band-Pass Filter Orders (Passband width: 2%)  

<table>
<thead>
<tr>
<th>Center frequency</th>
<th>Order</th>
</tr>
</thead>
<tbody>
<tr>
<td>3%</td>
<td>189</td>
</tr>
<tr>
<td>4%</td>
<td>142</td>
</tr>
<tr>
<td>5%</td>
<td>93</td>
</tr>
<tr>
<td>6%</td>
<td>80</td>
</tr>
<tr>
<td>7%</td>
<td>69</td>
</tr>
<tr>
<td>8%</td>
<td>61</td>
</tr>
<tr>
<td>9%</td>
<td>61</td>
</tr>
<tr>
<td>10%</td>
<td>54</td>
</tr>
<tr>
<td>11%</td>
<td>49</td>
</tr>
<tr>
<td>12%</td>
<td>45</td>
</tr>
<tr>
<td>13%</td>
<td>45</td>
</tr>
<tr>
<td>14%</td>
<td>37</td>
</tr>
<tr>
<td>15%</td>
<td>33</td>
</tr>
<tr>
<td>16%</td>
<td>34</td>
</tr>
<tr>
<td>17%</td>
<td>32</td>
</tr>
<tr>
<td>18%</td>
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### Sharp Band-Pass Filter Orders (Passband width: 5%)  

<table>
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<tbody>
<tr>
<td>5%</td>
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<tr>
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<td>112</td>
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<tr>
<td>7%</td>
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### Sharp Band-Pass Filter Orders (Passband width: 10%)  

<table>
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### Sharp Band-Pass Filter Orders (Passband width: 15%)  

<table>
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<tbody>
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<tr>
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<tr>
<td>12%</td>
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### Sharp Band-Pass Filter Orders (Passband width: 15%)  

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<th>Order</th>
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</table>
Appendix 1  Digital Filter and Real Time Math

Sharp Band-Pass Filter Orders (Passband width: 20%)

<table>
<thead>
<tr>
<th>Center frequency</th>
<th>12%</th>
<th>13%</th>
<th>14%</th>
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<th>20%</th>
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<table>
<thead>
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<th>23%</th>
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<th>25%</th>
<th>26%</th>
<th>27%</th>
<th>28%</th>
<th>29%</th>
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<tbody>
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<td>26</td>
<td>25</td>
<td>24</td>
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<table>
<thead>
<tr>
<th>Center frequency</th>
<th>30%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Order</td>
<td>20</td>
</tr>
</tbody>
</table>

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
**Gauss Filter**

**Characteristics**
- The passband is flat.
- At the cutoff frequency, the attenuation is –3 dB. The damping rate is \(-3.0 \times (f/f_c)^2\).
- The filter has linear phase and constant group delay.
- The filter can only be set to low-pass.

**Gauss Frequency Characteristics Example**

![Gauss Frequency Characteristics Example](image)

---

**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**

<table>
<thead>
<tr>
<th>Cutoff frequency</th>
<th>2%</th>
<th>3%</th>
<th>4%</th>
<th>5%</th>
<th>6%</th>
<th>7%</th>
<th>8%</th>
<th>9%</th>
<th>10%</th>
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<td>9</td>
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<table>
<thead>
<tr>
<th>Cutoff frequency</th>
<th>11%</th>
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<th>13%</th>
<th>14%</th>
<th>15%</th>
<th>16%</th>
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<th>19%</th>
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<th>22%</th>
<th>23%</th>
<th>24%</th>
<th>25%</th>
<th>26%</th>
<th>27%</th>
<th>28%</th>
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</thead>
<tbody>
<tr>
<td>Order</td>
<td>5</td>
<td>5</td>
<td>5</td>
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</table>

<table>
<thead>
<tr>
<th>Cutoff frequency</th>
<th>29%</th>
<th>30%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Order</td>
<td>5</td>
<td>5</td>
</tr>
</tbody>
</table>

**Math Delay**

The group delay can be calculated from the following equation. The group delay is constant based on the filter order.

\[
\text{Group delay} = \left(\text{filter order} - 1\right)/2
\]

Unit: s/\(\text{Ts}\) (\(\text{Ts}\) is the calculation period in seconds)

The math delay can be calculated from the following equation.

\[
\text{Math delay} = 1.4 \mu\text{s} + \left(\text{filter order} - 1\right)/2 \times \text{calculation period}
\]
Example of Characteristics

**Gauss Frequency Characteristics**

(f: Calculation frequency in Hz)
**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) Low-Pass Frequency Characteristics](image1)

**IIR (Butterworth) High-Pass Frequency Characteristics Example**

![IIR (Butterworth) High-Pass Frequency Characteristics](image2)
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](image)

In the IIR (Butterworth) band-pass filter, the bandwidth options vary depending on the center frequency.

**IIR (Butterworth) Band-Pass Filter Frequency Ranges**

<table>
<thead>
<tr>
<th>Center Frequency (kHz)</th>
<th>Bandwidth Setting (kHz)</th>
<th>Calculation Frequency (Hz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>300 to 102</td>
<td>200, 150, 100, 50, 20, 10</td>
<td>1 M</td>
</tr>
<tr>
<td>100 to 76</td>
<td>150, 100, 50, 20, 10</td>
<td>1 M</td>
</tr>
<tr>
<td>74 to 52</td>
<td>100, 50, 20, 10</td>
<td>1 M</td>
</tr>
<tr>
<td>50 to 26</td>
<td>50, 20, 10</td>
<td>1 M</td>
</tr>
<tr>
<td>24 to 12</td>
<td>20, 10</td>
<td>1 M</td>
</tr>
<tr>
<td>11.8 to 10.2</td>
<td>20, 15, 10, 5, 2, 1</td>
<td>100 k</td>
</tr>
<tr>
<td>10 to 7.6</td>
<td>15, 10, 5, 2, 1</td>
<td>100 k</td>
</tr>
<tr>
<td>7.4 to 5.2</td>
<td>10, 5, 2, 1</td>
<td>100 k</td>
</tr>
<tr>
<td>5 to 2.6</td>
<td>5, 2, 1</td>
<td>100 k</td>
</tr>
<tr>
<td>2.4 to 1.2</td>
<td>2, 1</td>
<td>100 k</td>
</tr>
<tr>
<td>1.18 to 1.02</td>
<td>2, 1.5, 1, 0.5, 0.2, 0.1</td>
<td>10 k</td>
</tr>
<tr>
<td>1 to 0.76</td>
<td>1.5, 1, 0.5, 0.2, 0.1</td>
<td>10 k</td>
</tr>
<tr>
<td>0.74 to 0.52</td>
<td>1, 0.5, 0.2, 0.1</td>
<td>10 k</td>
</tr>
<tr>
<td>0.5 to 0.26</td>
<td>0.5, 0.2, 0.1</td>
<td>10 k</td>
</tr>
<tr>
<td>0.24 to 0.12</td>
<td>0.2, 0.1</td>
<td>10 k</td>
</tr>
<tr>
<td>0.1 to 0.06</td>
<td>0.1</td>
<td>10 k</td>
</tr>
</tbody>
</table>

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 μs to the group delay characteristic.

The math delay can be calculated from the following equation.

\[
\text{Math delay} = (1.4 \, \mu\text{s} + \text{group delay}) \times \text{calculation period}
\]
Examples of Characteristics

IIR (Butterworth) Low-Pass

IIR (Butterworth) Low-Pass Frequency Characteristics

IIR (Butterworth) Low-Pass Group Delay Characteristics (1)

IIR (Butterworth) Low-Pass Group Delay Characteristics (2)
Appendix 1  Digital Filter and Real Time Math

IIR (Butterworth) High-Pass

IIR (Butterworth) High-Pass Frequency Characteristics

IIR (Butterworth) High-Pass Group Delay Characteristics (1)

IIR (Butterworth) High-Pass Group Delay Characteristics (2)

(f: Calculation frequency in Hz)
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)
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)
Appendix 1 Digital Filter and Real Time Math

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%)
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.

\[
\text{Group delay} = \frac{(\text{number of mean points} - 1)}{2}
\]

Unit: s/Ts (Ts is the calculation period in seconds)

The math delay can be calculated from the following equation.

\[
\text{Math delay} = 1.4 \mu s + \left(\frac{\text{(number of mean points} - 1)}{2}\right) \times \text{calculation period}
\]
IIR-Lowpass Filter

Characteristics

- The passband is flat.
- It has non-linear phase characteristics.

Frequency characteristics

![Frequency Characteristics Graph]

Phase characteristics

![Phase Characteristics Graph]
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).

\[ f_n' = \frac{1}{12T_s} (f_{n-4} - 8f_{n-3} + 8f_{n-1} - f_n) \]

The following chart shows the amplitude characteristic in the case where the fifth order Lagrange interpolation formula is used and the ideal differentiation characteristic.

![Differentiation Frequency Characteristics](chart)

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.

<table>
<thead>
<tr>
<th>Cutoff Frequency</th>
<th>Maximum Measurable Angular Acceleration</th>
</tr>
</thead>
<tbody>
<tr>
<td>2kHz</td>
<td>14000000rps²</td>
</tr>
<tr>
<td>1kHz</td>
<td>5400000rps²</td>
</tr>
<tr>
<td>250kHz</td>
<td>1800rps²</td>
</tr>
<tr>
<td>100Hz</td>
<td>180rps²</td>
</tr>
</tbody>
</table>

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.

\[ A \text{(float)} = A \text{(binary)} \times (1 \text{ LSB weight}) \]
\[ B \text{(float)} = B \text{(binary)} \times (1 \text{ LSB weight}) \]

Internal Math

All internal real time math operations are performed using floating-point data.

Example: \[ C \text{(float)} = A \text{(float)} + B \text{(float)} \]

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 \( 1 \text{ div} = 2400 \text{ LSB} \),

1 LSB weight of the output = \( \frac{\text{value/div}}{2400} \).

Math Output: Conversion of Floating-Point Data to 16-Bit Binary Data

The output is converted to 16-bit data through the following formula.

\[ C \text{(binary)} = C \text{(float)} / (1 \text{ LSB weight}) \]
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.

\[ Urms = \sqrt{\frac{1}{T} \int_0^T u(n)^2 \, dt} \quad Irms = \sqrt{\frac{1}{T} \int_0^T i(n)^2 \, dt} \]

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 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.

\[ Umn = \frac{\pi}{2\sqrt{2}} \times \frac{1}{T} \int_0^T |u(n)| \, dt \quad Irms = \frac{\pi}{2\sqrt{2}} \times \frac{1}{T} \int_0^T |i(n)| \, dt \]

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.

\[ Udc = \frac{1}{T} \int_0^T u(n) \, dt \quad Idc = \frac{1}{T} \int_0^T i(n) \, dt \]

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.

\[ Uac = \sqrt{Urms^2 - Udc^2} \quad Iac = \sqrt{Irms^2 - Idc^2} \]

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.

\[ P = Urms \cdot Irms \]
Appendix 2  Equations for Power Analysis and Harmonic Analysis

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 lags 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 lags the voltage.

\[ \varphi = \cos^{-1} \left( \frac{P}{S} \right) \]

These values are determined by multiplying together the instantaneous voltages and currents and integrating them for the number of samples.

\[ WP, WP+, \text{ or } WP- = \int_0^T u(n) \cdot i(n) \, dt \]

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.

\[ q = \int_0^T i_{\text{rms}} \, dt \quad q+, q- = \int_0^T i(n) \, dt \]

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.

\[ WS = \int_0^T U_{\text{rms}} \cdot I_{\text{rms}} \, dt \]

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.

\[ WQ = \int_0^T s \sqrt{S^2 - P^2} \, dt \]
Appendix 2 Equations for Power Analysis and Harmonic Analysis

Impedance ($Z$)
This value is determined by dividing the rms voltages and currents over one period.

$$Z = \frac{U_{\text{rms}}}{I_{\text{rms}}}$$

Series Resistance ($R_S$)
This value is determined by dividing the active power over one period by the square of the rms current.

$$\frac{P}{I_{\text{rms}}^2}$$

Series Reactance ($X_S$)
This value is determined by dividing the reactive power over one period by the square of the rms current.

$$\frac{Q}{I_{\text{rms}}^2}$$

Parallel Resistance ($R_P$)
This value is determined by dividing the square of the rms voltage by the active power over one period.

$$\frac{U_{\text{rms}}^2}{P}$$

Parallel Reactance ($X_P$)
This value is determined by dividing the square of the rms voltage by the reactive power over one period.

$$\frac{U_{\text{rms}}^2}{Q}$$
Appendix 2  Equations for Power Analysis and Harmonic Analysis

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
  \[
  U_1 = \sqrt{\frac{1}{6}(U_{rs}^2 + U_{st}^2 + U_{tr}^2) + \frac{2}{\sqrt{3}} \sqrt{U_a(U_a - U_{rs})(U_a - U_{st})(U_a - U_{tr})}}
  \]
  \[
  U_2 = \sqrt{\frac{1}{6}(U_{rs}^2 + U_{st}^2 + U_{tr}^2) - \frac{2}{\sqrt{3}} \sqrt{U_a(U_a - U_{rs})(U_a - U_{st})(U_a - U_{tr})}}
  \]
  \[
  U_a = \frac{U_{rs} + U_{st} + U_{tr}}{2}
  \]

- **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
  \[
  I_1 = \sqrt{\frac{1}{6}(I_1^2 + I_2^2 + I_3^2) + \frac{2}{\sqrt{3}} \sqrt{(I_a(I_a - I_1)(I_a - I_2)(I_a - I_3)}}
  \]
  \[
  I_2 = \sqrt{\frac{1}{6}(I_1^2 + I_2^2 + I_3^2) - \frac{2}{\sqrt{3}} \sqrt{(I_a(I_a - I_1)(I_a - I_2)(I_a - I_3)}}
  \]
  \[
  I_a = \frac{(I_1 + I_2 + I_3)}{2}
  \]
  The three-phase unbalance factor is calculated by determining the rms values from the following values for each sample for each wiring system.

<table>
<thead>
<tr>
<th></th>
<th>3P3W (3V3A)</th>
<th>3P4W</th>
<th>3P3W→3P3W (3V3A)</th>
<th>3P3W(3V3A)→3P4W</th>
<th>3P4W→3P3W (3V3A)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urs</td>
<td>u1</td>
<td>u1-u2</td>
<td>u1</td>
<td>u1</td>
<td>u1-u2</td>
</tr>
<tr>
<td>Ust</td>
<td>u2</td>
<td>u2-u3</td>
<td>u2</td>
<td>u2</td>
<td>u2-u3</td>
</tr>
<tr>
<td>Utr</td>
<td>u3</td>
<td>u3-u1</td>
<td>u1-u2</td>
<td>u3</td>
<td>u3-u1</td>
</tr>
<tr>
<td>I1</td>
<td>i1</td>
<td>i1</td>
<td>i1</td>
<td>i1</td>
<td>i1</td>
</tr>
<tr>
<td>I2</td>
<td>i2</td>
<td>i2</td>
<td>i2</td>
<td>i2</td>
<td>i2</td>
</tr>
<tr>
<td>I3</td>
<td>i3</td>
<td>i3</td>
<td>i3</td>
<td>i3</td>
<td>i3</td>
</tr>
</tbody>
</table>

**Motor Efficiency**
This value is determined by dividing the rotating speed by the total active power.

\[
\eta = \frac{\text{Pm}}{\text{P}_\Sigma} \times 100\%
\]

**Integration Time**
This is the time from integration start to integration stop.
### Power Analysis Equations (Wiring Unit Σ)

<table>
<thead>
<tr>
<th>Measurement Function (Σ Function)</th>
<th>Equation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Power analysis</strong></td>
<td></td>
</tr>
<tr>
<td>[U] [V]</td>
<td>U&lt;sub&gt;rms&lt;/sub&gt;Σ = (U&lt;sub&gt;rms1&lt;/sub&gt; + U&lt;sub&gt;rms2&lt;/sub&gt;) / 2</td>
</tr>
<tr>
<td></td>
<td>U&lt;sub&gt;mn&lt;/sub&gt;Σ = (U&lt;sub&gt;mn1&lt;/sub&gt; + U&lt;sub&gt;mn2&lt;/sub&gt;) / 2</td>
</tr>
<tr>
<td></td>
<td>U&lt;sub&gt;dc&lt;/sub&gt;Σ = (U&lt;sub&gt;dc1&lt;/sub&gt; + U&lt;sub&gt;dc2&lt;/sub&gt;) / 2</td>
</tr>
<tr>
<td></td>
<td>U&lt;sub&gt;ac&lt;/sub&gt;Σ = (U&lt;sub&gt;ac1&lt;/sub&gt; + U&lt;sub&gt;ac2&lt;/sub&gt;) / 2</td>
</tr>
<tr>
<td><strong>Harmonic analysis</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>UΣ = (U&lt;sub&gt;1&lt;/sub&gt; + U&lt;sub&gt;2&lt;/sub&gt;) / 2</td>
</tr>
<tr>
<td><strong>I [A]</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Power analysis</strong></td>
<td>I&lt;sub&gt;rms&lt;/sub&gt;Σ = (I&lt;sub&gt;rms1&lt;/sub&gt; + I&lt;sub&gt;rms2&lt;/sub&gt;) / 2</td>
</tr>
<tr>
<td></td>
<td>I&lt;sub&gt;mn&lt;/sub&gt;Σ = (I&lt;sub&gt;mn1&lt;/sub&gt; + I&lt;sub&gt;mn2&lt;/sub&gt;) / 2</td>
</tr>
<tr>
<td></td>
<td>I&lt;sub&gt;dc&lt;/sub&gt;Σ = (I&lt;sub&gt;dc1&lt;/sub&gt; + I&lt;sub&gt;dc2&lt;/sub&gt;) / 2</td>
</tr>
<tr>
<td></td>
<td>I&lt;sub&gt;ac&lt;/sub&gt;Σ = (I&lt;sub&gt;ac1&lt;/sub&gt; + I&lt;sub&gt;ac2&lt;/sub&gt;) / 2</td>
</tr>
<tr>
<td><strong>Harmonic analysis</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>IΣ = (I&lt;sub&gt;1&lt;/sub&gt; + I&lt;sub&gt;2&lt;/sub&gt;) / 2</td>
</tr>
<tr>
<td><strong>PΣ [W]</strong></td>
<td>P1 + P2</td>
</tr>
<tr>
<td><strong>SΣ [VA]</strong></td>
<td>S1 + S2</td>
</tr>
<tr>
<td><strong>QΣ [var]</strong></td>
<td>(\sqrt{PΣ^2 + QΣ^2})</td>
</tr>
<tr>
<td><strong>λΣ</strong></td>
<td>(\frac{PΣ}{SΣ})</td>
</tr>
<tr>
<td><strong>φΣ [°]</strong></td>
<td>(\cos^{-1}\left(\frac{PΣ}{SΣ}\right))</td>
</tr>
<tr>
<td><strong>ZΣ [Ω]</strong></td>
<td>(\frac{SΣ}{I&lt;sub&gt;rms&lt;/sub&gt;Σ})</td>
</tr>
<tr>
<td><strong>RSΣ [Ω]</strong></td>
<td>(\frac{PΣ}{I&lt;sub&gt;rms&lt;/sub&gt;Σ})</td>
</tr>
<tr>
<td><strong>XSΣ [Ω]</strong></td>
<td>(\frac{QΣ}{I&lt;sub&gt;rms&lt;/sub&gt;Σ})</td>
</tr>
<tr>
<td><strong>RPΣ [Ω]</strong> (= 1/G)</td>
<td>(\frac{U&lt;sub&gt;rms&lt;/sub&gt;Σ^2}{PΣ})</td>
</tr>
<tr>
<td><strong>XPΣ [Ω]</strong> (= 1/B)</td>
<td>(\frac{U&lt;sub&gt;rms&lt;/sub&gt;Σ^2}{QΣ})</td>
</tr>
<tr>
<td><strong>η (efficiency 1) [%]</strong></td>
<td>(\frac{PΣE}{PΣA}) - 100</td>
</tr>
<tr>
<td><strong>1/η (efficiency 2) [%]</strong></td>
<td>(\frac{PΣA}{PΣE}) - 100</td>
</tr>
</tbody>
</table>

**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>
<thead>
<tr>
<th>Measurement Function</th>
<th>Methods of Determination and Equation</th>
</tr>
</thead>
</table>
| Voltage Vrms [V]     | \[ U(k) = \sqrt{u(k)^2 + u_j(k)^2} \] \[
|                      | \[ U = \sqrt{\sum_{k=1}^{\text{max}} U(k)^2} } \]
| Current Irms [A]     | \[ I(k) = \sqrt{i(k)^2 + i_j(k)^2} \] \[
|                      | \[ I = \sqrt{\sum_{k=1}^{\text{max}} I(k)^2} } \]
| Active power P [W]   | \[ P(k) = u(k) \cdot i(k) + u_j(k) \cdot i_j(k) \] \[
|                      | \[ P = \sum_{k=1}^{\text{max}} P(k) } \]
| Apparent power S [VA]| \[ S = \sqrt{P^2 + Q^2} } \]
| Reactive power Q [var]| \[ Q(k) = u(k) \cdot i(k) - u_j(k) \cdot i_j(k) \] \[
|                      | \[ Q = \sum_{k=1}^{\text{max}} Q(k) } \]
| Power factor λ       | \[ \lambda = \frac{P}{S} } \]

Phase angle \( \varphi \) [°]

- When the source is voltage in Line RMS mode,
  \[ \tan^{-1}\left\{ \frac{u(k)}{u_j(k)} \right\} - \tan^{-1}\left\{ \frac{u(1)}{u_j(1)} \right\} \times k \]
- When the source is current in Line RMS mode,
  \[ \tan^{-1}\left\{ \frac{i(k)}{i_j(k)} \right\} - \tan^{-1}\left\{ \frac{i(1)}{i_j(1)} \right\} \times k \]
- When Power mode,
  \[ \tan^{-1}\left\{ \frac{Q(k)}{P(k)} \right\} - \tan^{-1}\left\{ \frac{Q(1)}{P(1)} \right\} \times k \]

Harmonic distortion factor (IEC) THDIEC

Calculates the ratio of the total rms value from the 2nd to the 40th harmonic to the fundamental wave.

\[ \text{Distortion factor (IEC)} = \sqrt{\frac{\sum_{n=2}^{40} \text{n-th harmonic rms voltage (or current)}^2}{\text{fundamental rms voltage (or current)}^2}} \]

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.

\[ \text{Distortion factor (CSA)} = \sqrt{\frac{\sum_{n=2}^{40} \text{n-th harmonic rms voltage (or current)}^2}{\sum_{n=1}^{40} \text{n-th harmonic rms voltage (or current)}^2}} \]

Note

- \( k \) denotes a harmonic order, \( r \) denotes the real part, and \( j \) denotes the imaginary part.
- \( \text{max} \) is 40 when the analysis mode is Line RMS and 35 when it is Power.
### Appendix 2 Equations for Power Analysis and Harmonic Analysis

#### Table 2/2

<table>
<thead>
<tr>
<th>Measurement Function</th>
<th>Methods of Determination and Equation</th>
<th>Harmonic order of measurement function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Harmonic voltage distortion factor (Uhdf [%])</td>
<td>$U(k) \cdot 100$</td>
<td>$U(1)$</td>
</tr>
<tr>
<td>Harmonic current distortion factor (Ihdf [%])</td>
<td>$I(k) \cdot 100$</td>
<td>$I(1)$</td>
</tr>
<tr>
<td>Harmonic active power distortion factor (Phdf [%])</td>
<td>$P(k) \cdot 100$</td>
<td>$P(1)$</td>
</tr>
</tbody>
</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>
<thead>
<tr>
<th>Delta Function</th>
<th>Substituted Sampled Data</th>
<th>Data Determined by Delta Math and Examples of Measurement Functions and Symbols</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Delta Math</strong></td>
<td>$u(t)$, $i(t)$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3P3W→3V3A</td>
<td>$u1–u2$, $i1–i2$</td>
<td>Unmeasured line current calculated in a three-phase three-wire system</td>
<td>Urms1, Umn1, Udc1, Uac1, Irms1, Imn1, Idc1, Iac1</td>
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<tr>
<td>Delta→Star</td>
<td>$u1– (u1+u2)/3$, $u2– (u1+u2)/3$, $u3– (u1+u2)/3$</td>
<td>Phase voltage calculated in a three-phase three-wire (3V3A) system</td>
<td>Urms1, Umn1, Udc1, Uac1</td>
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<tr>
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<td>$i1+i2+i3$</td>
<td>Neutral line current</td>
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<tr>
<td>Star→Delta</td>
<td>$u1–u2$, $u2–u3$, $u3–u1$</td>
<td>Line voltage calculated in a three-phase four-wire system</td>
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<td>$i1+i2+i3$</td>
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* 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

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<td>1P2W</td>
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### Appendix 2  Equations for Power Analysis and Harmonic Analysis

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### Channels/ Sub channels | Symbol | Math Item | Supported Wiring Systems |
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### Appendix 2 Equations for Power Analysis and Harmonic Analysis

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<th>3V3A-&gt;3P4W (Delta-&gt;Start)</th>
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<td>CH14_11</td>
<td></td>
<td>φ1</td>
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<td>CH14_18</td>
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<td>CH14_19</td>
<td>U-pk1</td>
<td>Minimum voltage</td>
</tr>
<tr>
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<td>CH14_20</td>
<td>U+pk2</td>
<td>Maximum voltage</td>
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<td>CH14_24</td>
<td>I+pk1</td>
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<td>CH14_26</td>
<td>I+pk2</td>
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<td>I-pk2</td>
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<td>I+pk3</td>
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<td>CH14_32</td>
<td>P+pk2</td>
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<td>CH14_33</td>
<td>P-pk2</td>
<td>Minimum power</td>
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Appendix 2 Equations for Power Analysis and Harmonic Analysis

<table>
<thead>
<tr>
<th>Channels/Sub channels</th>
<th>Symbol Math Item</th>
<th>Supported Wiring Systems</th>
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<tbody>
<tr>
<td>Wiring System1</td>
<td>Wiring System2</td>
<td>1P2W</td>
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<td>CH13_34 P+pk3</td>
<td>Maximum power</td>
<td>Yes</td>
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<tr>
<td>CH13_35 P-pk3</td>
<td>Minimum power</td>
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</tr>
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<td>CH13_36 WPΣ</td>
<td>Integrated power</td>
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</tr>
<tr>
<td>CH13_37 WP+Σ</td>
<td>Integrated power</td>
<td>Yes</td>
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<td>CH13_38 WP-Σ</td>
<td>Integrated power</td>
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</tr>
<tr>
<td>CH13_39 WP+1</td>
<td>Integrated power</td>
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<tr>
<td>CH13_40 WP-1</td>
<td>Integrated power</td>
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</tr>
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<td>CH13_41 WPΣ</td>
<td>Volt-ampere hours</td>
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</tr>
<tr>
<td>CH13_42 WP+Σ</td>
<td>Volt-ampere hours</td>
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<tr>
<td>CH13_43 WPΣ</td>
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<td>CH13_44 WP+1</td>
<td>Volt-ampere hours</td>
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<td>CH13_46 WP-1</td>
<td>Volt-ampere hours</td>
<td>Yes</td>
</tr>
<tr>
<td>CH13_47 WPΣ</td>
<td>Var hours</td>
<td>Yes</td>
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<tr>
<td>CH13_48 WP+Σ</td>
<td>Var hours</td>
<td>Yes</td>
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<td>CH13_49 WP+1</td>
<td>Var hours</td>
<td>Yes</td>
</tr>
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<td>CH13_50 WP-Σ</td>
<td>Var hours</td>
<td>Yes</td>
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<td>Var hours</td>
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<td>CH13_52 WPΣ</td>
<td>Load circuit impedance</td>
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<td>CH13_53 WP+Σ</td>
<td>Load circuit impedance</td>
<td>Yes</td>
</tr>
<tr>
<td>CH13_54 WP+1</td>
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<td>Load circuit impedance</td>
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<td>Load circuit impedance</td>
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</tr>
<tr>
<td>CH13_57 Pm</td>
<td>Motor output (drive efficiency)</td>
<td>Yes</td>
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<tr>
<td>CH13_58 η</td>
<td>Efficiency</td>
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<td>CH13_59 Uubf</td>
<td>Three-phase voltage unbalance factor</td>
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<td>CH13_60 lubf</td>
<td>Three-phase current unbalance factor</td>
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<td>CH13_61 In</td>
<td>Neutral line current</td>
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<td>CH13_62 Time</td>
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### Harmonic Analysis (Harmonics)

When the analysis mode is Line RMS

<table>
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<tr>
<th>Channels/Sub channels</th>
<th>Symbol</th>
<th>Math Item</th>
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<td>CH15_1 to CH15_40</td>
<td>RMS</td>
<td>Rms value (1st to 40th harmonic)</td>
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<tr>
<td>CH15_41 to CH15_64</td>
<td>Rhdf</td>
<td>Percentage content (1st to 40th harmonic)</td>
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<tr>
<td>CH16_1 to CH16_16</td>
<td>Φ</td>
<td>Phase angle (1st to 40th harmonic)</td>
<td></td>
</tr>
<tr>
<td>CH16_57</td>
<td>RMS</td>
<td>Total rms value</td>
<td></td>
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<td>CH16_58</td>
<td>THD (IEC)</td>
<td>Distortion factor (IEC)</td>
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<td>CH16_60</td>
<td>THD (CSA)</td>
<td>Distortion factor (CSA)</td>
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When the Analysis Mode is Power

<table>
<thead>
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<th>Channels/Sub channels</th>
<th>Symbol</th>
<th>Math Item</th>
<th>Supported Wiring Systems</th>
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<tr>
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<td>P</td>
<td>Active power (1st to 35th harmonic)</td>
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<td>Phdf</td>
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<td>Phase angle (1st to 35th harmonic)</td>
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<td>λ</td>
<td>Power factor</td>
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<td>1st harmonic rms voltage</td>
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<td>1st harmonic rms current</td>
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<td>U3rms</td>
<td>1st harmonic rms voltage</td>
<td>Yes Yes Yes Yes Yes Yes Yes Yes</td>
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<td>ΦU1-U1</td>
<td>1st harmonic voltage phase angle</td>
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<td>ΦU1-I1</td>
<td>1st harmonic current phase angle</td>
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<td>CH16_57</td>
<td>ΦU1-I3</td>
<td>1st harmonic current phase angle</td>
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</table>
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 $I_\text{msin} \omega t$ (where $I_\text{m}$ is the maximum value of the current, $\omega$ is the angular velocity defined as $\omega = 2\pi f$, 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:

\[ I = \sqrt{\text{The mean of } i^2 \text{ over one period}} = \sqrt{\frac{1}{2\pi} \int_0^{2\pi} i^2 \, dt} = \frac{I_\text{m}}{\sqrt{2}} \]

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 $I_{mn}$ as the mean value of the instantaneous current $i$ (which is equal to $I_m \sin \omega t$):

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

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.

**Crest factor** = $\frac{\text{Maximum value}}{\text{Rms value}}$

**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: $u = U_m \sin \omega t$

Current: $i = I_m \sin (\omega t - \Phi)$

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

When the current lags the voltage

![Diagram of current lagging voltage](image)

When the current leads the voltage

![Diagram of current leading voltage](image)

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

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

When the current lags the voltage

![Diagram of current lagging voltage with vector](image)

When the current leads the voltage

![Diagram of current leading voltage with vector](image)
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 \( \Phi \)°.
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:

\[
p = u \times i = U_m I_m \sin(\omega t) \times \sin(\omega t - \Phi) = UI \cos \Phi - UI \cos(2\omega t - \Phi)
\]

\( U \) 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:

\[
P = UI \cos \Phi \text{ [W]}
\]

Even if the voltage and current are the same, the power varies depending on the phase difference \( \Phi \). 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 \( \Phi = \pi/2 \), 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 \( \Phi \)

When phase difference between voltage and current is \( \pi/2 \)

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.

\[ S = UI \quad [\text{VA}] \]
\[ P = UI\cos\Phi \quad [\text{W}] \]

\( \cos\Phi \) is called the power factor and is expressed as \( \lambda \). It indicates the portion of the apparent power that becomes true power.

Reactive Power
If current I lags voltage U by \( \Phi \), current I can be broken down into a component in the same direction as voltage U, I\( \cos\Phi \), and a perpendicular component, I\( \sin\Phi \). Active power \( P \), which is equal to UI\( \cos\Phi \), is the product of voltage U and the current component I\( \cos\Phi \). The product of voltage U and the current component I\( \sin\Phi \) is called the reactive power. It is expressed as \( Q \). The unit of reactive power is the var.

\[ Q = UI\sin\Phi \quad [\text{var}] \]

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

Terminology
The terminology related to harmonics is described below.

- **Fundamental wave (fundamental component)**
  The sine wave with the longest period among the different sine waves contained in a periodic complex wave. Or the sine wave that has the fundamental frequency within the components of the complex wave.

- **Fundamental frequency**
  The frequency corresponding to the longest period in a periodic complex wave. The frequency of the fundamental wave.

- **Distorted wave**
  A wave that differs from the fundamental wave.

- **Higher harmonic**
  A sine wave with a frequency that is an integer multiple (twice or more) of the fundamental frequency.

- **Harmonic component**
  A waveform component with a frequency that is an integer multiple (twice or more) of the fundamental frequency.

- **Harmonic distortion factor**
  The ratio of the rms value of the specified nth order harmonic contained in the distorted wave to the rms value of the fundamental wave (or all signals).

- **Harmonic order**
  The integer ratio of the harmonic frequency with respect to the fundamental frequency.

- **Total harmonic distortion**
  The ratio of the rms value of all harmonics to the rms value of the fundamental wave (or all signals).

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.

![Resistance Diagram]

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.

![Inductance Diagram]

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.

![Capacitance Diagram]
Series RLC Circuits
The equations below express the voltage relationships when resistance $R_S$ [\Omega], inductance $L$ [H], and capacitance $C$ [F] are connected in series.

\[ U = \sqrt{(U_{RS})^2 + (U_L - U_C)^2} = \sqrt{(IR_S)^2 + (IXL - IXC)^2} \]

\[ I = \frac{U}{\sqrt{R_S^2 + X_S^2}}, \quad \Phi = \tan^{-1} \frac{X_S}{R_S} \]

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 $R_P$ [\Omega], inductance $L$ [H], and capacitance $C$ [F] are connected in parallel.

\[ I = \sqrt{(IR_P)^2 + (IL - IC)^2} = \sqrt{\left(\frac{U}{R_P}\right)^2 + \left(\frac{U}{XL} - \frac{U}{XC}\right)^2} \]

\[ U = \sqrt{\frac{1}{R_P^2} + \left(\frac{1}{XL} - \frac{1}{X_C}\right)^2} = U \left(\frac{1}{R_P^2}\right)^2 + \left(\frac{1}{X_P}\right)^2 \]

\[ U = \frac{IR_P X_P}{\sqrt{R_P^2 + X_P^2}}, \quad \Phi = \tan^{-1} \frac{R_P}{X_P} \]

The relationship between resistance $R_P$, reactance $X_P$, and impedance $Z$ is expressed by the equations below.

\[ X_P = \frac{X_L X_C}{X_C - X_L} \]
\[ Z = \frac{R_P X_P}{\sqrt{R_P^2 + X_P^2}} \]
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