Perception Harmonic Analysis according to IEC 61000-4-7

Introduction

Perception normally measures and shows signals in the time domain. In many situations, however, it is also useful to view time signals in the frequency domain. This Quick Start Guide is concerned with a dedicated frequency domain analysis described in the standard IEC 61000-4-7 [1]. This standard is concerned with determining the harmonics of signals with a fundamental frequency of 50Hz or 60Hz. This kind of signal typically appear in power grid and power line applications.

The RTFDB function @HarmonicsIEC61000()

The spectral information required for determining the harmonics according to IEC 61000-4-7 is generated using the function @HarmonicsIEC61000() in the Real-Time Formula Database (RTFDB). See Figure 1 for the inputs to this function.

HarmonicsIEC61000(*Sync:* **Input1;** *Cycles:* **Cd;** *Scalar:* **RatedFundamentalFrequency** **)**

Input	Type		Description
Input1:	*Sync*		Input used for the calculation
Cd:	*Cycles*		Cycle source used for the calculation
RatedFundamentalFrequency:	*Scalar*	Optional	Rated fundamental frequency in Hz (50 or 60, default is 50)

Figure 1: The format for RTFDB function @HarmonicsIEC61000

Input1 is a synchronous signal with a maximum and recommended sample rate of 50 kS/s. Using a higher sample rate will lead to a (runtime) deployment error. For a maximum flat frequency response, it is recommended to use the acquisition card's Butterworth anti-aliasing filter at 1/4th of the sample rate (in Perception, choose Settings → Input → Basic – Voltage/Current, columns Filter type and Filter frequency high) which for 50 kS/s leads to a bandwidth of 12.5 kHz and 0.1 dB passband of 8.75 kHz.

Cd is a cycle signal. The function will use 10 or 12 cycle events (for a rated fundamental frequency of 50 Hz or 60 Hz, respectively) to determine the time interval for spectral analysis. To follow the standard [1], **Cd** should be generated based on a single cycle to obtain a time interval of 10 or 12 cycles.

RatedFundamentalFrequency is a scalar stating the rated fundamental frequency of **Input1** (50 Hz or 60 Hz). The function will generate a (spectral) output for input signals with fundamental frequencies that deviate up to ±5% of the rated fundamental frequency. If the fundamental frequency of the input is outside this range, no output may be generated. Note that the output is an asynchronous spectral signal and cannot be used as the input of other real-time calculated formulas.

The function will only generate output for the acquisition modes 'On start of acquisition' and 'Wait for trigger'. The spectral output signal of every instantiation of the @HarmonicsIEC61000() function is visible in Perception in the Data Sources tree under RTFormulas. Spectral signals can be recognized by a special icon (see Figure 2).

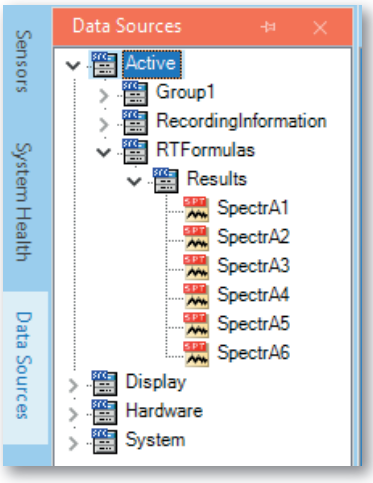

Figure 2: Spectral signals in the Data Sources tree

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The Harmonic Analysis Display

The spectral signals generated by the @HarmonicsIEC61000() function can viewed in the Harmonic Analysis Display indicated by a bar chart icon as shown in Figure 3.

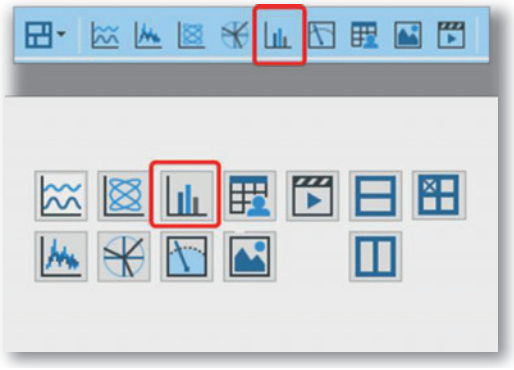

Figure 3: Adding a Harmonic Analysis Display from the toolbar (top) or from an empty component (bottom)

The Harmonic Analysis Display typically displays the harmonics in the form of a bar chart and in the form of a table (see Figure 4) and has the following areas.

- The bar chart representation ❶ of the harmonics with detailed information of the selected harmonic (in Figure 4, the 1st harmonic/order is selected)
- Table representation ❷ of the harmonics, including at the top:
  - the average fundamental frequency over the analysis interval (F)
  - the Total Harmonic Distortion (THD)
  - the Partially Weighted Harmonic Distortion (PWHD)
  - the Equivalent Disturbance Current (EDC)
  - the DC value of the signal over the analysis interval
  - the start time of the analysis interval for the given harmonics (t1)
  - the end time of the analysis interval for the given harmonics (t2)
- The buttons ❸ allowing to view only the bar chart, only the table, or both, either next to or on top of each other
- The analysis time interval ❹ for the given harmonics
- The replay control area ❺ to step through time

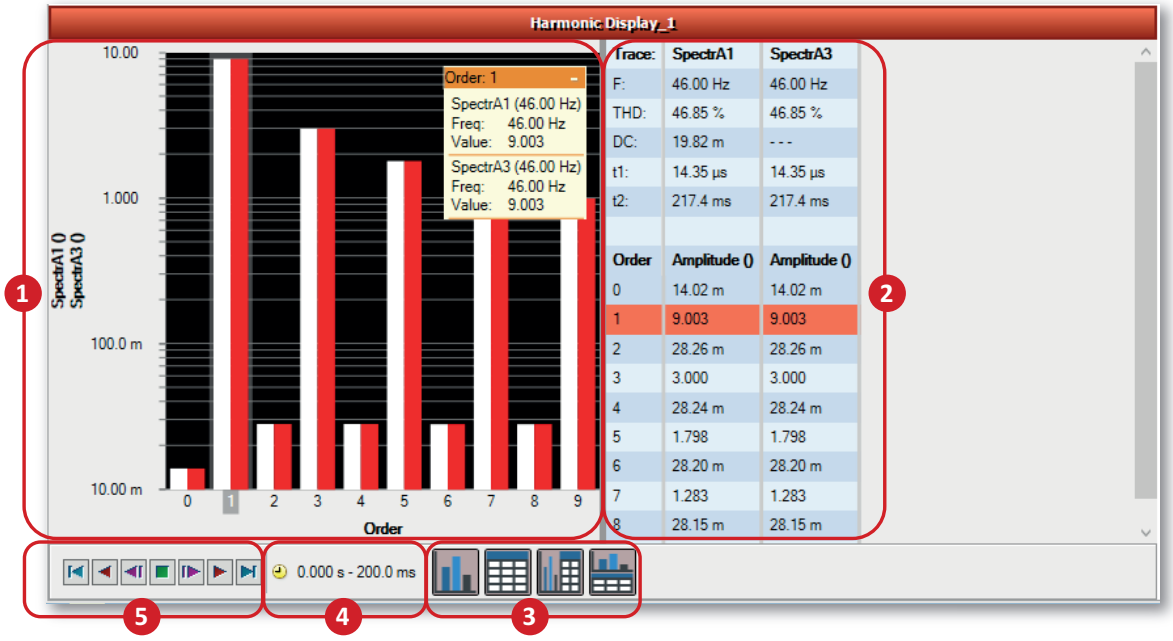

Figure 4: Overview of the Harmonic Analysis Display

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Right-clicking on the Harmonic Analysis Display pops-up the context menu in Figure 5:

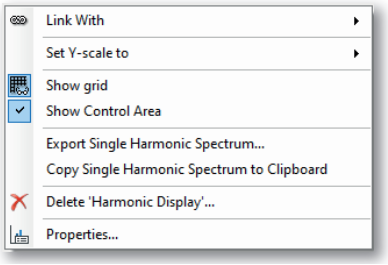

Figure 5: Context menu of the Harmonic Analysis Display

- Link with: select a Y-t display to be linked to the Harmonic Analysis Display. This will show the analysis interval of the shown harmonics in the linked Y-t display. The interval is indicated by dark blue cursors ( ).
- Set Y-scale to: allows to set the Y-scale to one of the following
  - Logarithmic Technical Units
  - Linear Technical Units
  - Decibel (dB)
- Show grid: toggles between showing and not showing a grid in the bar chart area ❶ of the Harmonic Analysis Display (see Figure 4)
- Show Control Area: toggles between showing and not showing the total control area (the buttons ❸, the analysis time interval ❹, and the replay control area ❺) at the bottom of the Harmonic Analysis Display (see Figure 4)
- Export Single Harmonic Spectrum: allows exporting the harmonics visible in the display in ASCII format to a file
- Copy Single Harmonic Spectrum to Clipboard: copies the harmonics visible in the display in ASCII format to the clipboard
- Delete ‘Harmonic Display’: opens a dialog to delete the named display

When selecting Properties… in the context menu, the window in Figure 6 appears with the tab Display Setup visible.

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The Display Setup tab contains the following areas:

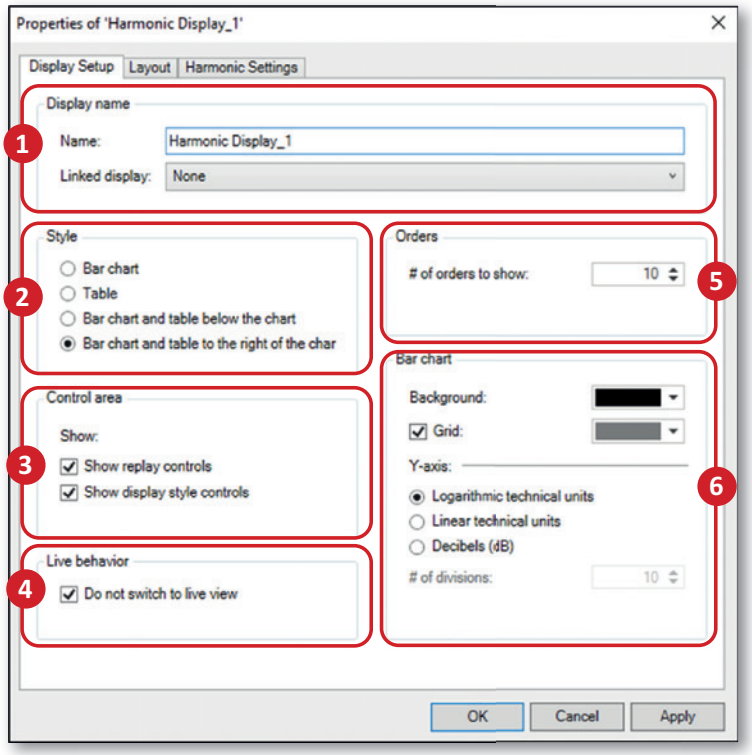

Figure 6: The Display Setup view of the properties window of the Harmonic Analysis Display

- Display name ❶: allows changing the display name and linking to one of the other displays to show the analysis interval for the current harmonics. The interval is indicated by dark blue cursors ( ).
- Style ❷: allows selecting to view only the table, only the bar chart, or both, either on top or next to each other (see also Figure 4; buttons to toggle between bar chart, only the table, etc.)
- Control areas ❸: allowing to select if certain controls are shown in the Harmonic Analysis Display
- Live behavior ❹: select to show Live or Review data. When checked, Review data will be shown
- Orders ❺: select the number of harmonics to be displayed in the bar chart and the table
- Bar chart ❻: select certain graphical properties of the bar chart

The Layout tab of the Properties window (see Figure 7) allows selecting which spectral signals to be shown in the Harmonic Analysis Display.

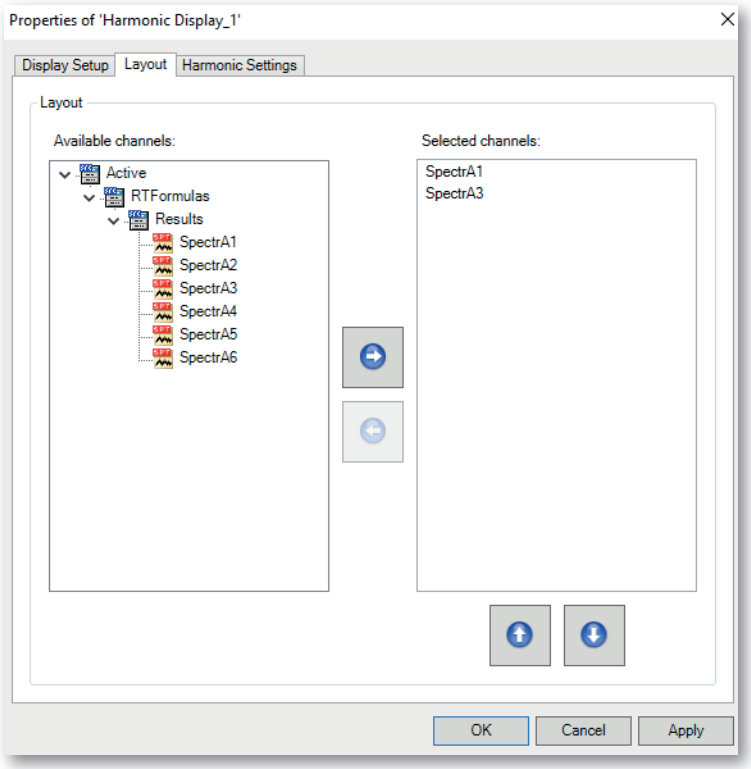

Figure 7: The Layout view of the properties window of the Harmonic Analysis Display

The Harmonic Settings tab of the Properties window (see Figure 8) allows selecting how the harmonics and distortion numbers are calculated from the spectrum. In this context, the concept of grouping as used in the IEC 61000-4-7 standard [1] is important. The frequency resolution of the spectrum (i.e., the frequency difference between 2 adjacent lines in a spectrum generated according to IEC 61000-4-7) is about 5Hz. When considering pure harmonics of a 50Hz (60Hz) signal, those will be 10 (or 12) spectral lines apart.

Grouping refers to incorporating spectral lines (so-called interharmonics) left and right of the pure harmonic to calculate the harmonic RMS value. So, a different type of grouping will lead to a different amplitude for the harmonics. For further details refer to [1].

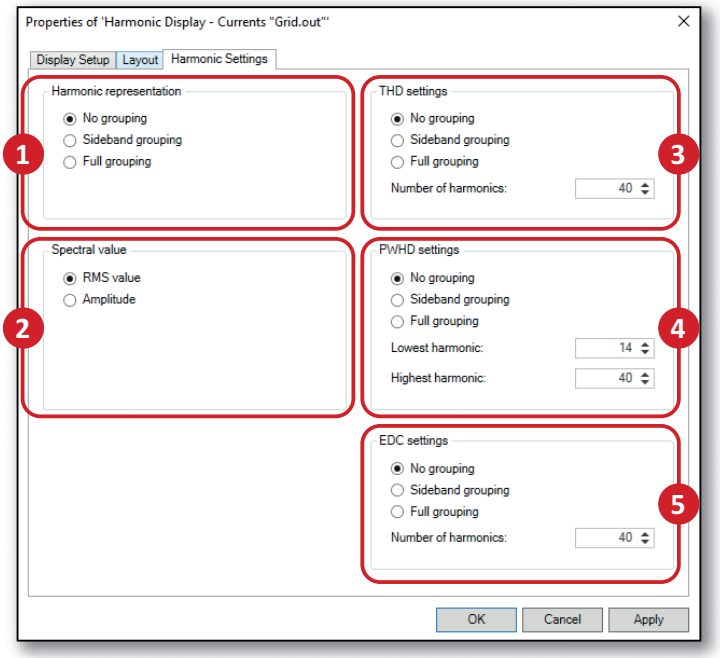

Figure 8: The Harmonic Settings view of the properties window of the Harmonic Analysis Display

The Harmonic Settings tab of the Properties window contains the following areas:

- Harmonic representation ❶: choose the type of grouping to determine the harmonics for the bar chart and the table
- Spectral value ❷: represent a spectral value for the bar chart and table as an RMS value or as an amplitude, where the amplitude is √2 times the RMS value for non-zero orders. For order 0, this factor is 1.
- THD settings ❸: choose the type of grouping to determine the harmonics for determining the Total Harmonic Distortion (THD) and select the number harmonics that is used to determine the THD
- PWHD settings ❹: choose the type of grouping to determine the harmonics for determining the Partially Weighted Harmonic Distortion (PWHD) and select the range of harmonics that is used to determine the PWHD
- EDC settings ❺: choose the type of grouping to determine the harmonics for determining the Equivalent Disturbance Current (EDC) and select the range of harmonics that is used to determine the EDC.

Harmonic analysis in the ePower suite

Harmonic Analysis is also available in the ePower suite and builds on the Perception functionality explained in the previous sections. In the ePower suite, Harmonic Analysis according to IEC 61000-4-7 is an optional analysis that can be selected per connector. It is important to note that in case Harmonic Analysis is selected for a connector, the acquisition card(s) belonging to this connector will be placed into a Slow rate sample rate group with a maximum of 50 kS/s. Because an acquisition card can only have a single sample rate, this means that if there are signals on this card(s) that do not belong to the connector, the sample rate of those signals will also be changed to sample rate of the Slow rate group. This is important to consider when assigning connector signals to an acquisition card.

The different sample rate groups are indicated in the left panel in the ePower suite (see Figure 9).

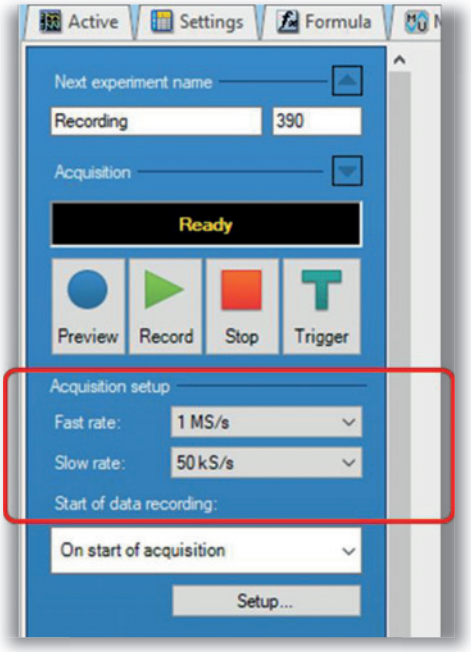

Figure 9: The different sample rate groups as indicated in the ePower suite

When starting an ePower suite application and clicking Optional Analysis in the left panel, the window Optional Analysis settings appears. An example is given in the lower part of Figure 10.
This window allows selecting optional analyses per connector and it can be seen in the right column that for Powersource.out, Harmonic Analysis is selected. When Harmonic Analysis is selected for a connector, this opens an addition sheet named Harmonics_ followed by the name of the connector. This sheet contains both Y-t Displays and Harmonic Analysis Displays for the signals of this connector. In the first column, it is indicated that the 'out' connector of Powersource is assigned to the Slow rate group which is typically using 50 kS/s. Note that the sample rate of a connector is also shown in the overview when clicking the icon at the top-right of a connector.

Selecting three dots in the 3rd row of the last column pops up the window in Figure 11 allows selecting the rated fundamental frequency (50Hz or 60Hz) and the time signals in this connector for which Harmonic Analysis should be done.

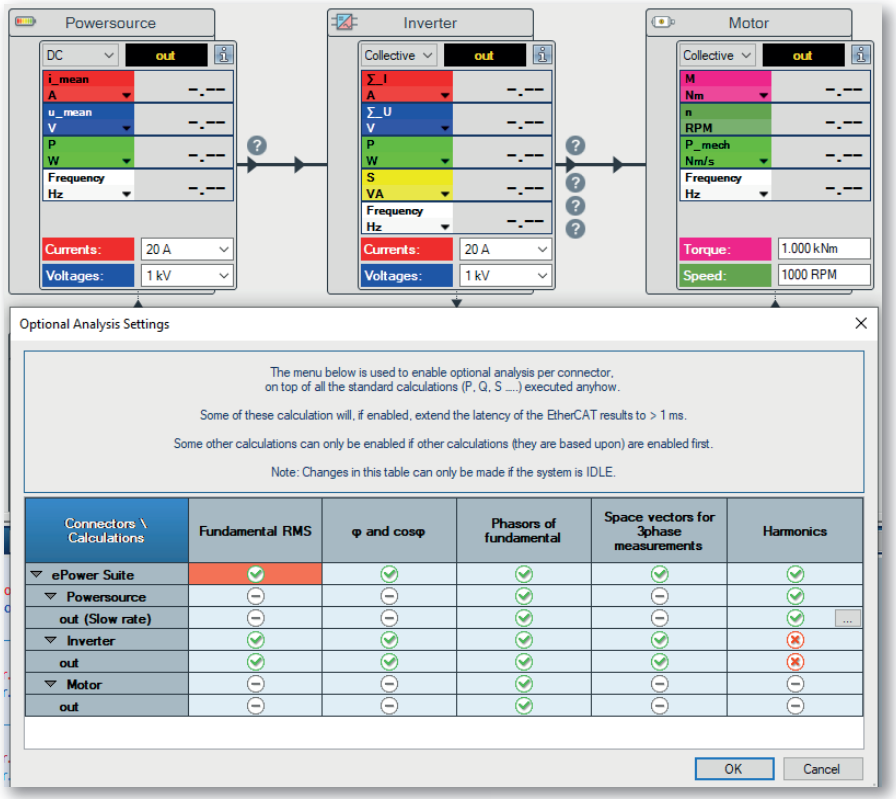

Figure 10: The Optional Analysis window (bottom) together with the schematic measurement setup (top)

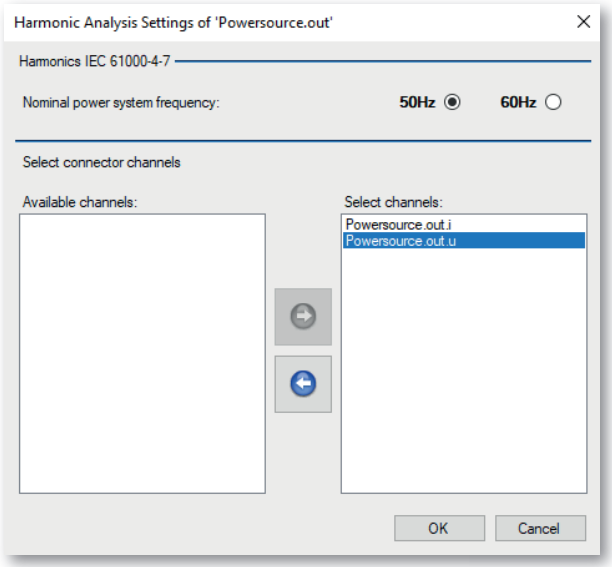

Figure 11: Selecting rated fundamental frequency and time signals for Harmonic Analysis

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When enabling Harmonic Analysis, for example, Inverter.out as well by clicking the red cross in the right column, the window in Figure 12 will pop up indicating that the card belonging to this connector will be placed in the Slow rate group. For all the signals belonging to the connector (not for all signals on the card) the card's anti-aliasing filter will be set to Butterworth with a bandwidth equal to 1/4th of the sample rate.

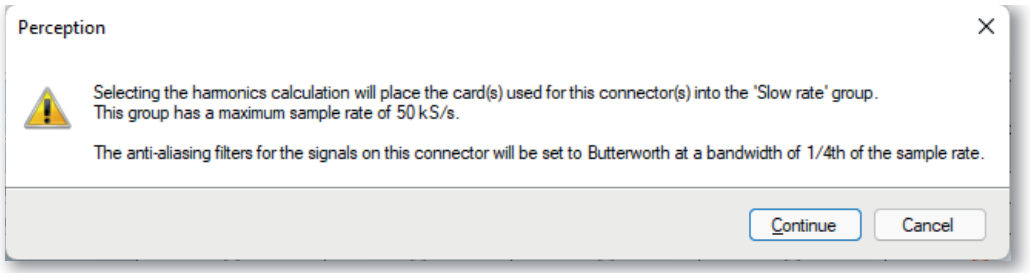

Figure 12: Perception warning that the sample rate will be changed because Harmonic Analysis is selected

The Optional Analysis window in Figure 10 indicates which connectors are in the Slow rate group. If Harmonic Analysis is selected for a connector, the acquisition card(s) belonging to this connector will be places in the Slow rate group. To get an overview of all recorders in the Slow rate group from the menu bar, click ePower Suite → Channel Assignment List…. This will show the Channel Assignment window which indicates which acquisition cards (recorders) are in the Slow rate group. An example is given in Figure 13.

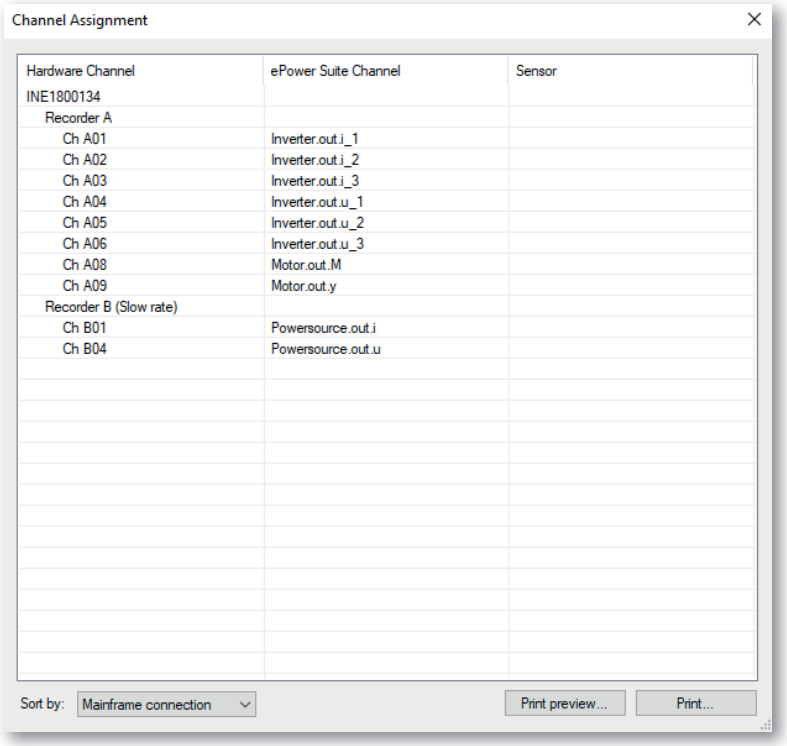

Figure 13: The Channel Assignment window showing acquisition cards (recorders) in the Slow rate group

It is possible to select Harmonic Analysis (and other optional analyses) as default when starting a new ePower suite project. From the menu bar, click File → Preferences → ePower suite → Optional Analysis and check the box Calculate harmonic analysis. This option is most useful for grid projects because all connectors in the project will be set to a sample rate of 50kS/s.

Specifications

Fourier algorithm	According to IEC 61000-4-7 (using sampled data)
Spectral grouping	According to IEC 61000-4-7
Range of the fundamental frequency of the input signals	At least 50Hz, 60Hz ± 5%
Maximum spectral frequency	10kHz
Maximum sample frequency (fs)	50kS/s
Recommended Anti-Aliasing filter	Butterworth at bandwidth fs/4
Number of simultaneous channels acquisition card	≥ 6 (GN310B, GN311B, GN610B, GN611B)

References

[1] IEC 61000-4-7: General Guide On Harmonics And Interharmonics Measurements And Instrumentation, for power supply systems and equipment connected thereto.

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