ibaInSpectra CM Library

Library for Vibration Monitoring and Frequency Band Analysis

Manual

Issue 1.0

Measurement and Automation Systems

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The current version is available for download on our web site http://www.iba-ag.com.

Protection note

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1.0	18.11.2013	First issue	RM	6.30.0

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1 About this manual

This documentation describes the function, the design and the application of the software ibaInSpectra Expert.

1.1 Target group and prior knowledge

This manual addresses in particular the qualified professionals who are familiar with handling electrical and electronic modules as well as communication and measurement technology. A person is regarded as professional if he/she is capable of assessing safety and recognizing possible consequences and risks on the basis of his/her specialist training, knowledge and experience and knowledge of the standard regulations.

Furthermore, this documentation addresses in particular the qualified professionals who are concerned with acquisition and analysis of vibration measurement data. Because ibaInspectra is an integrated part of ibaPDA-V6 the following knowledge is required for a proper configuration of the modules of the ibaInSpectra CM Library:

- ❑ Operating system Windows
- ❑ Basic knowledge about ibaPDA-V6
- ❑ Knowledge about vibration measurement
- ❑ Knowledge about frequency analysis

1.2 Notations

In this manual the following notations are used:

Action	Notation
Menu command	Menu "Logic diagram"
Calling the menu command	„Step 1 – Step 2 – Step 3 – Step x” Example: Select the menu "Logic diagram - Add - New function block".
Keys	<Key name> Example: <Alt>; <F1>
Press the keys simultaneously	<Key name> + <Key name> Example: <Alt> + <Ctrl>
Buttons	<Key name> Example: <OK>; <Cancel>
File names, paths	"Filename", "Path" Example: "Test.doc"

1.3 Used symbols

If safety instructions or other notes are used in this manual, they mean:

⚠ DANGER

The non-observance of this safety information may result in an imminent risk of death or severe injury:

- From an electric shock!
- Due to the improper handling of software products which are coupled to input and output procedures with control function!

⚠ WARNING

The non-observance of this safety information may result in a potential risk of death or severe injury!

⚠ CAUTION

The non-observance of this safety information may result in a potential risk of injury or material damage!

Note

A note specifies special requirements or actions to be observed.

Important note

Note if some special features must be observed, for example exceptions from the rule.

Tip

Tip or example as a helpful note or insider tip to make the work a little bit easier.

Other documentation

Reference to additional documentation or further reading.

2 Introduction

Industrial machines and systems must feature high availability to reach maximum productivity. Downtimes – in particular unplanned ones – are therefore to be avoided as far as possible. Changes due to wear and tear or other reasons usually become noticeable in mechanical vibrations. A condition monitoring system can permanently monitor the mechanical components and recognize possible sources of error at an early stage.

2.1 ibaInSpectra – the concept

With ibaInSpectra, iba provides a graduated solution for the acquisition, display and analysis of mechanical vibrations in machines and systems.

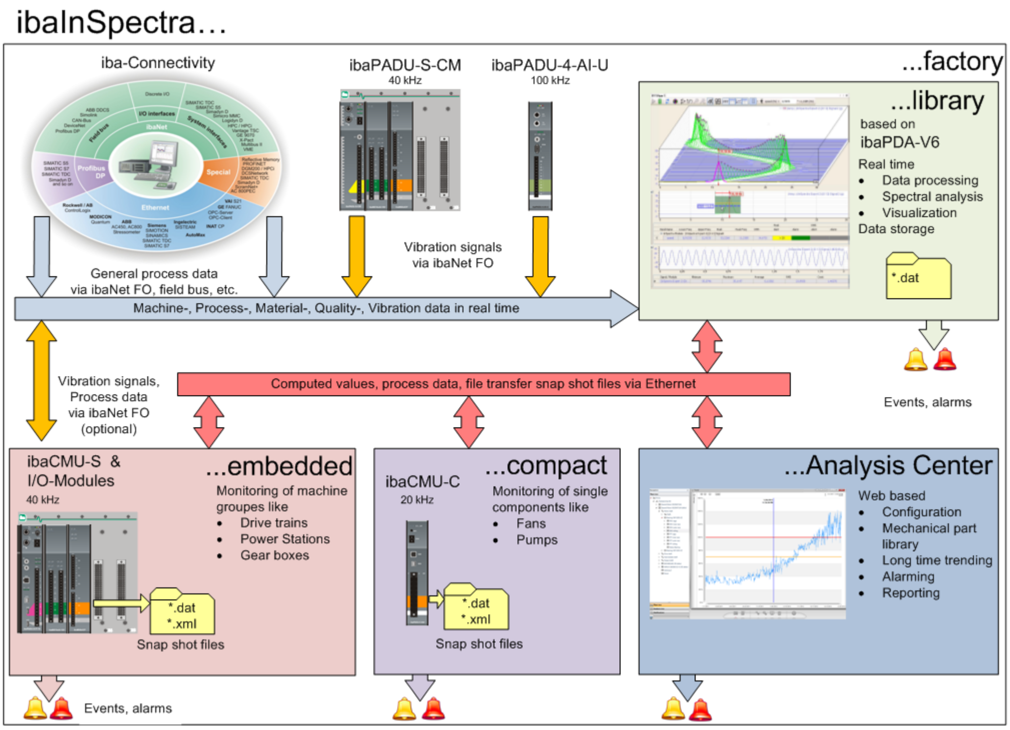


figure 1: ibaInSpectra overview

Based on different platforms and with sampling rates of up to 100 kHz, ibaInSpectra can be optimally scaled to the individual requirements in three stages of expansion.

- "compact"
  Condition Monitoring Unit (CMU)
  A solution for monitoring individual components, with technological applications, e. g. as vibration monitor with parameter generation

- "embedded"
  The powerful solution for machine groups, complex spectrum analyses and special applications, independent and yet integrated in the data acquisition of the overall system

- "factory"
  The production-wide and cross-production solution with visualization and full connectivity of ibaPDA-V6. ibaInSpectra Expert is the first of a series of software modules for the "factory" variant.

When acquiring mechanical vibrations, the emphasis is on the vibration sensors. For connecting vibration sensors, different input modules from the ibaPADU product family are at choice.

Basically, ibaInSpectra can also process all other vibration-related measurands, e. g. revolutions per minute, velocity, torque, force, etc. Due to analyzing the vibrations (causing damage) interfering these measurands, conclusions from the cause can be drawn by means of mathematical operations and knowledge of the system geometry. For the acquisition of such measurands, the entire connectivity of ibaPDA-V6 can be used.

2.2 ibaInSpectra CM Library

There are special software modules for the processing and visualization of vibration measured values in ibaPDA-V6 which are designed for different applications and objects to be monitored.

The ibaInSpectra Expert module is the first technology module of this library. It is in large areas freely parameterizable which makes it extremely versatile. The name points to the necessary expertise which the user must have regarding the specific application to configure the module correctly.

Name	Order no.	Description
ibaInSpectra CM Library	30.681.220	Condition Monitoring Library Library of freely parameterizable technology modules for ibaPDA-V6 to analyze the frequency of preferably mechanical vibrations

Table 1: ibaInSpectra order information

2.3 License model

By acquiring an ibaInSpectra CM Library license, the function of the modules in ibaPDA-V6 is enabled. If the license is not enabled in the dongle, the "ibaInSpectra" branch does not appear in the signal tree of the I/O manager.

With a license, up to 1024 modules of the ibaInSpectra CM Library can be created in the I/O manager in theory. The actually usable quantity depends on the type and number of signals as well as the computing power of the computer.

3 System requirements

3.1 Hardware

- ❑ IBM PC compatible computer, Multicore CPU 2 GHz, 2048 MB RAM, 100 GB HDD
- ❑ Input card ibaFOB-io-D, -2io-D, -4io-D (PCI or PCIe) or ibaFOB-io-ExpressCard
- ❑ Suitable acquisition devices in the field for vibration sensors:
  - ibaPADU-8-M / -8-ICP / -16-M (sampling rate 25 kHz)
  - ibaPADU-S-IT / -S-CM with input modules,
e. g. ibaMS8xICP (sampling rate 40 kHz)
  - ibaCMU-S

3.2 Software

- ❑ ibaPDA-V6, version 6.30.0 or higher

4 Installation

ibaInSpectra modules are contained in the standard installation of ibaPDA-V6 (≥ 6.30.0). No further action is needed. The module functions are enabled by a licensed dongle.

5 Configuration of an ibaInSpectra Expert module

5.1 Introduction

ibaInSpectra Expert is capable to monitor multiple frequency bands in the frequency spectrum of a signal. The parameters for frequency analysis are freely parameterizable and can be stored in profiles. Hence, profiles created once, can be reused multiple times. The configuration of one ibaInSpectra Expert module per signal to be monitored is mandatory. For an improved clarity the modules may be structured by a folder structure.

As an ibaInSpectra Expert module cannot be properly configured without a valid calculation profile the configuration of a profile is explained first in following, before the setup of the module.

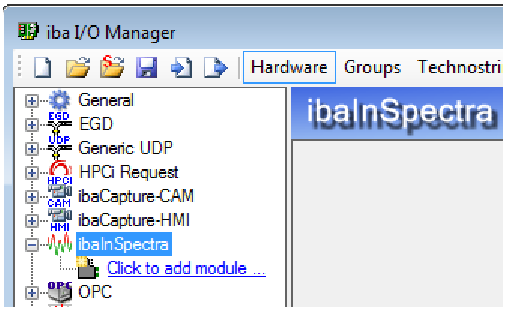
5.2 Defining and configuring the calculation profile

The configuration of the calculation profiles for the frequency band analysis is the core of the module configuration. Here, detailed knowledge of the matter is needed to configure a profile that corresponds to the requested input signal and yields the required results. Any number of profiles can be configured to adequately analyze different input signals or sensor types.

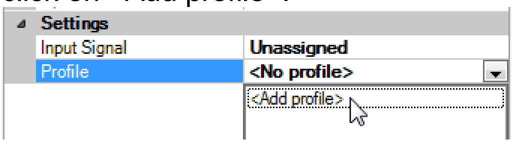
5.2.1 Creating a profile

If you create an ibaInSpectra Expert module for the first time, no profiles are yet available. In order to create and edit profiles you should add an ibaInSpectra module first. Follow these steps:

1. Open the I/O manager in ibaPDA-V6.
2. If necessary, expand the "ibaInSpectra" branch and click on the blue link "Click to add module...".



3. Select the "ibaInSpectra Expert" module type in the following "Add module" dialog and enter a module name in the corresponding field. Then click <OK>.
   The module is now created and you see the "General", "Analog", "Digital" and "Diagnostics" tabs in the right part of the I/O manager.
   Alternatively, you can make a right mouseclick on the "ibaInSpectra" interface and select "Add module" in the context menu. The module is created immediately. You can rename it after.
4. Open the drop-down list in the field "Profile" on the "General" tab of the module and click on <Add profile>.



   Alternatively, you can click on the blue link "Configure profiles" at the bottom of the dialog window.

5.2.2 Setting calculation parameters

By entering the calculation parameters, you determine as to how the frequency spectra are to be calculated mathematically.

The calculation parameters are entered in the configuration dialog for the profiles, in the "Calculations" tab. You can open the dialog as follows:

- Click <Add profile> (see above)
- Click "Configure profiles" link in the below "General" tab of the module

- Click "Configure the calculation settings of the current profile" at the lower border of the "Diagnostics – calculations" tab

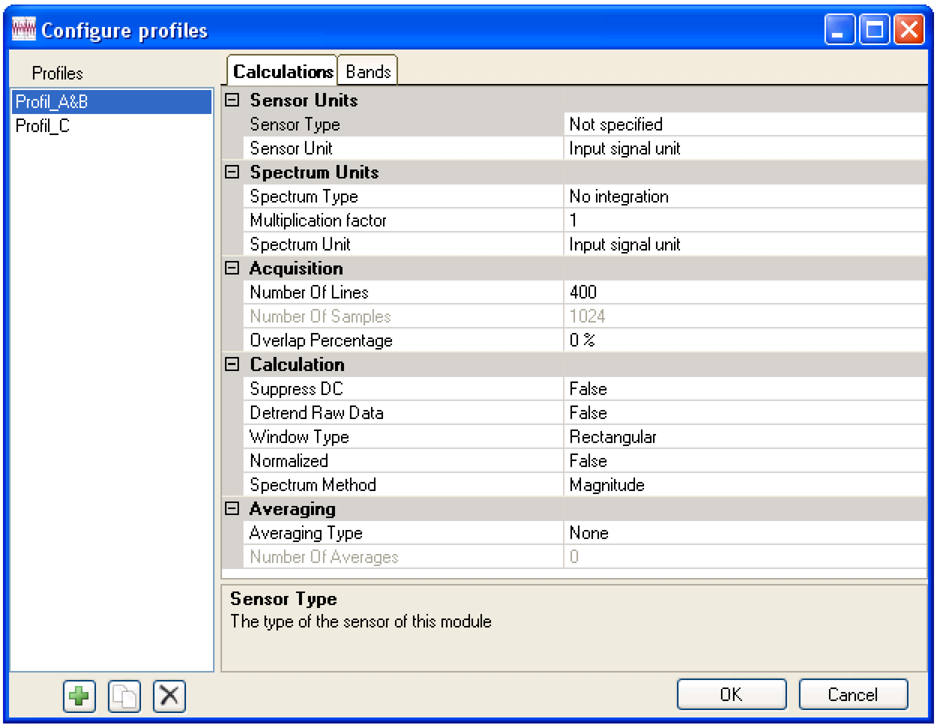


figure 2: Configuration dialog for profiles

The left part of the dialog shows a list of the available profiles. Here, you can rename the profiles anytime. The renaming is automatically incorporated in the module settings where the relevant profile is used.

Below the list, there are 3 buttons with the following functions:

Adding profile
Adds a new profile with default name and factory settings.

Copying profile
Creates a new profile with the same settings of the profile currently marked.

Deleting profile
Deletes the profile currently marked.

For setting the calculation parameters, select the desired profile and then the "Calculations" tab.

The following explains the calculation parameters and their meanings:

5.2.2.1 Sensor

❑ Type

Select the type of the sensor which provides the signal to be monitored.

Selection	for sensor type...	Examples
Not specified	unknown or other signal	
Displacement	Amplitude sensor	Displacement or differential displacement sensor
Velocity	Vibration velocity sensor	Electrodynamic velocity sensor, Doppler laser
Acceleration	Acceleration sensor	Capacitive, piezoelectric or piezoresistive sensors; this group also contains ICP sensors

Table 2: Sensor types

❑ Unit

This practically complies with the unit of the input signal.

The selection of the sensor units is adjusted according to the selected sensor type. Select the suitable unit which can be found in the data sheet of the sensor.

If no sensor type is set, all units are provided.

If the suitable unit is not available or unknown, select "Input signal unit".

5.2.2.2 Spectrum

❑ Type

The selection of the spectrum type is automatically preset in accordance with the setting of the sensor type. However, it can be modified.

If you choose different settings for sensor and spectrum, ibaInSpectra Expert automatically converts the frequency spectrum (by means of corresponding integration or differentiation).

If, for example, an acceleration sensor is used, but the spectrum type velocity is set, ibaInSpectra automatically performs a corresponding integration.

If you do not specify the sensor type, different differentiation and integration options are available for the type of spectrum.

❑ Multiplication factor

With this factor, you can change the amplitude of the spectrum. This factor mainly serves to convert the unit of the input signal (sensor unit) to another unit in the spectrum. The multiplication factor is automatically adjusted, if you select another predefined setting for the spectrum unit than for the sensor unit. In other cases, you can also enter the factor manually.

For example, you can select in/s² for the spectrum of an acceleration sensor even if the sensor unit is mm/s².

Example

Sensor unit	Spectrum unit	Multiplication factor
mm/s^2	in/s^2	0.03937....
g	mm/s^2	9806.65...
Input signal unit (mm/s^2)	1000 mm/s^2 (= m/s^2)	0.001

Table 3: Connection between sensor unit, spectrum unit and factor

❑ Unit

The spectrum unit is automatically set to the value of the sensor unit. If you still opt for another setting, the multiplication factor is automatically adjusted (see above).

5.2.2.3 Acquisition

❑ Number of lines and number of samples

The "Number of lines" setting defines the number of the frequency values (bins) in the spectrum. The number of the lines is directly related to the number of samples used for the calculation of the spectrum.

By selecting the number of lines, the number of samples is automatically set which cannot be changed manually. The following combinations are possible:

Number of lines	Number of samples
200	512
400	1024
800	2048
1600	4096
3200	8192

Table 4: Number of lines and number of samples

Note

The relationship between lines and samples is as follows:

Number of lines = number of samples / 2

With the recording of 1024 samples, e. g., only 1024/2 = 512 frequencies per measurement can be computed. As the higher frequencies often do not yield reliable values, ibaInSpectra Expert always computes slightly less frequencies, in this example, the lower 400 instead of the total 512 lines. This is why the number of lines to number of samples ratio is not exactly 1/2 but 1/2.56: 1024/2.56=400.

A higher number of lines also increases the period for the calculation of the spectrum, as more values (samples) have to be acquired. This explains the waiting time until the first spectrum appears in the display.

The advantage of a high number of lines is the higher frequency resolution of the spectrum, i. e. the distances between the frequency values are smaller than with a small number of lines.

Note

This setting does not affect the maximum frequency which can be displayed in the spectrum! The maximum frequency of the spectrum solely results from the time base of the input signal.

❑ Overlap

The overlap can be set between 0 % and 95 %. It indicates how many of the recorded values are used again for each calculation. In case of a 0 % overlap, all recorded values are used only once for a calculation. In case of an overlap of 50 %, only half of the values are overwritten by new values so that every value is used twice in a calculation. An overlap of 75 % results in every measured value being used in 4 successive calculations.

The greater the overlap, the more calculations are carried out in the same time, as with an increasing overlap, fewer (new) values have to be recorded which reduces the waiting time.

Example

An input signal is acquired with a time base of 1 ms. The number of lines is 800 (number of samples = 2048). In case of an overlap of 0 %, a new spectrum is calculated every 2048*0,001 s = 2.048 s. If the overlap is 75 %, the calculation time is only 2048*0,001*(1 – 0.75)= 0.512 s. The first calculation after each measurement start is exempted. The first calculation always takes approx. 2 s, irrespective of the overlap set.

5.2.2.4 Calculation

❑ Suppress DC

If you set this parameter to TRUE, the DC component is removed from the input signal by subtraction of the mean value. This setting suppresses every pulse at the frequency of 0 Hz.

This results in a better presentation of the AC components which matters in the end.

❑ Detrend Raw Data

If you set this parameter to TRUE, a slow drift of the measured values is suppressed (detrending).

This is achieved by removing the linear component from the input samples for the FFT computation. With the method of least squares, a linear function (y=a*t+b) is determined matching the input data. This function is subtracted from the input samples before the FFT is computed.

If you want to make sure that the DC component = 0, you have to additionally activate the suppression of the DC component (see above).

❑ Window Type

By selecting one of the window functions, the so-called leakage effect can be reduced when analyzing the frequency. Select the most suitable type of window for your application:

- Hamming
- Hanning
- Bartlett
- Blackman
- Blackman-Harris
- Rectangular

The Hanning window is often used for the vibration analysis.

❑ Normalized

If you set this parameter to TRUE, the values of the FFT are normalized, i. e. the result values are independent of the scaling of the input values.

❑ Spectrum Method

By selecting the spectrum method, you determine whether the amplitude spectrum (magnitude) or the power spectrum (power) is computed. The latter is computed by squaring the amplitude spectrum. Therefore, the spectrum unit is displayed squared in the "Power" setting.

❑ RMS method

This setting determines as to how the RMS of a band is to be computed.

- Mathematical (default setting)
  Root mean square of all values of the spectrum within the band.
  Is seldom used in the machine analysis.
- Vibration Overall
  Approximate value of an ideally filtered input signal approaching the RMS.
  This method is preferably suitable for wide frequency bands, i. e. with a great distance between lower and upper cut-off frequency.
- Dominant Peak
  The result is calculated by dividing the peak value of the amplitude spectrum by the square root of 2 or
  RMS = Peak * 0.707
  This simple method of calculation is usually used in the practical machine analysis.

➚ Further information on RMS methods can be found in the glossary.

5.2.2.5 Averaging

❑ Averaging Type and Number Of Averages

If the averaging is activated, the results of several frequency analyses are combined to an averaged spectrum. The ibaInSpectra module in this case only shows the averaged spectrum. By setting the number of mean values, you can determine how many spectra are included in the averaging.

For calculating mean values, you may choose between different methods:

Method	Description
None:	No averaging is carried out. ibaInSpectra Expert always displays the results of each calculation.
Linear	Averaging *n* spectra at time T is made from the calculations at times T, T-δ, T-2δ,.., T-(*n-1)*δ. *n* = number of mean values (spectra) δ = (time base)*(number of samples)*(1-overlap/100) $X = \frac{1}{N}\left(\sum_{i=1}^{N} x_i\right)$ *N* = number of the FFTs for the mean value calculation *i* = Index of the FFT; i = 1 oldest, i = N latest FFT *xi* = amplitudes or power value of a frequency line in the i^{th} FFT
Exponential	The exponential method of the averaging represents a weighted mean value calculation where the most recent FFT results are weighted more than former ones. $X = \frac{1}{N}\left(\sum_{i=1}^{N}\left(\frac{N-1}{N}\right)^{N-i} x_i\right)$ *N* = number of the FFTs for the mean value calculation *i* = Index of the FFT; i = 1 oldest, i = N latest FFT *xi* = amplitudes or power value of a frequency line in the i^{th} FFT
Peak hold	For each frequency the highest available value is used.

Table 5: Methods of the mean value calculation

Since ibaInSpectra Expert calculates a sliding mean value, the result is displayed every δ seconds.

5.2.3 Configuring frequency bands

In the "Bands" tab in the configuration dialog for the profile, configure the settings for the frequency bands to be monitored.

You determine in the table which bands you want to monitor, at which frequency the band should be and how wide the band is. Moreover, you can also configure the warning and alarm limits.

For every profile, you can define up to 32 frequency bands.

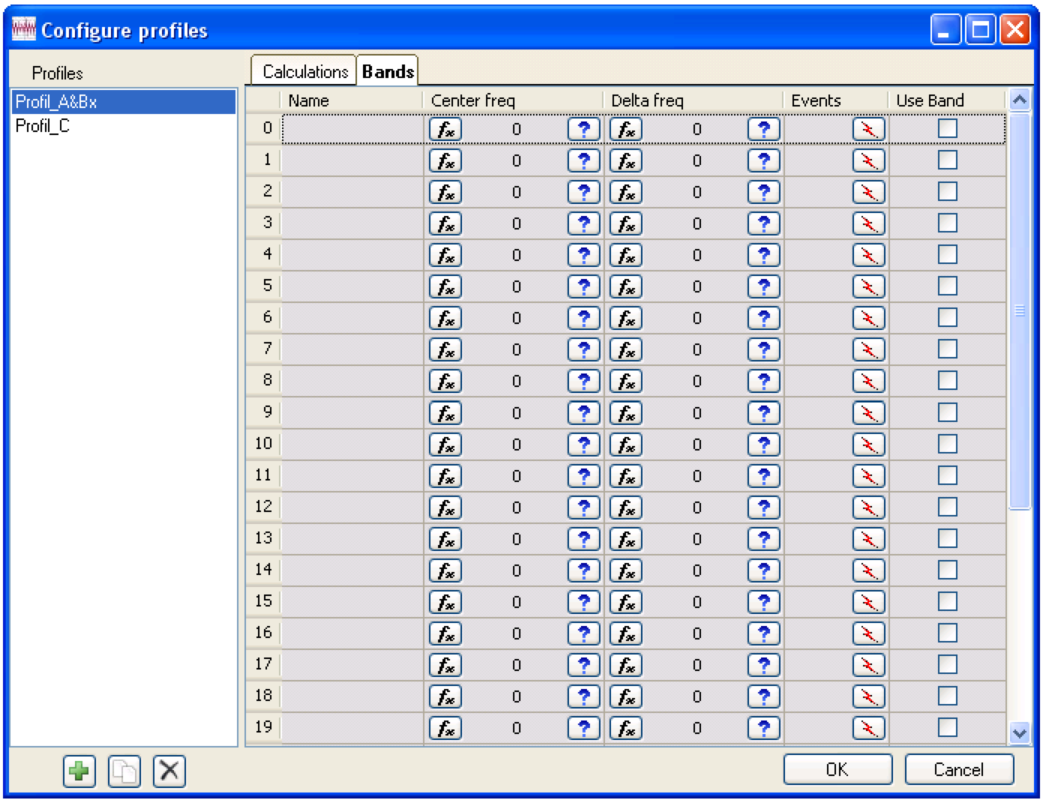


figure 3: Configuration dialog for profiles, frequency bands tab

For every profile, 3 analog values are created which are visible in the "Analog" tab of the module later on:

- Peak
  The peak value in the spectrum within the band.
- Peak frequency
  The frequency where the peak value occurred
- RMS
  Average calculated according to selected calculation method (see chapter *Calculation* , Page 15, item "RMS method").

The settings and their meanings:

❑ Name

Enter a real name in this column to be able to identify the band later on.

❑ Center frequency

The center frequency is the frequency value in the middle of the band. The center frequency can be a constant value or specified by another analog signal.

If you want to use an analog signal for controlling the center frequency, click the <fx> button in the table cell. The expression builder opens and you can select either an existing signal or enter an expression for calculating the center frequency.

- Delta frequency

The setting of the delta frequency determines the distance of the lower and upper frequency limit of the band to the center frequency and therefore defines the width of the frequency band (width = 2*delta frequency). This value can also be either a fixed number or an analog signal and expression, respectively.

- Events

This column shows whether events of type warning ( ) and/or alarm ( ) were configured for this band.

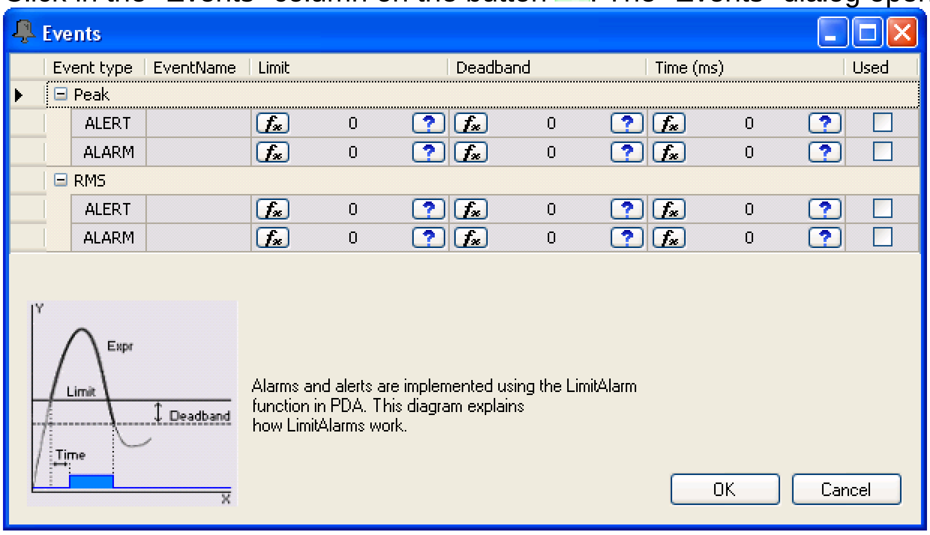
For every band, up to 2 warnings and 2 alarms can be configured. These events relate to the peak value (peak) and the average value of the band as calculated by the selected RMS-method.

If the events were enabled, there is a digital signal in the module for every event and ibaInSpectra monitors the corresponding values during measurement operation. When exceeding the entered limit value, the corresponding digital signal is set to TRUE (logical 1) and can be used for signaling.

5.2.3.1 Configuration of the events

To configure the events for a frequency band, proceed as follows:

1. Click in the "Events" column on the button . The "Events" dialog opens.

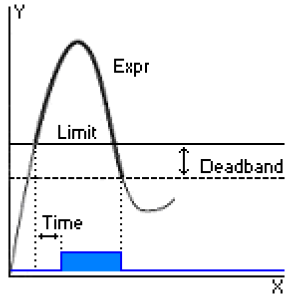


2. Enter a name in the "Event name" column to be able to clearly identify the event later on.
3. Configure the settings for limit value, deadband and delay time. You can enter fixed numerical values, select analog signals or define expressions for these values.
   - The limit value defines the response limit for the event.
   - By means of the deadband, you prevent an event from being reset too fast. The event is reset only after the measuring value comes below the mark (limit value – deadband).
   - With the delay time, you can delay the triggering of the event. The event is triggered only after the measuring value exceeds the limit value for a longer period than the time set.

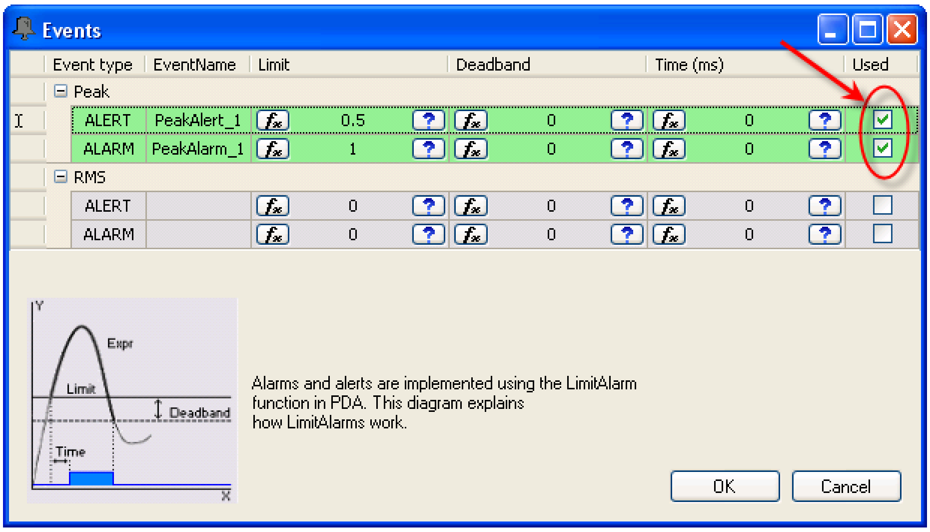
Note

The response for the events conforms to the "LimitAlarm" function.

Limit Alarm



1. Please make sure that the check boxes are enabled in the "Used" column.



2. Close the dialog with <OK>.

If you configured all settings, also close the "Configure profile" dialog by clicking <OK>. As described in the "General" chapter, you can now assign the profile to the module. Then exit the I/O manager for the new configuration to be applied.

With this, the configuration of the profile is completed and you may now proceed to make further settings on the InSpectra module or proceed to the display.

After the configuration has been validated and the acquisition started you can check the results in the diagnostics tab of the module in the I/O-Manager.

5.3 Arranging and structuring ibaInSpectra modules

Below the ibaInSpectra interface, the user can establish a hierarchic structure, e. g. in accordance with the system installation, by means of folders. Such folders can be created by right-clicking on the ibaInSpectra interface or an existing folder.

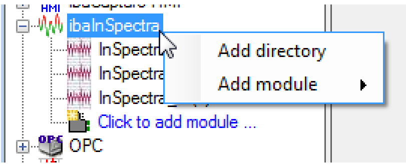


figure 4: I/O manager, context menu ibaInSpectra interface

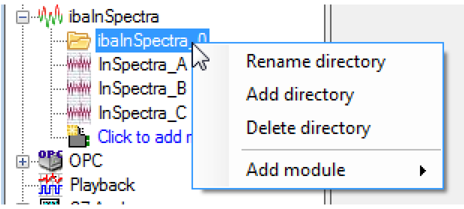


figure 5: I/O manager, context menu ibaInSpectra sub-folders

If several folders were created on the same hierarchical level, they can be marked by mouseclick and moved within the level by using the key combination <Ctrl>+<cursor up> or <cursor down> or via drag & drop.

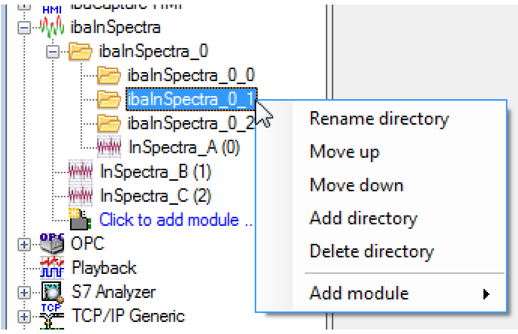


figure 6: I/O manager, context menu ibaInSpectra sub-folder (several subdirectories)

ibaInSpectra modules can be moved to folders by drag & drop. New modules can be directly added to a folder via the context menu, too.

The folders can be renamed just as you like.

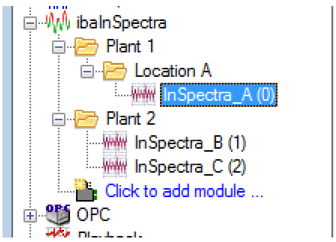


figure 7: Example of a hierarchic ibaInSpectra Expert structure

Based on this hierarchic structure, ibaInSpectra groups are automatically created in the "Groups" section in the I/O manager. These groups are locked and cannot be modified. You cannot add signals to a locked group or its sub-group(s).

When using ibaInSpectra in conjunction with the ibaInSpectra Analysis Center the group structure can be stored in the measuring file (*.dat). The structure will then be checked in the Analysis Center when loading the measuring files. New structures will be automatically stored in the database of the ibaInSpectra Analysis Center.

A precondition for that is that ibaInSpectra modules are arranged on levels from 2 to 4 only. The first level represents the plant level while at least one sublevel (e.g. unit) is required.

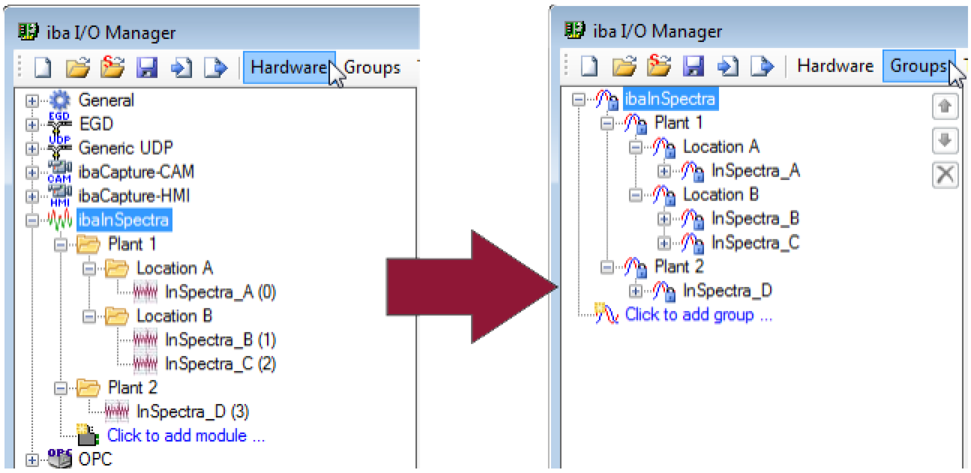


figure 8: ibaInSpectra interface structure and resulting group structure

5.4 Creating an ibaInSpectra Expert module

1. Open the I/O manager in ibaPDA-V6.
2. Follow the steps 2 and 3 as described in chapter *Creating a profile* , Page 10. If suitable profiles are available you don't need to create a new profile.
3. Now configure the general settings for the module in the "General" tab. Please follow the explanations in the chapter "*Configuring the module settings* , Page 23".

5.5 Configuring the module settings

5.5.1 General

Basic settings

❑ Locked

A module can be locked in order to prevent change of module settings by accident or unauthorized users. The lock-function is linked to the user management in ibaPDA-V6. A module can be locked (true) or unlocked (false) only by users who have the required right, provided the user management is activated.

- If False, any user can change the module settings.
- If True, no change of module settings possible. Module must be unlocked by authorized users first in order to change the settings.

❑ Enabled

By selecting the options in the drop-down list in the field on the right side of "*Enabled*" , you determine whether the module is enabled (TRUE) or disabled (FALSE). If a module is disabled, its signals are excluded from acquisition. This means they are neither available for display nor for recording. Furthermore, the number of signals of a disabled module will not be taken into account in the signal statistics (signal-o-meter).

❑ Name

Enter a comprehensible name for the module here.

It is recommended to use an application-specific naming rule for a better clearness and comprehension, particularly with vast numbers of modules. The name may refer to a technological purpose or a special location in the plant where the module is used or installed. The number of characters in the name is unlimited. The name of the module is stored in the data file and visible in ibaAnalyzer.

❑ Module No.

If you add modules to the configuration, the system automatically assigns the numbers in chronological order. However, you can select another order for subsequent analysis in the data file by changing the number. Feel free to change the module number according to your needs. It must be ensured that the number is unambiguous. The order of the modules in the signal tree of ibaAnalyzer is determined by their numbers.

❑ Time base

As *time base* , you may enter a value here, given in ms, which is an integer multiple of the general time base as configured in the "*General*" branch of the I/O manager. The time base of the module determines the update time of the output signals of the module. It should be smaller than the interval between two calculations (see update time display below). Usually, 100 ms is enough.

The ratio between maximum and minimum time base is limited to the value 1000. The value of the time base is limited to 1000 ms.

Calculations

❑ Enabling calculations

With this setting, you can control whether the calculations are to be always performed or controlled by a signal. Click on the drop-down arrow in this field and select one of the following options from a reduced signal tree:

- Always
  With this setting, the frequency band calculation is permanently being executed. Please note that the system load can be quite high due to a permanent computation depending on the type and number of signals and the profile settings.
- Signal tree
  As an alternative, all other (digital) signals, incl. the virtual signals, are at choice to activate the calculation (selected signal = TRUE) or deactivate it (selected signal = FALSE). This allows you to link the calculation of the ibaInSpectra module to particular process states or e. g. to an ibaQPanel entry.

❑ Hold values

If you set this option to "TRUE", the values of the most recent computation remain visible in the online display of the ibaInSpectra Expert module, even if the calculation is deactivated by means of a control signal.
If you set this option to "FALSE", the display is cleared and the computed values are set to 0 if the calculation is disabled by means of a control signal.

❑ Frequency resolution, max. frequency and update time (only display)

These values result from the calculation parameters set and are only displayed.

Settings

❑ Input signal

Select the input signal whose frequency bands are to be analyzed. All signals projected in ibaPDA are available in the signal tree.

If no input signal is selected or available, an error message is output when checking the I/O configuration:

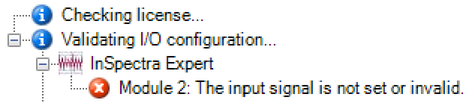


figure 9: Error message when input signal is missing

❑ Profile

Select the requested profile from the drop-down list for analyzing the selected signal. If no profile is available or a suitable profile is missing, you have to define a profile first. For more information, read the explanations in the chapter *Defining and configuring the calculation profile*, page 10".

If no profile is selected or available, an error message will be output when validating the I/O configuration.

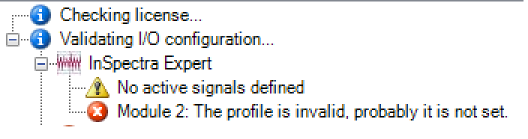


figure 10: Error message when profile is missing

Example

Our example defines 3 vibration signals in the I/O manager with an ibaInSpectra Expert module being created for each of these signals:

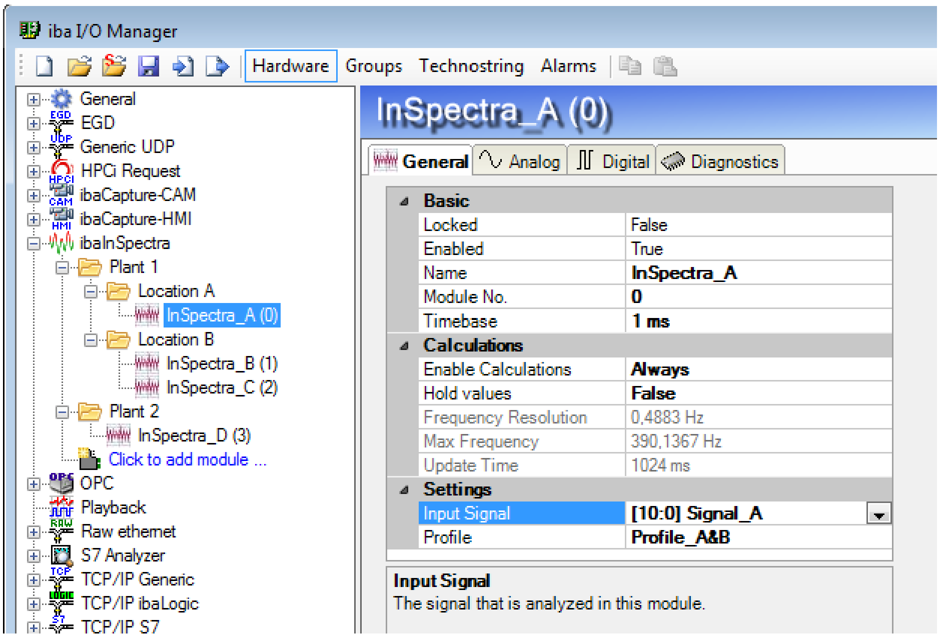


figure 11: General settings of an InSpectra expert module

A profile (Profile_A&B) was already prepared for the I/O configuration to be accepted. How to create a profile is described in the chapter *Defining and configuring the calculation profile* , Page 10.

5.5.2 Analog

After completely configuring the general module settings, the "Analog" tab automatically creates 5 signals in the "time domain" group.

- ❑ Minimum, maximum
  Minimum and/or maximum of the input signal
- ❑ Mean value
  Arithmetic mean value of the input signal
- ❑ RMS
  The root mean square of the input signal
- ❑ Crest factor
  Crest factor (maximum-RMS-ratio) of the input signal

You can see the current values of these signals in the "Diagnostics – current values" tab provided measuring is being carried out.

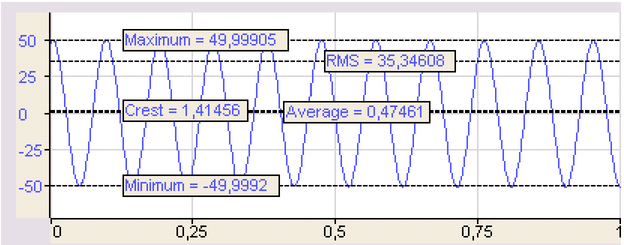


figure 12: ibaInSpectra Expert module, Diagnostics – Actual value display, input values

Furthermore, these 5 signals are later available in the signal tree for display and recording. For the online display in the ibaPDA client, activate the time slave graph in the FFT display of the ibaInSpectra module.

Furthermore, in the "Analog" tab, the calculation results "peak", "peak frequency" and "RMS" are created for every frequency band defined in the selected profile. You can see the current values of these results (frequency domain) in the "Diagnostics – current values" tab.

Band Name	Lower Freq	Upper Freq	Peak	Peak Freq	RMS	Peak		RMS	
						Alert	Alarm	Alert	Alarm
speed	0,951841	4,95184	37,7963	2,92969	16,0874	> 20	> 40		

figure 13: ibaInSpectra Expert module, Diagnostics – Actual value display, result values

Also these values will be available later in the signal tree for display and recording. For the online display in the ibaPDA client, activate the "Frequency spectrum data" table in the FFT display of the ibaInSpectra module.

General | Analog | Digital | Diagnostics

	Name	Unit	Active
	Time Domain		
0	InSpectra_A_Minimum	mm²	☑
1	InSpectra_A_Maximum	mm²	☑
2	InSpectra_A_Average	mm²	☑
3	InSpectra_A_RMS	mm²	☑
4	InSpectra_A_Crest	mm²	☑
	Band1 (Band 0)		
5	InSpectra_A_Band1 (Peak)	mm²	☑
6	InSpectra_A_Band1 (Peak frequency)	Hz	☑
7	InSpectra_A_Band1 (RMS)	mm²	☑
	Band2 (Band 1)		
8	InSpectra_A_Band2 (Peak)	mm²	☑
9	InSpectra_A_Band2 (Peak frequency)	Hz	☑
10	InSpectra_A_Band2 (RMS)	mm²	☑
	Band3 (Band 2)		
11	InSpectra_A_Band3 (Peak)	mm²	☑
12	InSpectra_A_Band3 (Peak frequency)	Hz	☑
13	InSpectra_A_Band3 (RMS)	mm²	☑

figure 14: Example of an InSpectra Expert module with 3 bands

Note

The signals are enabled for the display and recording by default. If required, they can be disabled, too. Other signal properties such as name and unit cannot be modified in the tables. These properties are specified by the profile and the module name. A modification of the module name automatically results in a modification of the signal names.

5.5.3 Digital

In the "Digital" tab, the configured warning and alarm messages are created for every frequency band defined in the selected profile. You can see the current values of these results (frequency domain) in the "Diagnostics – current values" tab (see figure 11). For the online display in the ibaPDA client, activate the "Frequency spectrum data" table in the FFT display of the ibaInSpectra module.

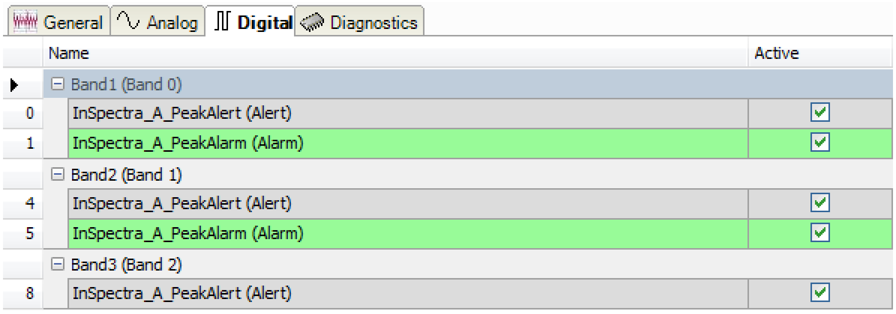


figure 15: Example of an InSpectra Expert module with 3 bands

Note

The signals are enabled for the display and recording by default. If required, they can be disabled, too. Other signal properties such as name and unit cannot be modified in the tables. These properties are specified by the profile and the module name. A modification of the module name automatically results in a modification of the signal names.

5.5.4 Diagnostics

The "Diagnostics" tab and its following tabs provide all information on the settings of the selected profile and the frequency bands as well as a display of the actual values in the frequency and time domain.

Calculations

This tab shows the calculation parameters of the profile set which was assigned to this module in the general settings. If you want to change the profile settings, click on the "Configure the calculation settings of the current profile" link at the lower border of the dialog.

Current values

If the measurement is running, this tab shows the current output values of the module. Both the spectrum and the time-based input signal are displayed as graphs. A table shows the computed values for all active bands.

By means of this diagnostic feature you can easily check the calculation results and thus the settings without creating a view in the ibaPDA client.

For displaying the warnings and alarms for peak and RMS, the following color scheme is used:

Color	Meaning
Gray	No warning/no alarm defined
Green	Warning/alarm defined but not activated
Yellow	Warning activated
Red	Alarm activated

Table 6: Color scheme for event display

Example

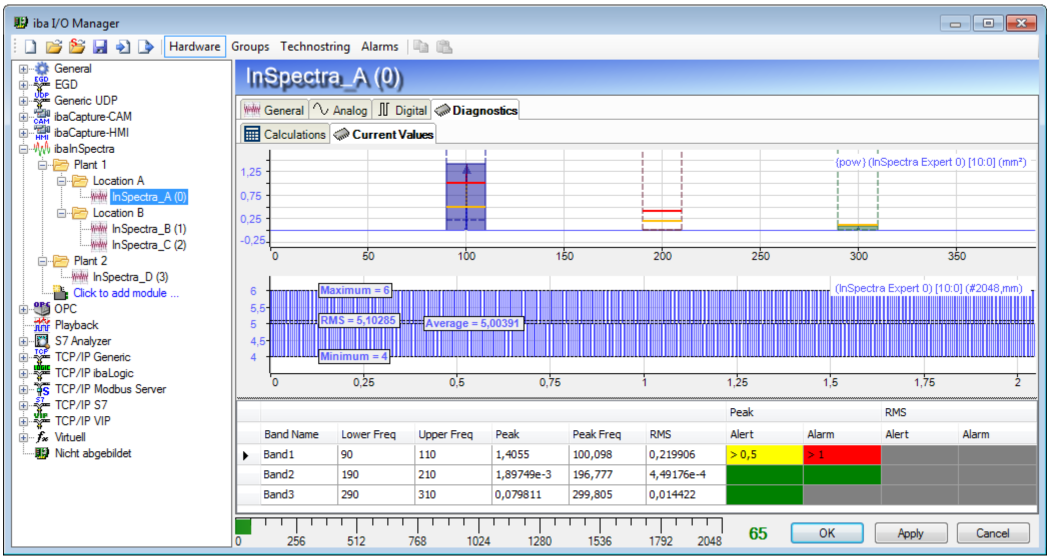


figure 16: Current value display in the I/O-Manager

6 Operation and visualization

6.1 Display functions

As soon as the acquisition in ibaPDA-V6 starts, the InSpectra modules are computed. In the signal tree, the computed analog and digital values of every module are available for display purposes. These signals can be dragged into the usual trend graphs or visualized in digital meters and in ibaQPanel or other views, respectively.

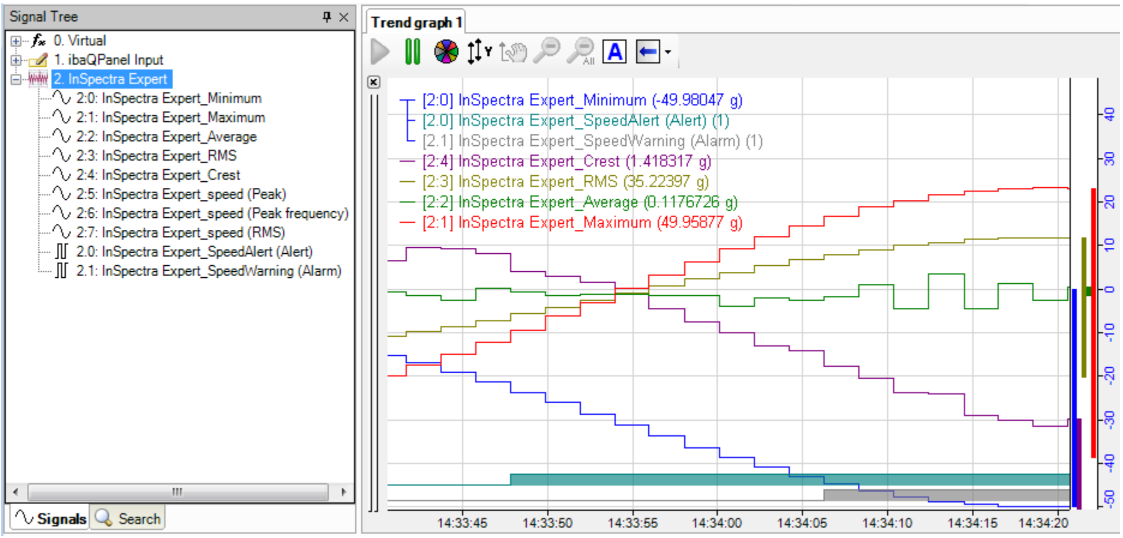


figure 17: Display of the computed values in standard trend graph

The FFT view can be used for the presentation of a complete InSpectra module with the spectra and frequency bands as well as the computed values. Open a new FFT view and drag the InSpectra module from the signal tree into the FFT view.

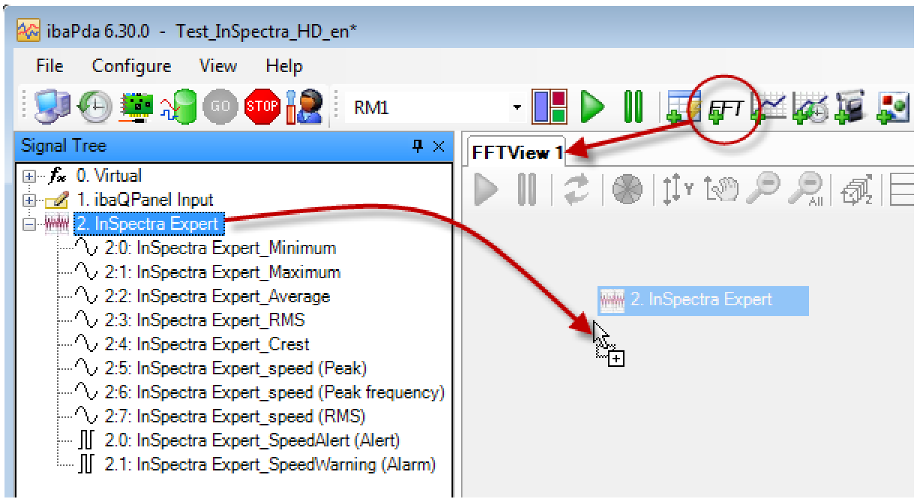


figure 18: Opening an InSpectra module in the FFT display

This view is described in detail below.

A third way for displaying current values from the InSpectra module can be found - as described in chapter "*Diagnostics* , Page 28" - in the "Diagnostics" tab of the corresponding module and there in the "Current values" sub tab while the measurement is running in the I/O manager.

6.2 Operation and display in the FFT view

Basically, the same conditions apply with regard to the display and operation of the InSpectra modules in the FFT view as for other analog signals. For the InSpectra modules, the FFT view was extended by several functions, setting options and additional windows with version 6.30.0 of ibaPDA-V6.

6.2.1 Overview of the FFT display with ibaInSpectra Expert

With one InSpectra module, drag the entire module using drag & drop from the signal tree into the FFT view. In doing so, relevant parameters for the FFT view are copied from the module settings.

If you dragged an InSpectra module into an FFT view, it looks, for example, as follows:

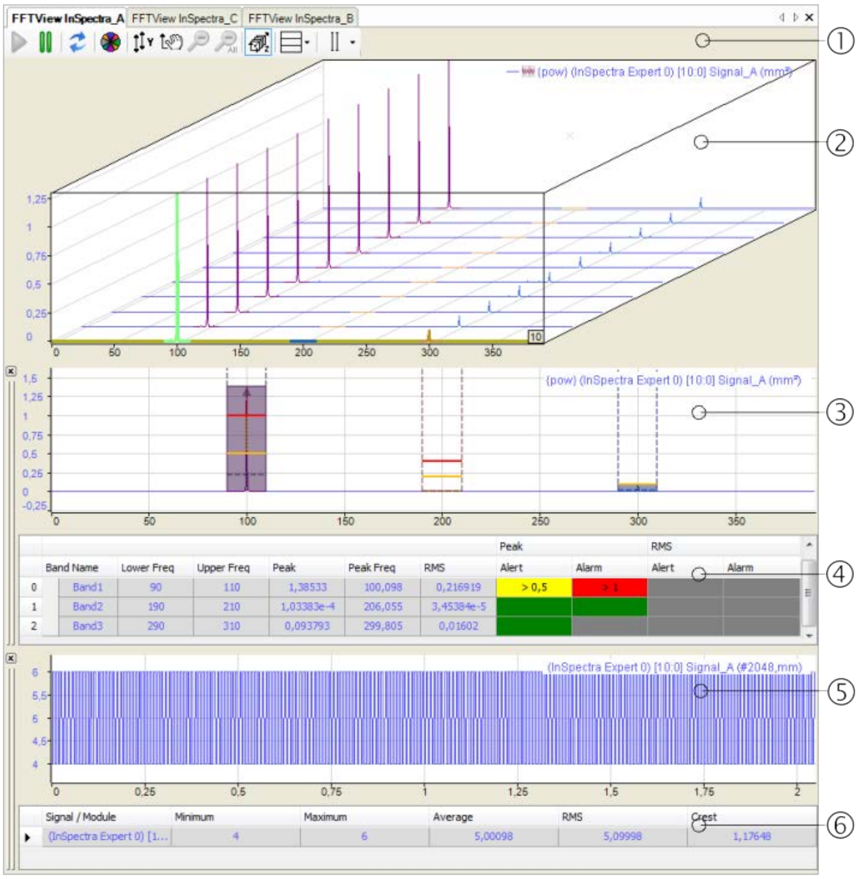


figure 19: ibaInSpectra module in the FFT view (complete)

Legend

1 Tool bar

2 Main window, spectrum of the input signal (waterfall display possible)

3 Spectrum slave graph (bands, frequency domain)

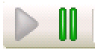
4 Spectrum slave table (data, frequency domain)

5 Time slave graph (signal, time domain)

6 Time slave table (data, time domain)

The main window is always displayed at the top. The additional windows for display and data of spectrum and time domain are grouped in pairs. In analogy to normal signal strips, their position can be changed at the header bar by using the mouse. You can display or hide the individual graphs and tables within the FFT view by means of the icon buttons as shown in the above figure.

Tool bar

	Resume / Pause FFT display Stop or continue the FFT display update
	Reset all painted data The display is cleared only once and all values are set to zero until the next FFT calculation is completed.
	Auto scale value axes
	Restore vertical manual scale **1)**
	Remove one/all zoom levels **1)**
	Toggle isometric perspective Switching on/off the isometric presentation in the FFT main window (waterfall)
	Open the sub menu for showing/hiding the windows Main window with/without waterfall (graph, frequency domain) Spectrum slave graph (bands, frequency domain) Spectrum slave table (data, frequency domain) Time slave graph (signal, time domain) Time slave table (data, time domain)
	Show/hide interactive marker No function for fixed markers

1) Individually affects the main window, spectrum or time slave graphs, depending on the focus

Table 7: Icon buttons for FFT view

6.2.2 Main window and waterfall display

When switching to the isometric perspective, the individual results of the frequency analysis are displayed spatially offset. This provides an overview of the history of the frequency response curve.

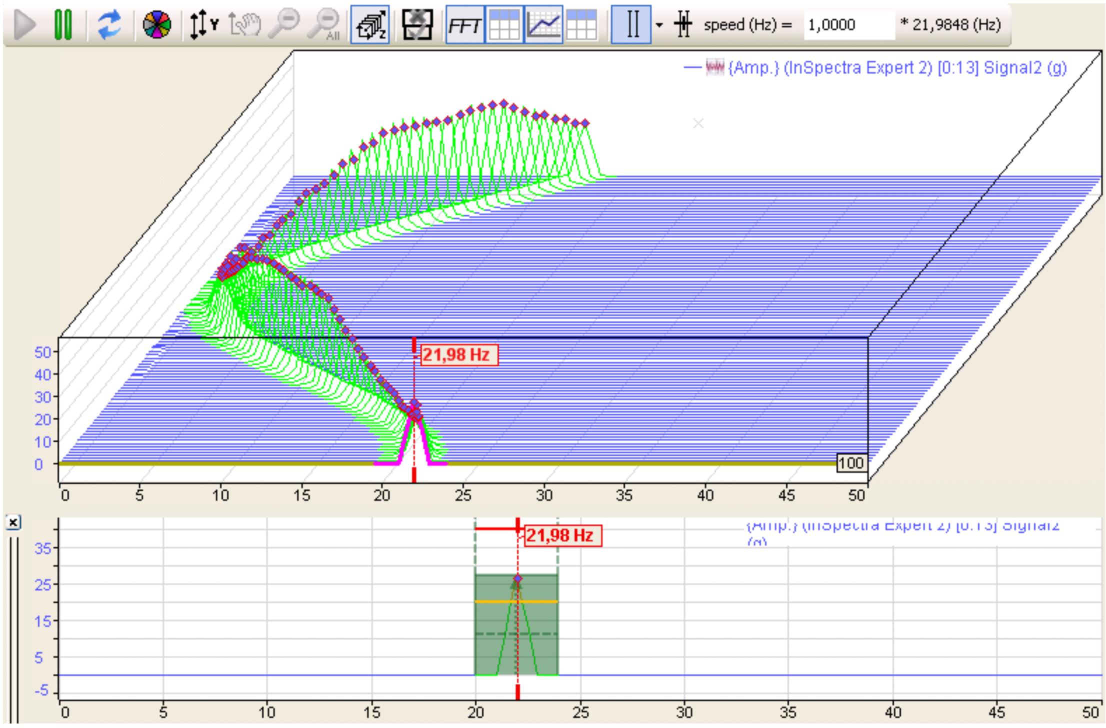


figure 20: Visualization of the signal history by means of waterfall display

In the above figure, you can see the results of the last 100 calculations and it is clearly visible how the frequency changed in the course of time.

In the properties dialog of the display, you can adjust the number of the planes, which are to be displayed one behind the other.

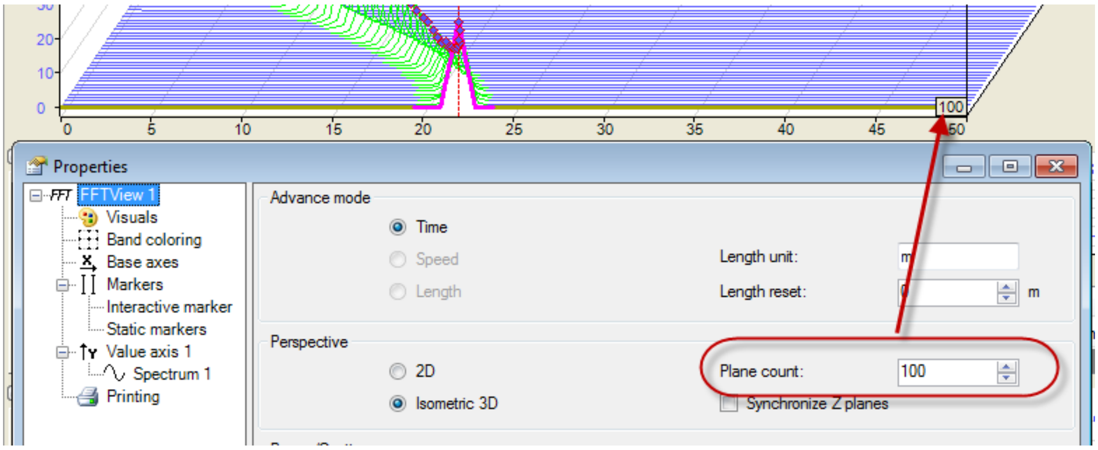


figure 21: Adjustment of the number of levels for the waterfall display

By using the <Up> and <Down> cursor keys, you can move through the planes and have displayed the related spectra and parameters.

When moving the mouse with the <Ctrl> key pressed, you can change the angle and perspective of the view.

Further information

Please refer to the ibaPDA-V6 manual or the online help for further information on the isometric display.

6.2.3 Spectra

Usually, only one spectrum, i. e. the input signal of the InSpectra module, is displayed in the main window. You can also drag further signals or ibaInSpectra modules into the main window if you want to.

If you have already defined frequency bands in the profile definition, they are marked in color in the spectrum.

You can modify the colors of the bands in the properties of the FFT view. There, you can also add further frequency bands (without alarm function). A frequency band can be assigned to either all spectra or signals in the display or to an individual spectrum.

In the properties of the FFT view, you can also define value bands and assign colors to them. The value bands refer to the amplitudes and induce a change in color with exceeding of the value band limits. All defined value bands always apply to the entire main window and all contained spectra.

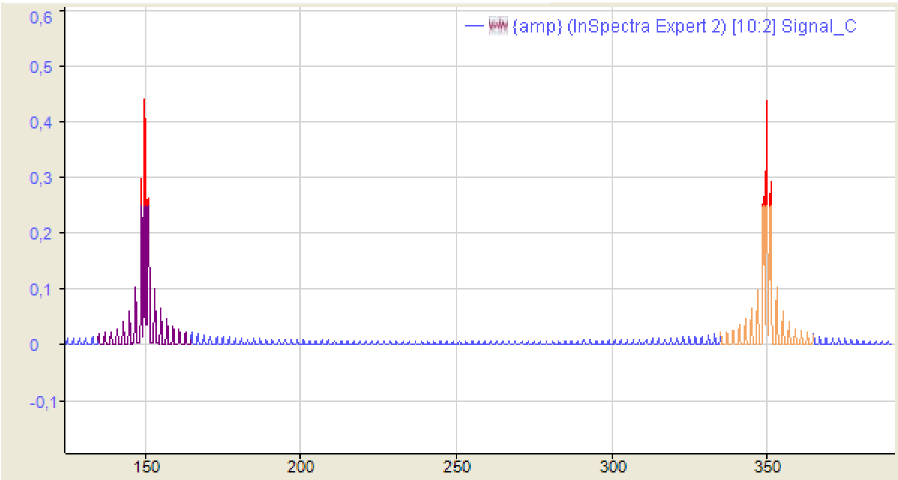


figure 22: Spectrum with 2 frequency bands (violet, yellow) and 1 value band >0.25 (red)

The following image shows the corresponding settings for the above display:

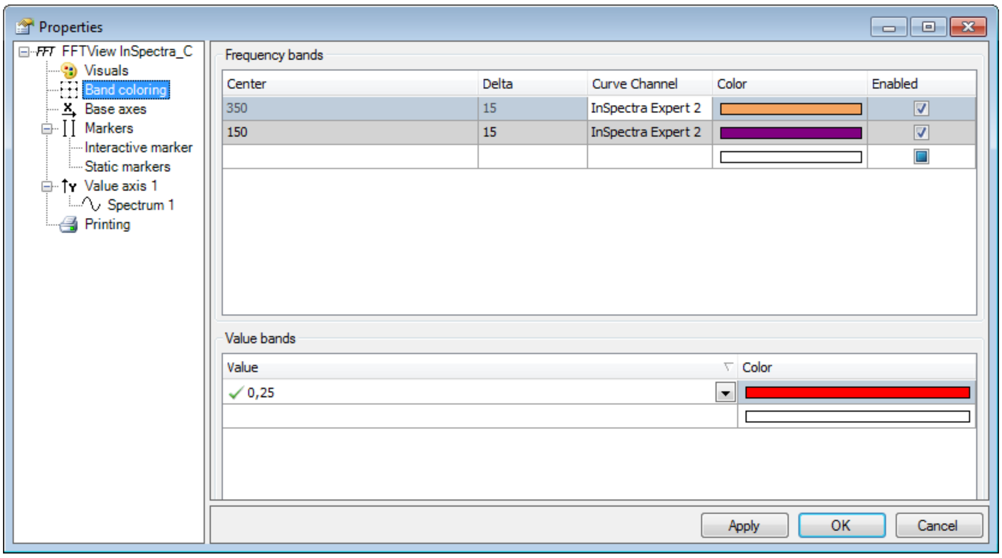
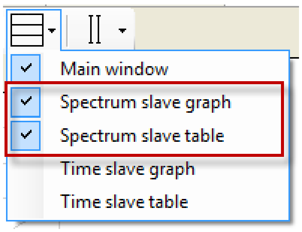


figure 23: Settings for frequency and value bands of an FFT view

6.2.4 Spectrum slave graph and table

In addition to the main window, you can open a graphical and/or tabular display of the data of the frequency spectrum. For this purpose, click on the button for the window menu in the tool bar of the FFT view.



Graphical display and data table form one group, as the table always provides the data matching the spectrum in the display. However, graph and table can be shown or hidden individually.

6.2.4.1 Spectrum slave graph

The graphical display of the frequency range always shows the last result of the FFT in two-dimensional view:

- Spectrum
- Frequency bands
- Characteristic values

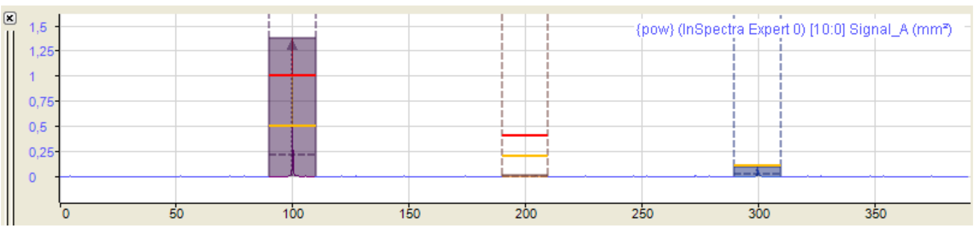


figure 24: Display of 3 different frequency bands

When zooming in, more details can be seen.

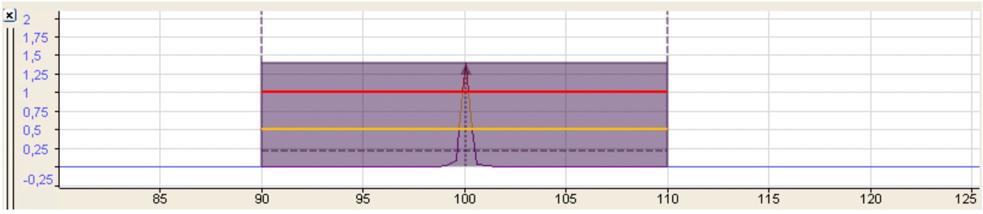
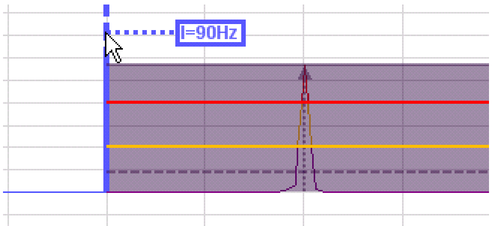
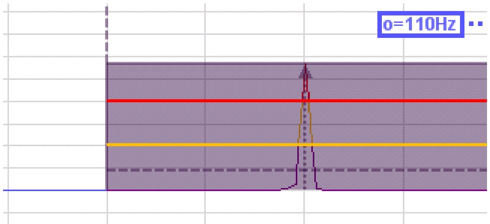


figure 25: Frequency band display

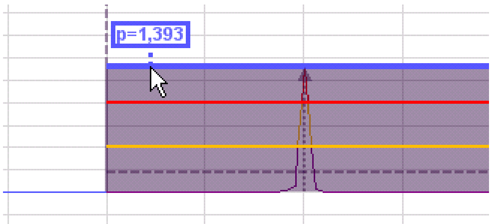
The most important parameters of the frequency band and the spectrum are displayed dashed and in colored lines for which you are displayed the values by placing the cursor on the lines (hovering).



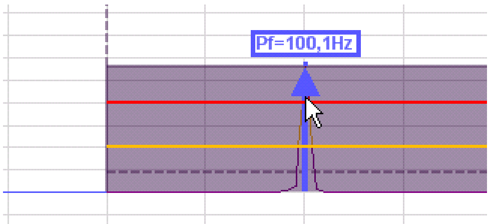
Lower cut-off frequency



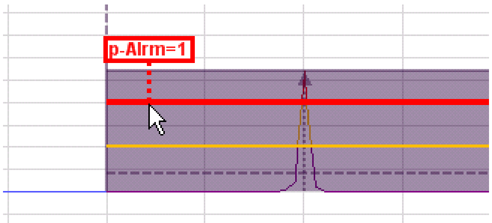
Upper cut-off frequency



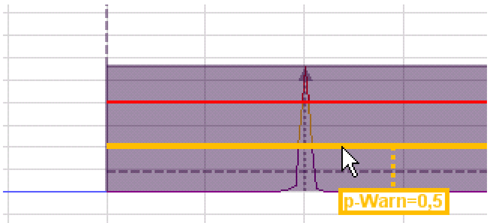
Peak (peak amplitude)



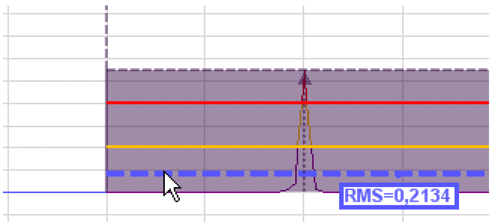
Peak frequency



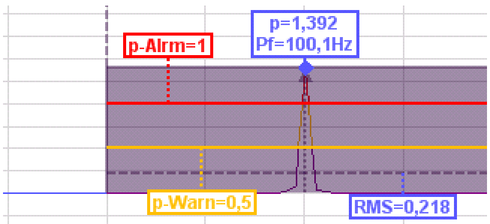
Alarm limit



Alert limit



RMS



Display of all descriptors by selection in the spectrum properties

Table 8: Information in the spectrum graph

You can decide in the spectrum properties (by using the context menu of the display) which markings and parameters are to be displayed (permanently) and whether the curve is to obtain a color change when violating the alarm limits.

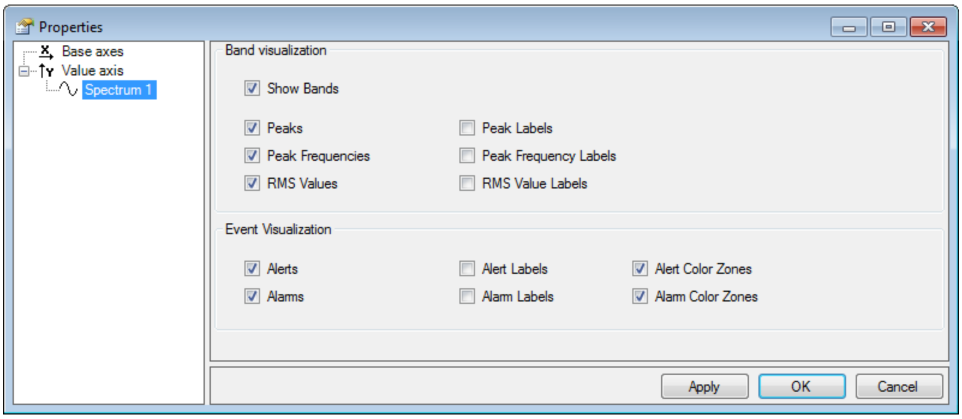


figure 26: Properties of the spectrum slave graph

Basically, the frequency spectrum of the input signal of the InSpectra module is displayed. However, you can also drag further signals from the signal tree into the display of the frequency spectrum. If there are several signals in the main window already, you can select those in the context menu of the display.

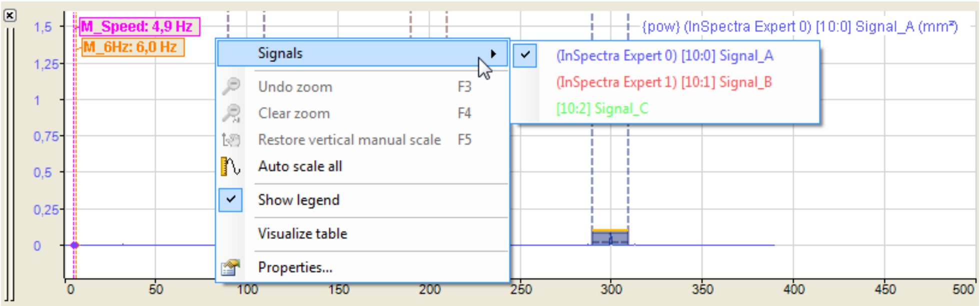


figure 27: Spectrum slave graph, context menu for adding further signals

If there are several spectra in the display, individual display properties can be assigned to every spectrum.

If the spectrum slave graph has the focus (after a mouse click on the header bar), the tool buttons for zooming out and restoring the manual scale relate to this graph and not to the main window. The same applies to the assigned function keys <F3>, <F4> and <F5>.

Basic axis

The graph has a basic axis conforming with that of the main window. You can still modify the settings of the basic axis in the display properties to, e. g., opt for a logarithmic instead of a linear division or provide for a manual scaling.

If you zoom in the spectrum slave graph or in the main window, this is usually independent of each other. By using the "Synchronize actual scale with main window" option, you can determine that a zoom action in one of the windows also affects the other, yet **only in horizontal direction**.

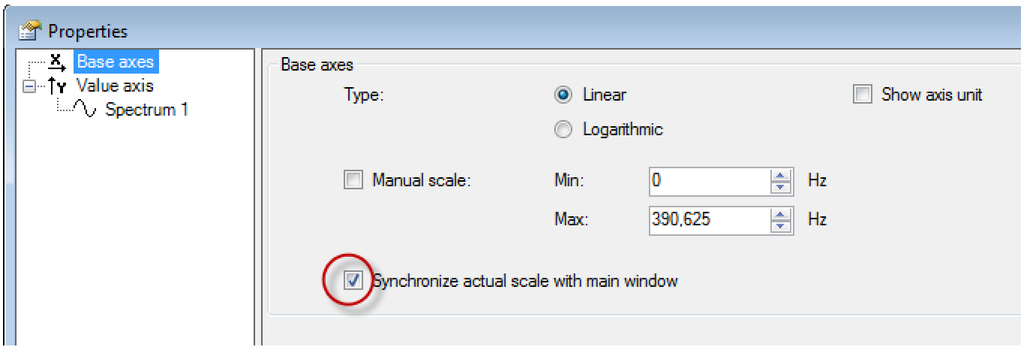


figure 28: Properties Spectrum slave graph, basic axis

Value axis

The spectrum slave graph has only one value axis. All curves in the graph are displayed on the same scale of values. You can change the settings of the value axis in the properties of the graph.

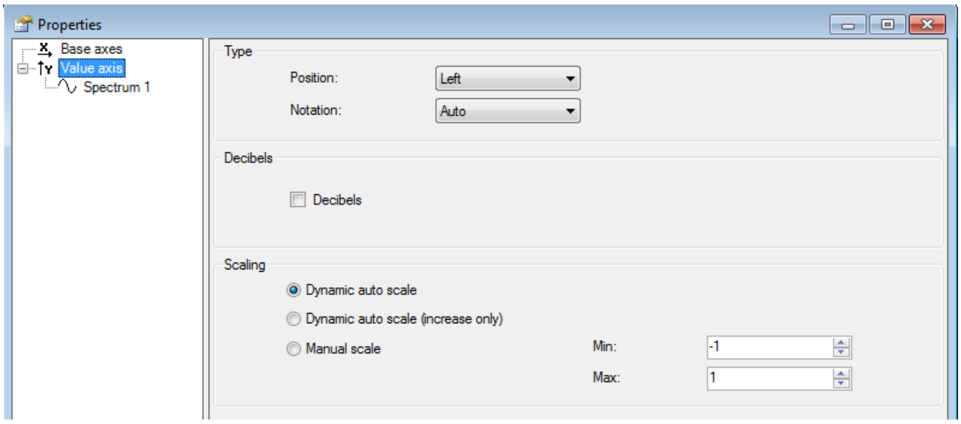


figure 29: Properties frequency spectrum display, value axis

With the "Decibel" option, you switch the scale of values to decibel.

6.2.4.2 Spectrum slave table

The data table regarding the frequency spectrum only contains data if it is an InSpectra module. In case of a simple analog signal, the table remains empty.

In the table, a line is automatically created for every defined band of the displayed InSpectra module.

							Peak		RMS	
	Band Name	Lower Freq	Upper Freq	Peak	Peak Freq	RMS	Alert	Alarm	Alert	Alarm
	InSpectra Module: (InSpectra Expert 0) [10:0] Signal_A									
0	Band1	90	110	1,37585	100,098	0,215456	> 0,5	> 1		
1	Band2	190	210	7,87383e-4	195,801	1,88428e-4				
2	Band3	290	310	0,082767	299,805	0,014147				

figure 30: Spectrum slave table

The parameters and – if configured – the events are displayed for every band, similar to the "Diagnostics" tab of the InSpectra module in the I/O manager.

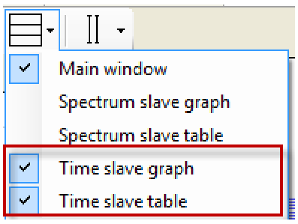
If there are several InSpectra modules in the spectrum slave graph, the table also shows the data for the bands of the other spectra.

	Band Name	Lower Freq	Upper Freq	Peak	Peak Freq	RMS	Peak Alert	Peak Alarm	RMS Alert	RMS Alarm
	InSpectra Module: (InSpectra Expert 0) [10:0] Signal_A									
0	Band1	90	110	1,39689	100,098	0,218653	> 0,5	> 1		
1	Band2	190	210	2,99266e-4	200,684	8,39312e-5				
2	Band3	290	310	0,083414	299,805	0,014649				
	InSpectra Module: (InSpectra Expert 2) [10:2] Signal_C									
0	Band1	135	165	0,439941	149,902	0,073891				
1	Band2	335	365	0,439048	350,098	0,073865				

figure 31: Example of a spectrum slave table with 2 InSpectra modules

6.2.5 Time slave graph and table

In addition to the main window, you can open a graphical and/or tabular display of the data of the input signal in the time domain. Click on the button for the window menu in the tool bar of the FFT view.



Graphical display and data table form a group, as the table always provides the data suitable for the graph in the display. However, graph and table can be individually displayed or hidden.

6.2.5.1 Time slave graph

In the time slave graph, the time curve of the input signal is graphically displayed. The displayed section contains exactly the samples of the input signal which were included in the FFT calculation.

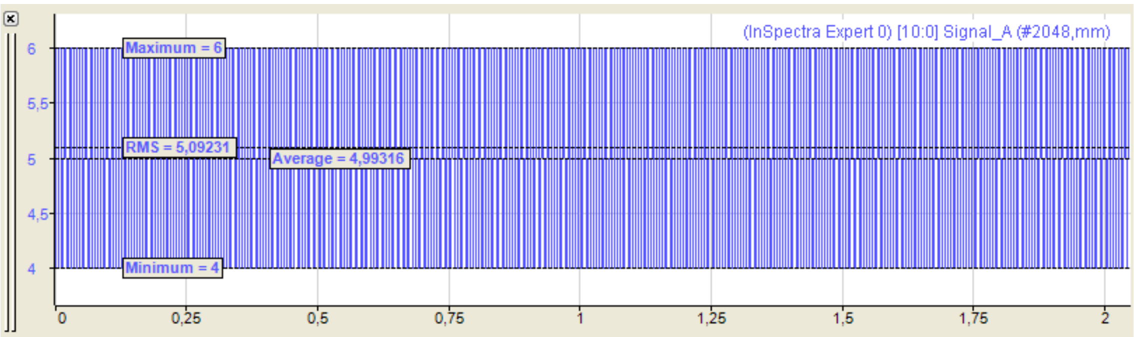


figure 32: Time slave graph

If the averaging function was enabled in the calculation settings of the profile, the display shows the time signal of the last internal FFT computation. The displays of the FFT results in the main window and frequency range, however, are also based on prior values of the input signal.

As a basic principle, the input signal of the InSpectra module is displayed. However, you can also drag further signals from the signal tree into the time slave graph. If there are several signals in the main window already, you can select those in the context menu of the graph.

If the time slave graph has the focus (after a mouse click on the header bar), the tool buttons for zooming out and restoring the manual scale relate to this graph and not to the main window. The same applies to the assigned function keys <F3>, <F4> and <F5>.

Markers

Moreover, the context menu of the display can be used to enable a marker, which can be seen both in the pause and live mode of the display.

Legend

The legend of the display contains various information:

- Name of the ibaInSpectra module
- Module number: channel number of the input signal
- Name of the input signal
- Number of samples for the FFT, unit of the input signal

Basic axis

The time slave graph has a base axis. When autoscaling, the length of the base axis results from the number of samples and the acquisition time. You can modify the settings of the base axis in the properties of the graph.

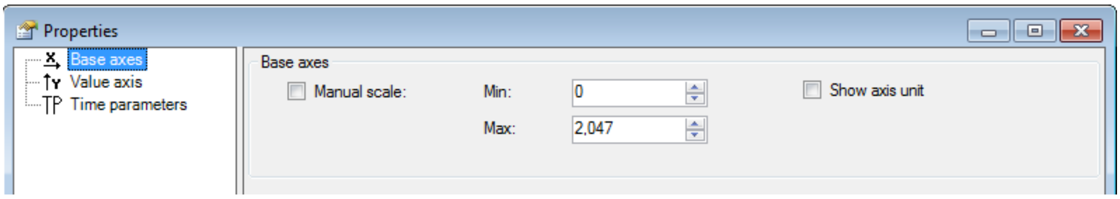


figure 33: Properties time slave graph, basic axis

Value axis

The time slave graph has only one value axis. All curves in the graph are displayed on the same scale of values. You can modify the settings of the value axis in the properties of the graph.

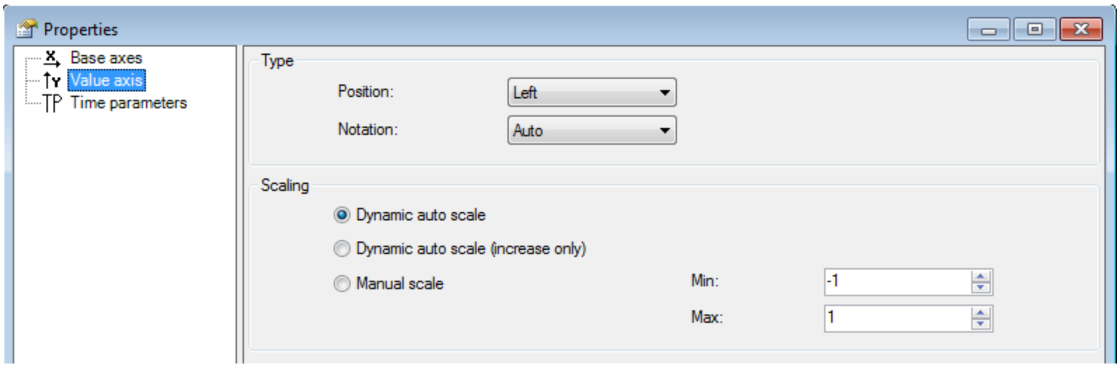


figure 34: Properties time slave graph, value axis

Time parameters

The statistical values (average, minimum, maximum, RMS, crest factor) determined for the input signal in the shown time range can be displayed in the graph. For this purpose, select the desired parameters in the properties dialog of the graph.

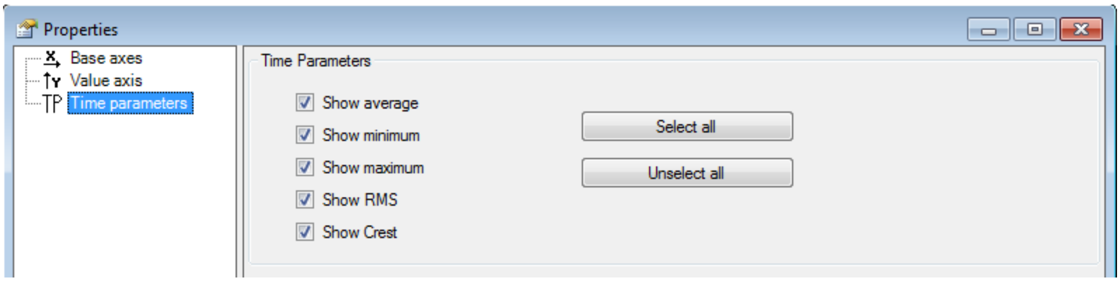


figure 35: Properties time slave graph, time parameter

Note

Sometimes, the crest factor is not immediately visible in the graph, as it can be significantly higher or lower than the values of the signal curve. Change the scale of the value axis to see the crest factor.

6.2.5.2 Time slave table

The data table of the time domain shows the same statistical values of the input signal which were described as time parameters above.

6.2.6 Markers

For better evaluating the frequency analysis, markers can be displayed in the main window and in the spectrum slave graph. The markers mark frequency values along the x-coordinate. Frequencies of interest can be, for example, a constant or variable fundamental frequency, known resonance frequencies or the harmonic components.

There are two types of markers having different functions:

- Interactive marker
  There is an interactive marker. This marker can be switched on or off and manually moved.
  In the time slave graph, only this type of marker is available.
- Static marker
  Several markers of this type can be used in a display. This marker cannot be moved manually but its position is not necessarily fixed. The marker position can be set to a constant value or controlled by a signal.

For all markers, harmonic markers and sideband markers can be additionally configured.

You can enable or disable the display of the interactive marker by clicking the button in the tool bar of the FFT view (see above). Depending on the focus, the button refers to the main window and the spectrum slave graph or to the time slave graph.

You enable or disable the display of the fixed markers solely in the properties dialog of the main window.

The intersections of the markers with the spectrum are displayed by small diamonds. The markers are configured in the properties of the FFT view (main window).

6.2.6.1 Interactive marker

The interactive marker can be shown or hidden at any time. When activating for the first time, the marker is displayed at the position 1 Hz. Every time the marker is switched off and on again, it memorizes the last position.

You can change the marker position either by clicking on the thick ends at the top or at the bottom of the marker or by using the cursor keys:

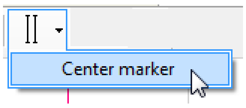
Keys	Function
<Cursor to the left>/<cursor to the right>	Normal step width
<Shift>+<cursor to the left>/<cursor to the right>	Large steps
<Ctrl>+<cursor to the left>/<cursor to the right>	Small steps

Table 9: Key operation for marker movement

Center marker

Since the marker has a certain position on the frequency axis, it is possible that it is not visible in the image anymore after zooming. Switching the marker off and on to bring it back into the image is useless, as it does not change its position because of that.

This is what the center marker function is for. With this function, you place the marker in the center of the section currently visible.



Click on the arrow symbol at the marker button in the tool bar and then on "center marker".

Configuration

For the interactive marker, you can still configure some settings.

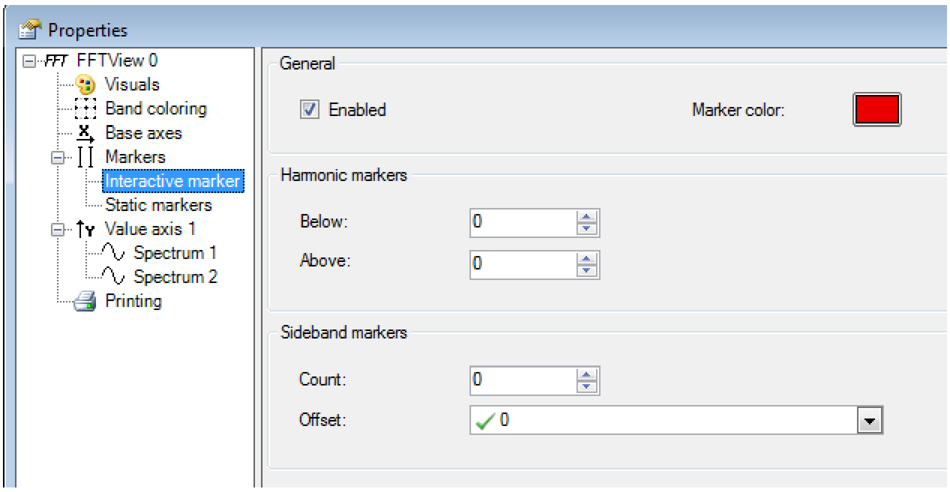


figure 36: Interactive marker properties

Besides the color, you can define harmonic and sideband markers.

For the harmonic markers, determine the requested number of the harmonic components below and above the current marker frequency. For the harmonic frequencies, further lines are displayed. Additionally, enable the "Show harmonic labels" option in the "Marker" branch to display the frequency values at the markers.

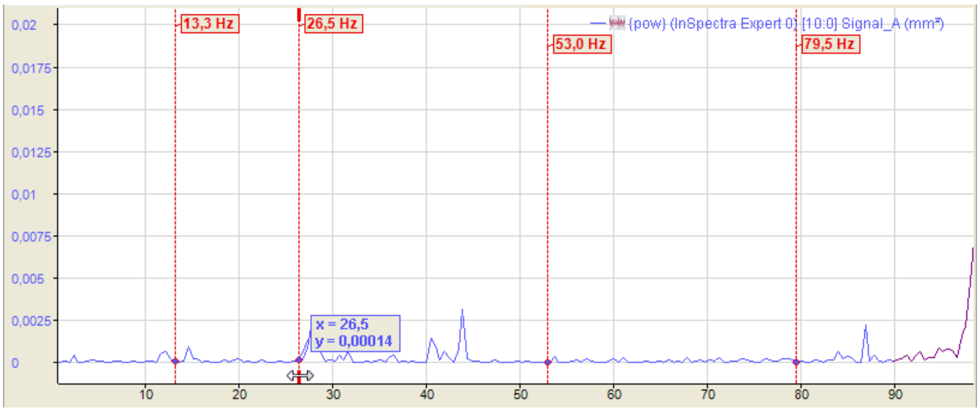


figure 37: Example of interactive markers with harmonic components

The above figure shows an interactive marker with 1 harmonic component below and 2 harmonic components above the marker frequency of 26.5 Hz.

An adjustable number of sideband markers is added symmetrically right and left of the main marker. The distance to the main marker and the neighboring sidebands is the sideband offset, represented in units of the base axis. The sideband offset can be a constant value or an analog signal.

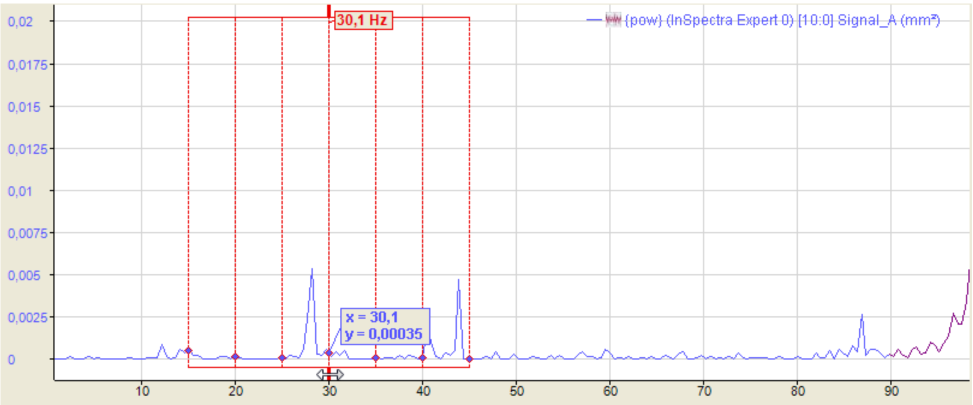


figure 38: Example of interactive markers with sidebands

The above figure shows an interactive marker with 3 sidebands and offset of 5 Hz each.

Note

If the sideband offset is specified by a signal, the value of this signal always has to be ≥0. If the value is negative, then offset = 0 and no sideband markers are displayed.

Harmonic component and sideband markers can be displayed in combination, too.

6.2.6.2 Static markers

The so called static markers have to be defined and configured first. Configure the markers in the properties dialog of the FFT view, in the "Marker" branch.

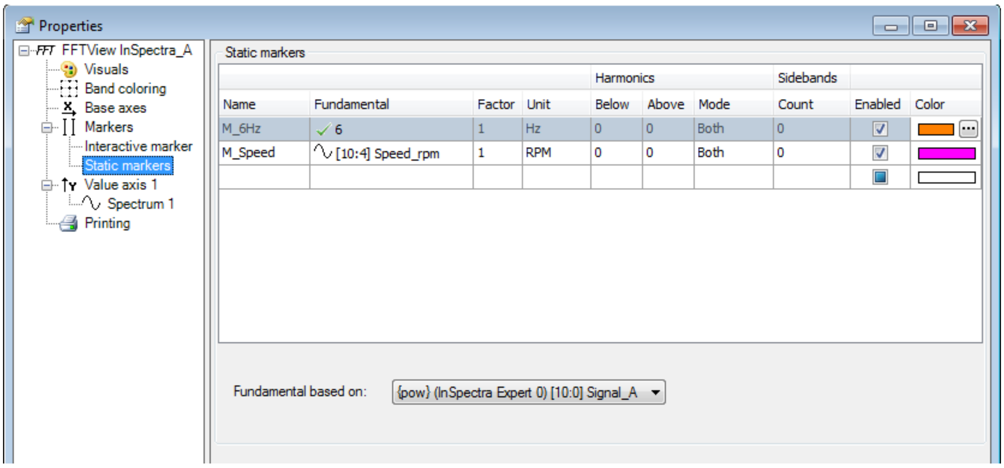


figure 39: Static marker properties

To create a marker, you simply have to enter the required information in the table line. As soon as you click in the empty space below, a new, empty line is added.

- Name

Enter a clear name to be able to easily identify the marker. The name is shown in the display later on, too.

The entries for fundamental frequency, factor and unit determine the position of the marker on the base axis. The marker position is calculated by multiplying these three parameters.

- Fundamental frequency

For the fundamental frequency, you can enter a static value or select a signal. For selecting a signal, click in the table line and then on the arrow symbol. Select the signal from the signal tree.

If you want to use a signal for controlling the marker position, select a signal complying with the frequency you want to monitor.

In the example of the above image, we have selected a velocity, more precisely the speed of a drive in rpm, to control the marker. In doing so, frequencies of interest can be easily tracked, e. g. during the acceleration and braking phase of a machine. In particular, this can be easily seen in the 3D perspective of the main window.

Note

If the signal for the fundamental frequency is negative, the marker is not displayed.

❑ Factor

The default value of the factor is 1. You can enter another factor if, for example, the marker is to be positioned at a multiple or a fractional part of the fundamental frequency.

❑ Unit

As to the unit, you can choose between Hertz (Hz) and revolutions per minute (rpm). Depending on the settings, another, internal factor is taken into consideration:

- Hz: Factor = 1
- rpm: Factor = 1/60

❑ Harmonics

As with the interactive marker, you can individually determine the number of harmonic markers above or below the marker frequency for every static marker. Additionally, this mode allows you to select whether only the even or odd harmonic components are taken into consideration or both types.

❑ Sidebands

As with the interactive marker, you can individually determine the number of sideband markers and the sideband offset for every static marker.

Note

If the sideband offset is specified by a signal, the value of this signal always has to be ≥0. If the value is negative, then offset = 0 and no sideband markers are displayed.

❑ Enabled

This option decides whether a static marker is displayed or not. This is the only possibility of enabling or disabling static markers for the display. The marker button in the tool bar of the FFT view does not control the static markers!

❑ Color

Here, you can assign an individual color to every static marker.

"Fundamental based on" option

This setting is only relevant if several curves are contained in the main window and frequency spectrum display.

The position of a fixed marker is calculated as mean value of the values of the fundamental frequency within the time of an FFT calculation, multiplied with factor and unit factor. In the isometric 3D display, a mean value, i. e. a marker position, is calculated for every FFT calculation, that is per plane. However, if several curves (signals) are contained in the display, every plane contains the results of several FFT calculations performed at more or less different times.

By means of this option, you can determine which FFT is to be used for calculating the mean value of the fundamental frequency and therefore for determining the position.

Select the requested input signal via the button.

7 Glossary

Crest factor

The crest factor describes the ratio between amplitude maximum and root means square (RMS) of a signal.

$$k_s = \frac{|X|_{\max}}{X_{eff}}$$

FFT

Abbreviation for Fast Fourier Transformation.
Simplified algorithm for an efficient calculation of the values of a discrete Fourier Transformation.
Used during frequency analysis to determine the different frequency components in a measured signal.

Leakage Effect

Due to the time limit of the input signal (limited number of samples) for each FFT calculation, the input signal is practically cut off. A signal can only be transformed correctly with the FFT if it is periodically continuable. Otherwise, it will contain frequencies, which do not belong to the frequencies calculated by the FFT. The FFT approximates these frequencies by the neighboring frequencies and thereby distributes the energy to these frequencies. This is also called leakage effect. The window functions are used to reduce the leakage effect.

RMS method Dominant Peak

The result is determined by the peak value of the amplitude spectrum divided by the square root of 2. Applies to sinusoidal parameters.

$$RMS = \frac{\hat{X}}{\sqrt{2}} = \hat{X} * 0{,}707$$

This method is typically used in the mechanical machine analysis. This method is particularly suitable if the frequency band to be measured is not very wide.

RMS method Mathematical

$$RMS = \sqrt{\frac{1}{n}\sum_{i=1}^{n} {x_i}^2}$$

In practice of the mechanical vibration analysis, this method is rarely used.
A change of the spectrum method or window type (provided that it is the same band definition and input signal) also causes a change of the RMS value.

RMS method Vibration Overall

This method calculates an RMS which approximately complies with the RMS of the input signal after it had been filtered by an ideal filter in accordance with the band frequencies (lower cut-off frequency to upper cut-off frequency). Preconditions are as follows:
- Multiplication factor = 1
- No integration or differentiation
- Detrending = False

A change of the spectrum method or window type (provided that it is the same band definition and input signal) usually does not cause a change of the RMS value. However, there could be minor deviations due to the approximation. If the multiplication factor is not equal to 1, the RMS is scaled accordingly.
This method is rather used in case of wide frequency bands.

Window

Mathematical filters for reducing the leakage effect during FFT. According to the window type, there is a different weighting of the sample values within a section (window).

8 Support and contact

Support

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Note

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