ORDER ANALYSIS

DEWESoft®

SOLUTION USER MANUAL

ORDER TRACKING ANALYSIS V23-1

1. Table of contents

2. About this document

This is the users manual for the Order Tracking math module.

2.1. Legend

The following symbols and formats will be used throughout the document.

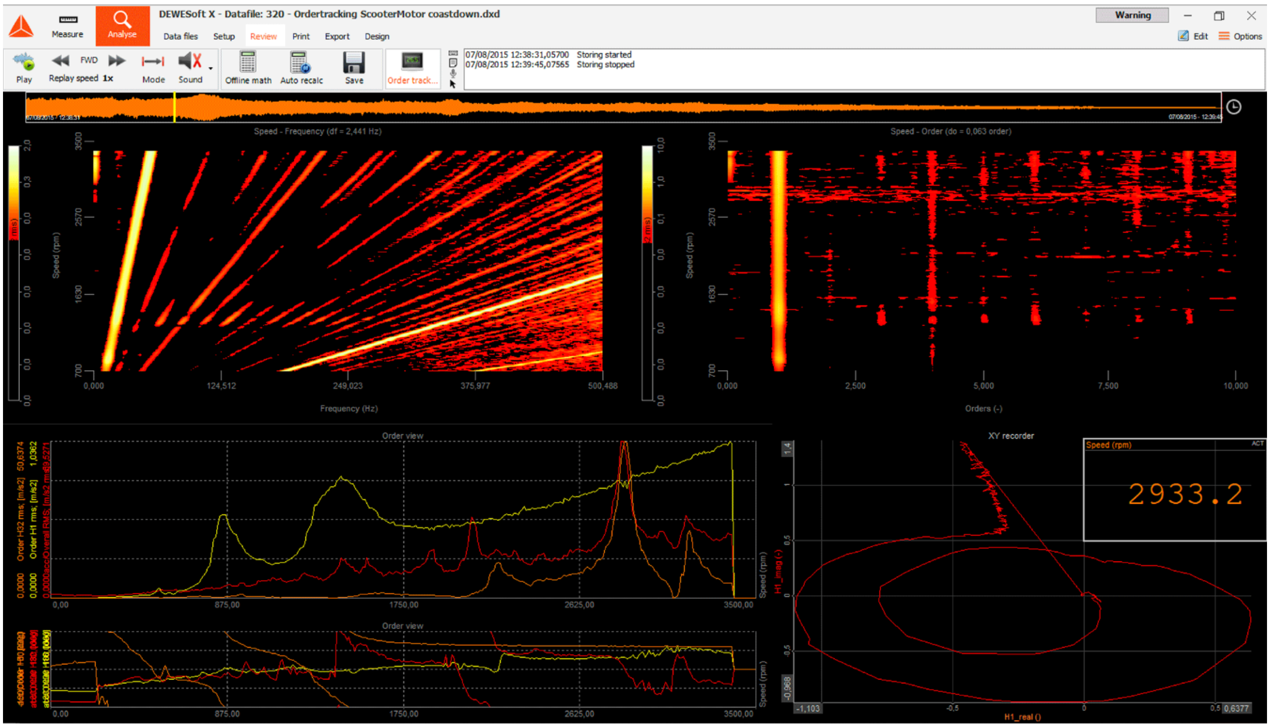
Important
It gives you important information about the subject.
Please read carefully!

Hint
It gives you a hint or provides additional information about a subject.

Example
Gives you an example of a specific subject.

3. Introduction

Order tracking analysis is a perfect tool for determining the operating condition of rotating machines (resonances, stable operation points, determining a cause of vibrations). It is extremely powerful in combination with other math modules like torsional analysis, combustion or power analysis. Order analysis is a true electrocardiogram for rotating machinery.



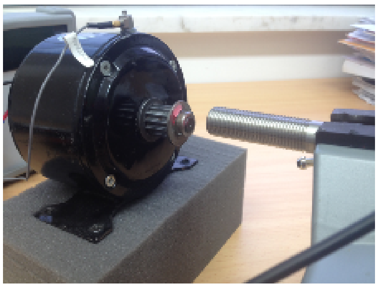
OrderTracking Display in DewesoftX®

For additional information about order analysis please also have a look at the online Order Analysis Ultimate Guide article.

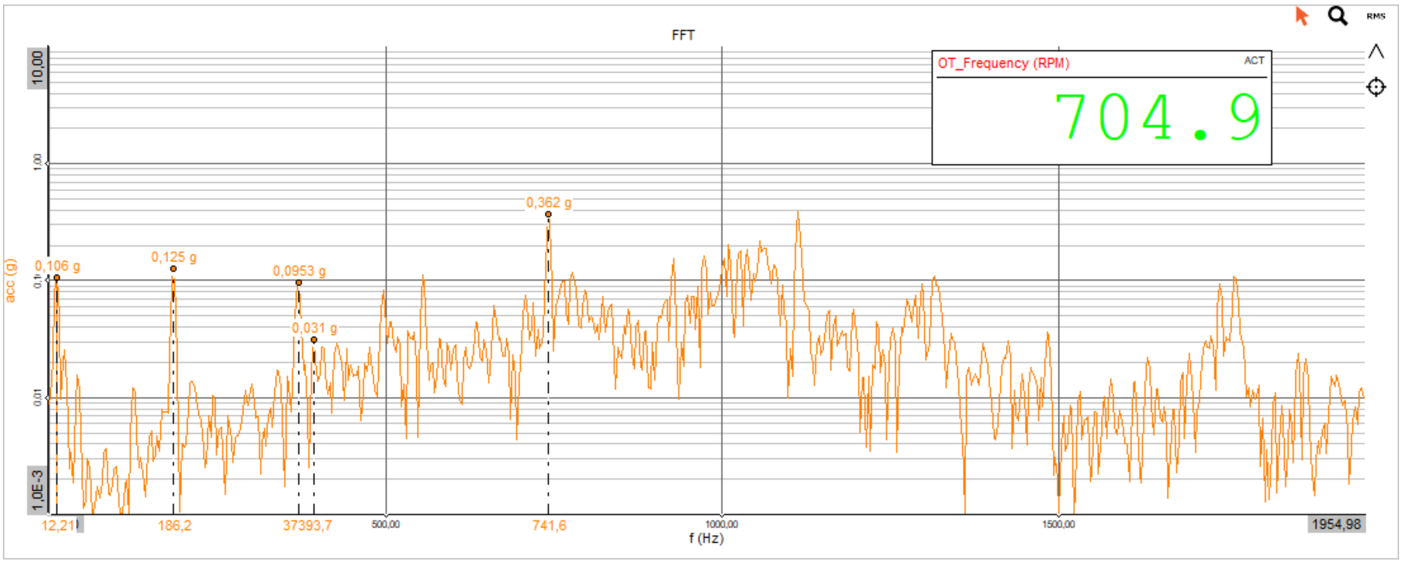
3.1. Basic theory

Before we start explaining all the different options of the setup, let's check at first why we need the Order tracking module inside DewesoftX® at all.

An electrical scooter motor standing on foamed rubber is analyzed. The rpm is controlled by DC voltage and measured by an optical probe (reflective sticker on shaft), the vibration by an acceleration sensor mounted on top.



3.1.1. FFT spectrum at 700 RPM

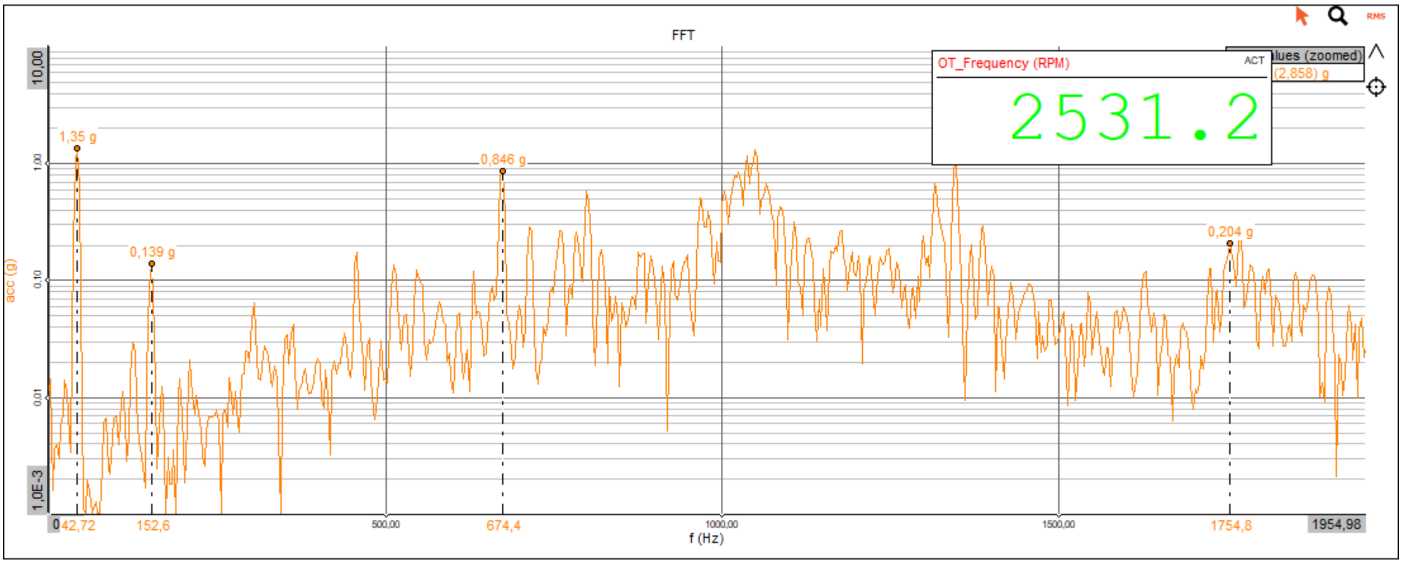


In the first example the engine is running at a constant speed of 700 rpm.

When we look at the vibration spectrum, the lowest frequency with the highest peak is 12,2 Hz, which is most likely the first order. The next peak could be the 16th order.

When we increase the rpm now, the distance between some of the spectral lines gets bigger. We call the lines moving with rpm harmonics. They can be calculated by multiplying the base frequency with an integer number.

3.1.2. FFT spectrum at 2530 RPM



Then we run the engine at a constant speed of 2530 rpm.

The first order is again the lowest frequency peak 42,7 Hz. Around 670 Hz is most probably the 16th order. The 1754 Hz more or less stays the same and doesn't seem to be related to rpm (compared with 800 rpm measurement).

So, the spectrum consists of harmonics of the rotation speed and other frequencies.

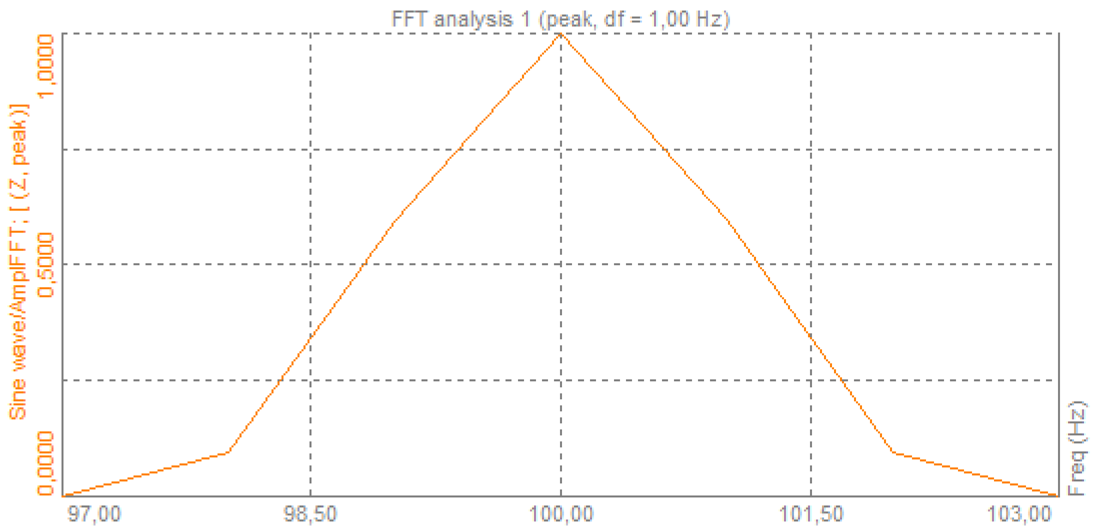
3.1.3. FFT spectrum during runup/coastdown

Of course it would take too much time to make an FFT for each RPM, so we can try to use the FFT during engine runup or coastdown.

During a fast runup or coastdown it can happen that the FFT spectrum does not have sharp lines anymore. The reason is that the rpm is changing, while the FFT still needs time for calculating. This effect is called “smearing”.

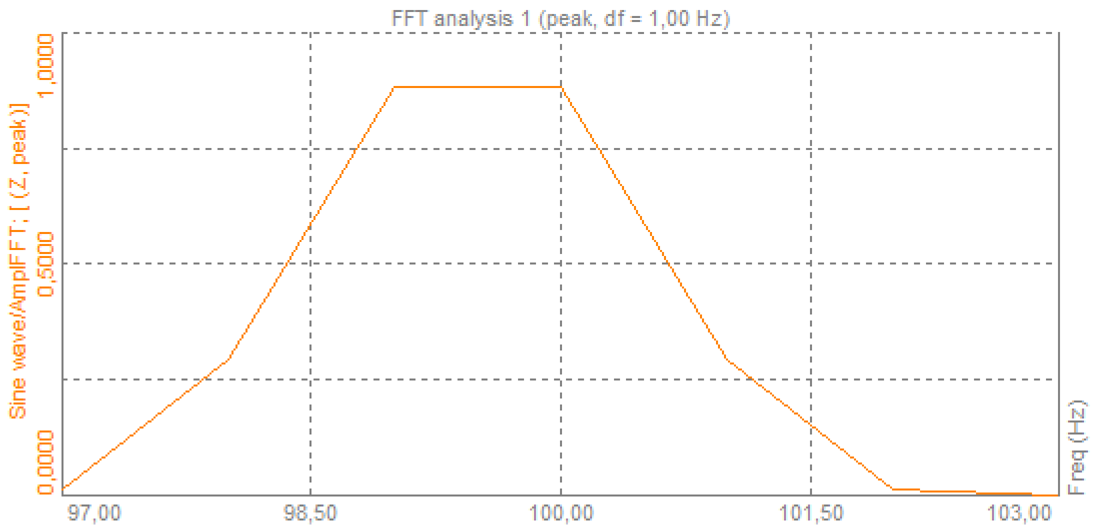
Furthermore, from its nature, FFT always has a frequency and amplitude error.

To demonstrate, we generate a simple 100 Hz sine wave using Dewesoft's mathematics (sine(100)). When we use a sampling frequency of 2048 Hz and an FFT with 1024 points we get (because of Nyquist criteria) a line resolution of exactly 1 Hz. Amplitude and frequency in the FFT are correct.



FFT spectrum at 100 Hz

Now we change the sine wave to 99.5 Hz. The energy of the peak is now distributed to both neighboring lines at 99 and 100 Hz, therefore the amplitude is also not exact any more.



FFT spectrum at 99.5 Hz

In real life it is very unlikely that the input signal will be at a constant frequency directly at the FFT line. Different windowing algorithms are designed for each application ("flat top" for example shows the correct amplitude).

3.1.4. Conclusion

Manual order tracking would mean setting up each constant rpm sequentially, e.g. 600, 700, 800 ... then manually extracting the peaks from the FFT, and sorting them out to find the orders. This is quite a task, and you cannot be absolutely sure you catch the right peaks (some frequency lines are not related to rpm and you can mix them up).

Using FFT during runup / coastdown would result in imprecise measurement because of smearing and other FFT disadvantages.

With the Order Tracking module of DewesoftX® the order analysis is very easy to set up and easy to use, let's take a look at the different analysis options available.

3.2. Order tracking module

The Dewesoft's Order Tracking module is used for e.g. vibration analysis on engines or other rotating machinery, both in development and optimization. With the small, handy form factor of the Dewesoft instruments (DEWE-43, SIRIUSi) it is also a smart portable solution for service engineers coping with failure detection.

The Order Tracking module is included in the DSA package (along with other modules like Torsional vibration, Frequency response function, ...).

How does it work? - Usually a runup or coastdown of the engine is done. The measured vibration sensor data is calculated according to the angle sensor data, split up into orders, which can then be analyzed across the whole rpm range. With order tracking the frequencies can be separated into those related to the RPM, and spurious ones. The powerful visualization and mathematical options lead to a clear picture of the situation.

Furthermore calculations can also be done offline (after the measurement), like with most other modules, e.g. if a very high sampling rate is required or the CPU of the used computer simply is too weak.

If the powerful integrated post processing features of DewesoftX® are not enough, you can even export the data to several different file formats.

3.3. System overview

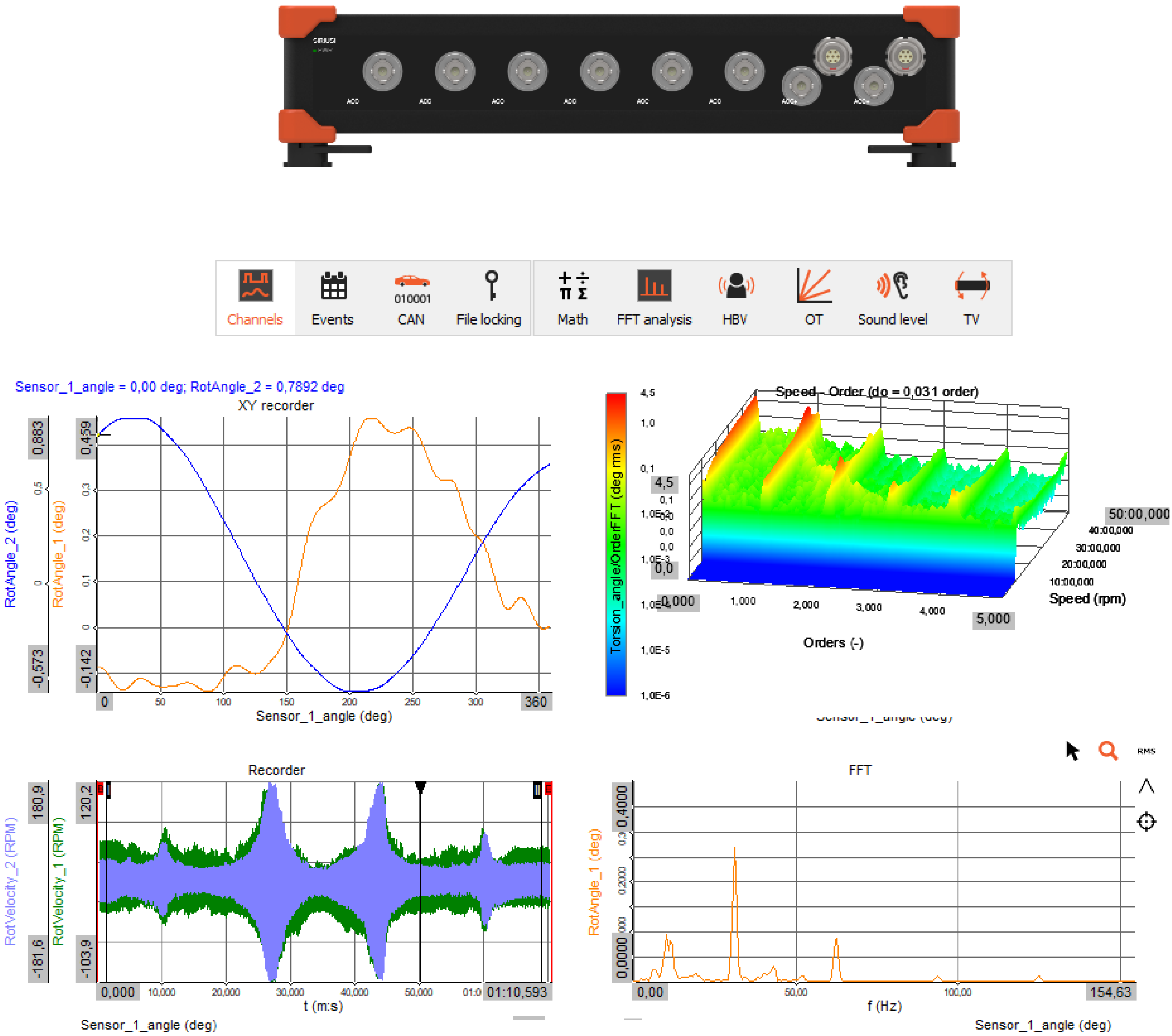
Depending on what to analyze, e.g. acceleration sensors, microphones or pressure sensors are used on the analog input to measure sound/vibration. If they are e.g. voltage or ICP type, they are connected to the SIRIUS ACC amplifier, or DEWE-43 with MSI-ACC adapter.

For the angle sensor you have various possibilities: you can use either an Encoder with individual pulse count, CDM-360/-720 or a simple tacho probe with 1 pulse / revolution (TTL or analog output), or 60-2, 36-2 tooth wheel sensor. If the RPM is changing slowly and the phase information is not of interest, the RPM can also be derived from any kind of signal (e.g. 0...20mA, which equals 0...6000 rpm) or data channel, e.g. the CAN bus of a car.

System overview

3.4. Basic operating concept

The Order Tracking module inside DewesoftX® is just one out of several other application modules which offers dedicated mathematics and visual controls like angle based XY-diagram.



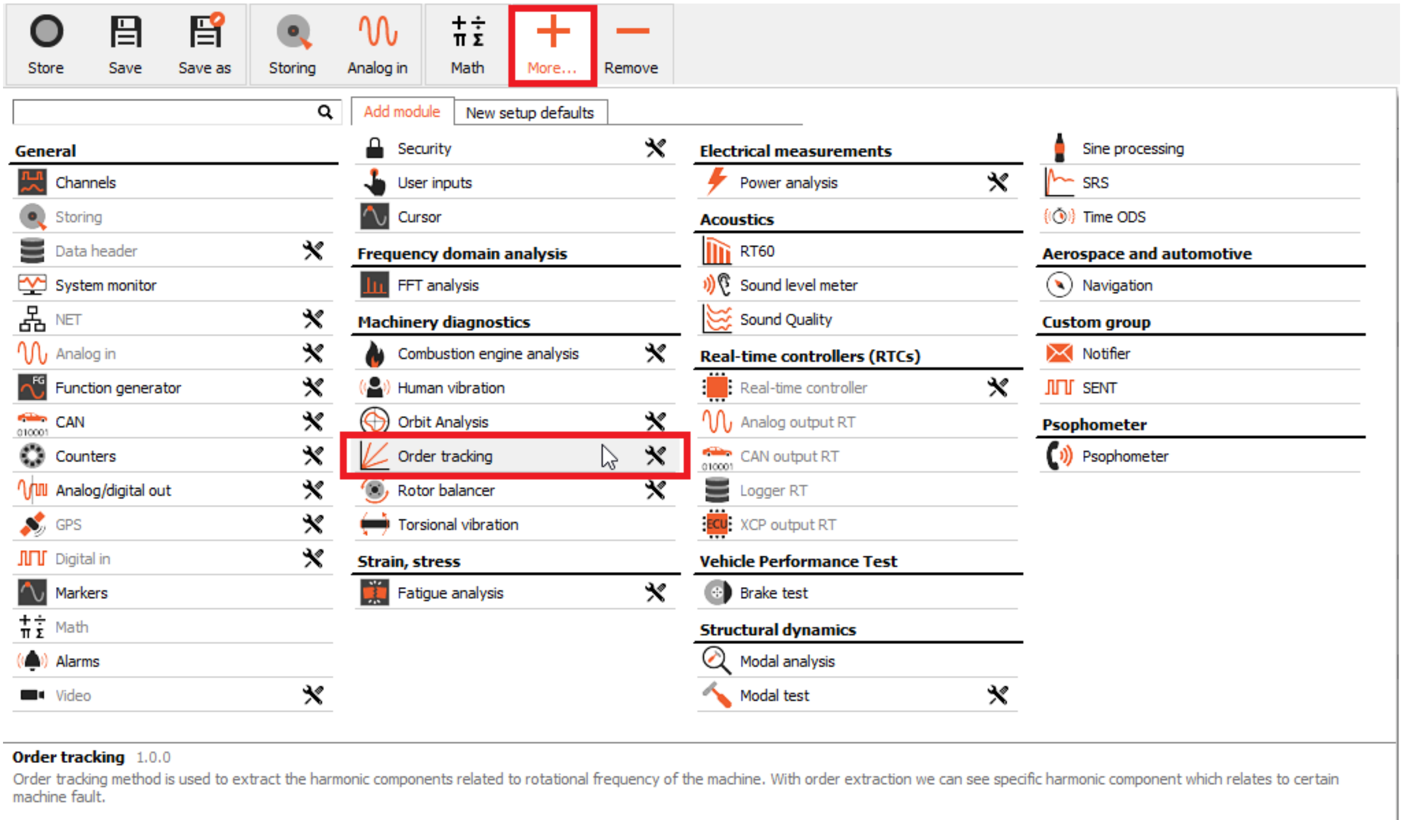
Basic operating concept - input channels, application mathematics and visualization

Hint

You can use the output of the Torsional vibration module as an input for the Order Tracking module, and then apply additional mathematics on it.

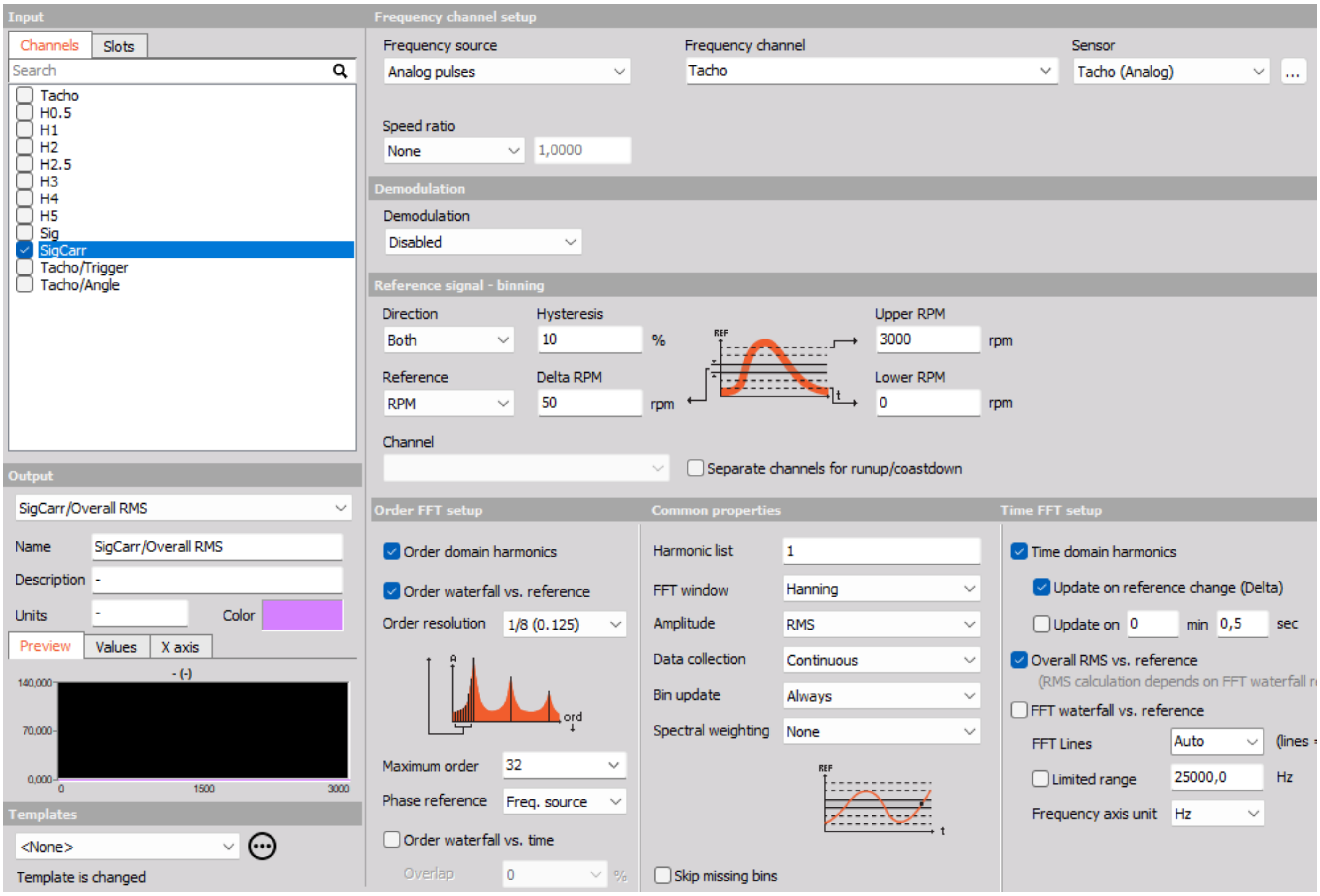
3.4. General setup

In the first step we add the OT module:



Adding Order tracking module

The input mask of the order tracking module is split into following sections:



Order tracking setup

- **Input** channels define the input channels to perform the analysis on (e.g. acceleration sensor)
- **Output** channels: switch the output channels with arrow buttons and see preview values
- **Frequency channel setup** defines the type of angle sensor (e.g. Enc-512, Tacho)
- **Demodulation** can be set to demodulate signals like Pulse Width Modulated (PWM) signals.
- **Reference signal - binning** sets the reference quantity range limits, RPM limits, delta REF (bin width) and Direction to runup/coastdown/both/First direction
- **Order FFT setup** specifies maximum orders and the resolution (e.g. 1/16th order), order FFT vs. time, order FFT vs. reference and order domain harmonics
- **Common properties** define the Harmonic list, FFT window, output Amplitude scaling, Data collection method, Bin update type, and possible spectral weightings.
- **Time FFT setup** defines the change calculation method from resampled data to FFT, time domain harmonics and update rate on REF change

4. Setup

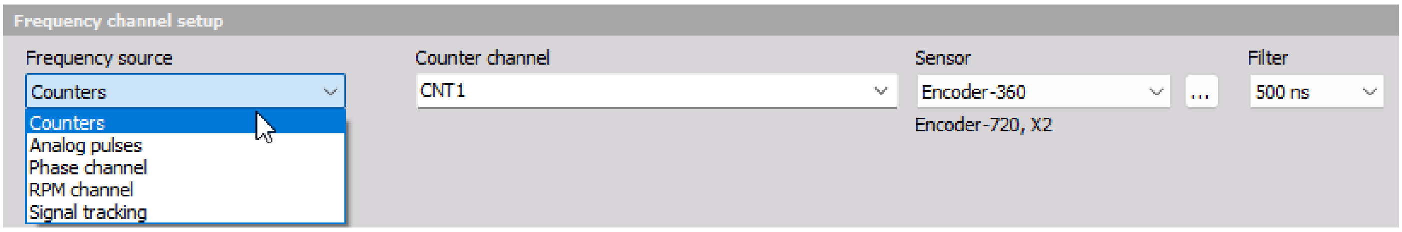
4.1. Analog input signal to analyze

In most of the cases, the analysis will be done with a vibration sensor. Just enable the desired channel in the list on the left upper side of the module setup. Basically, any analog input can be used, here are some examples:

- acceleration sensor
- microphone
- pressure sensor
- output of the rotational vibration / torsional vibration module

4.2. Frequency channel setup

For determining the engine speed (rpm), an RPM sensor is needed. A lot of different sensors are supported:



Frequency channel setup

- Tacho probe (1 pulse/revolution; connect to analog or digital input)
- 36-2 or 60-2 sensor (connect to an analog input)
- Encoder (e.g. 1800 pulses/revolution or CDM-360 / CDM-720 or 60-2; connect to Counter input)
- any RPM channel (e.g. analog voltage or RPM from CAN bus; but then the absolute phase of the harmonics relative to the zero-angle cannot be extracted, because there is no angle information (only speed). Instead the phase information will be relative to the first order phase component.
- A dedicated phase channel can also be used which will provide the absolute phase and zero angle.
- No frequency channel - by using Signal tracking based on one of the measured analog channels.

4.2.1. Counters

Select “Counters” if you connect an Encoder to the Dewesoft instrument Counter input (usually 7 pin Lemo connector).

An encoder (e.g. 1800 pulses/revolution) or CDM (CDM-360, CDM-720) or Tacho (digital = TTL levels) or tooth wheel sensor (60-2) can be used. The counter setup in the background is then controlled (locked) by the Order tracking module, the counters will not be accessible (grayed out), to prevent double-usage.

In Counter mode, you can optionally set the filter, to suppress glitches/spikes shorter than the shown value (100ns...5µs). The optimal setting is derived from following equation:

$$InputFilter[s] \leq \frac{1}{10 \frac{RPM_{max}}{60} PulsesPerRev}$$

RPM .... max revolutions per minute $[min^{-1}]$
$PulsesPerRev$... pulses per revolution of encoder

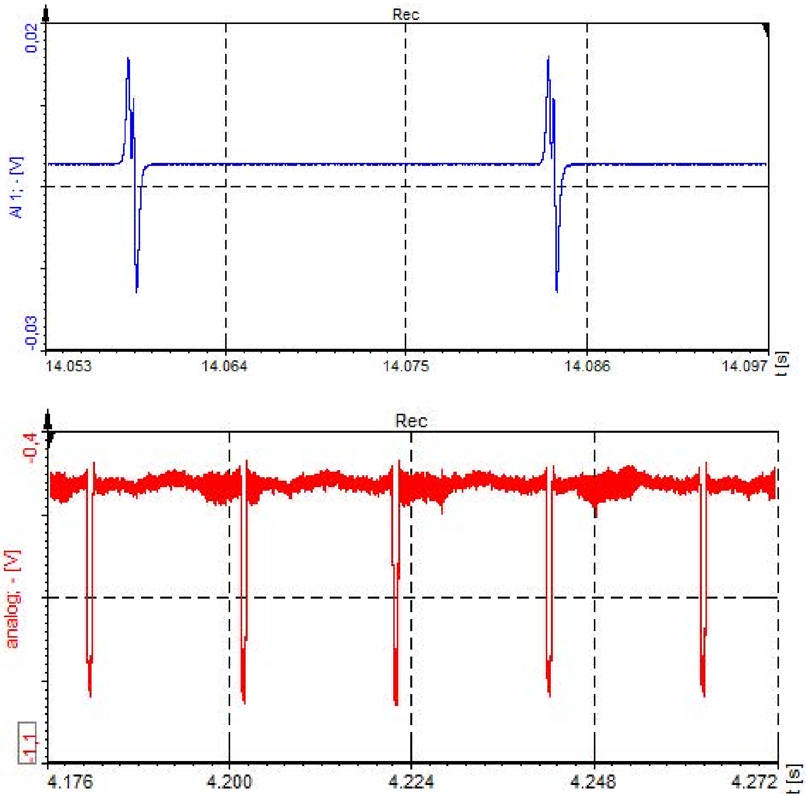
The biggest error is caused by improper mounting of an encoder. There are different mounting errors using a coupling, such as parallel, skewed, angled. The error will appear as periodic angle/frequency deviation during constant engine speed.

The easiest way is using a tacho probe with digital output. It can be directly connected to the Dewesoft instrument's counter input and is easy to mount. For example, the optical tacho probe only requires a reflective sticker on the rotating part.

4.2.2. Analog pulses

If you have a tacho probe (1 pulse/rev, optic, magnetic or any other type) with analog output signal, you can just connect it to an analog input (e.g. SIRIUS-ACC module) and use the “analog” setting of the frequency section.

Below, example signals of a magnetic and an optic probe are shown.



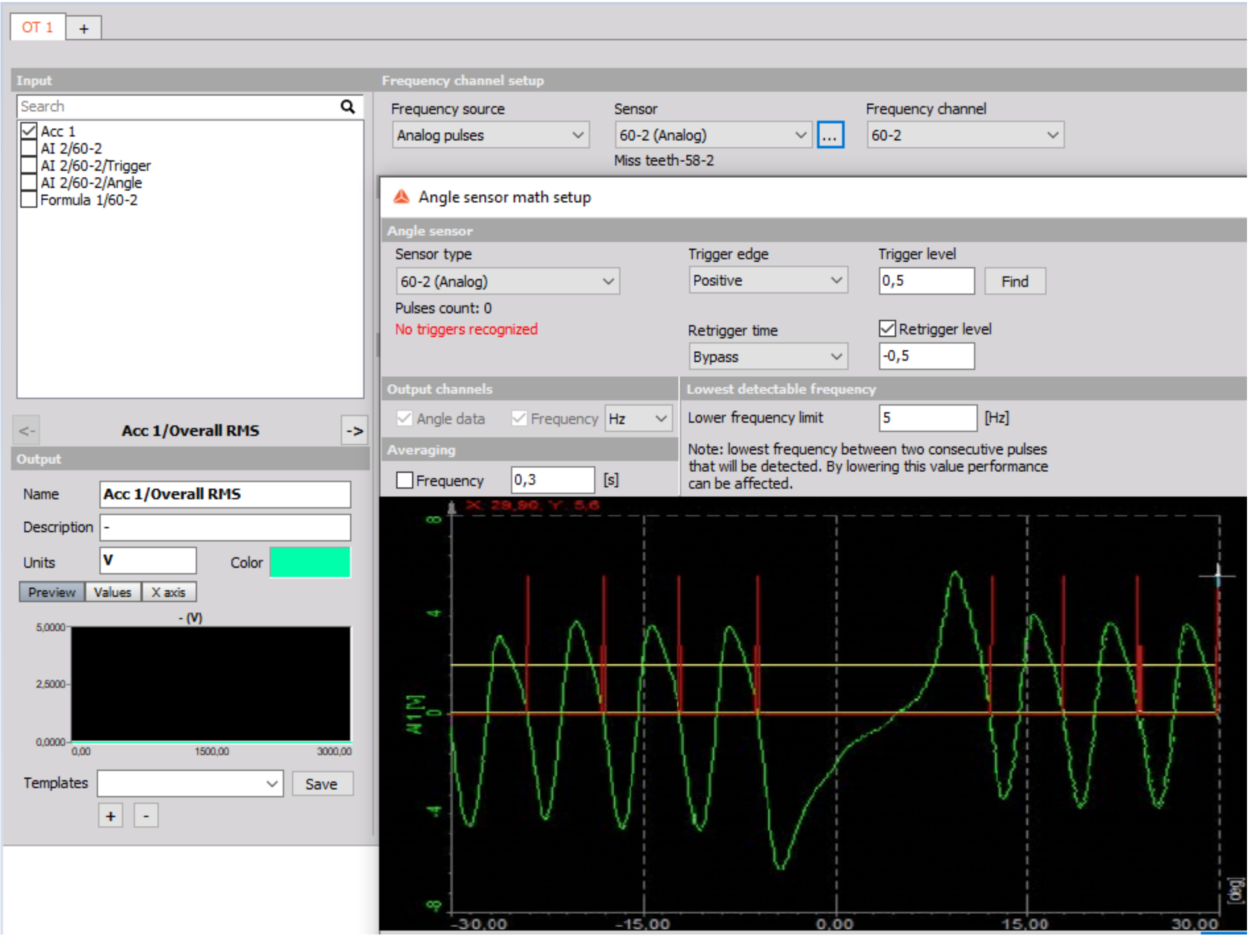
Signals of a magnetic and optic probe

Beyond that, also 60-2 and 36-2 analog signals from the crank sensor (inside nearly every vehicle) are supported.

Click the “...” button to adjust the correct trigger level. You can also use the “Find” algorithm, which will automatically determine the best possible value. Please take care when using a magnetic probe, that also the induced voltage will change depending on the RPM, resulting in a different trigger level.

Therefore perform some test runs across the interesting RPM range to find the best trigger level.

Below, an example of a 60-2 analog sensor is shown.



Analog sensor math setup

Hint

If machines with high rpm dynamic, or with a high rotational vibration are analysed (big rpm deviations during one revolution), and also high orders should be extracted, an encoder or a tacho probe with more than one pulse/rev. (180p/rev or higher) is recommended, to get higher accuracy.

Reason: The order tracking algorithm resamples the time domain data into angle domain. If we get more information from the RPM probe, we have more pulses per revolution and resampling to the angle domain will be much more accurate!

4.2.3. Phase channel

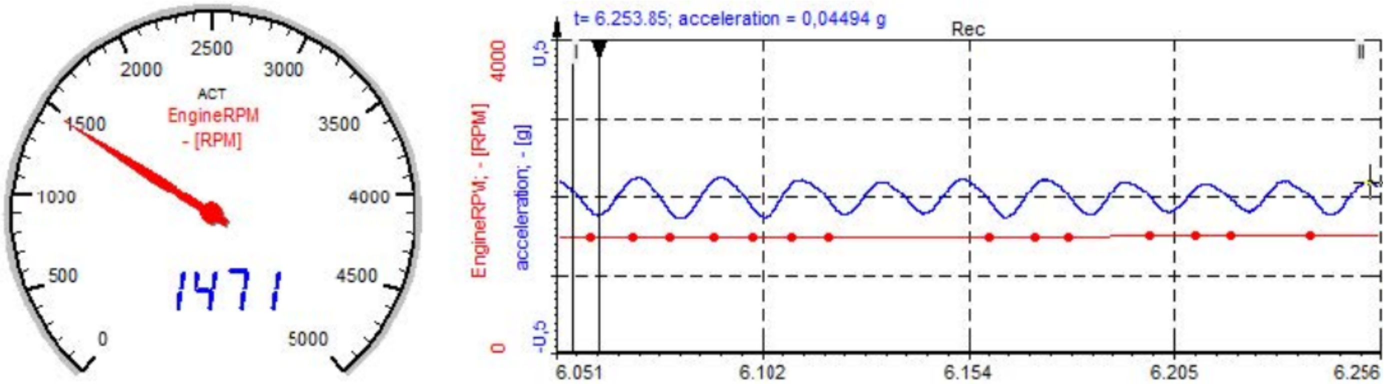
In case you have a dedicated input channel directly providing angle data then you can also use that as the Frequency source.
For example, when reviewing data from distributed DEWESoft NET measurement configurations, then Phase channels can be toggled between for which to control the order tracking.

4.2.4. RPM channel

You can also use any signal or channel as input, which directly represents the RPM (e.g. 0...10V equals 0...5000 rpm).

The disadvantage, however, is that there is no zero-angle information, and therefore the extraction of the phase angles relative to the zero-angle, for the individual orders is not possible. Instead a phase angle can be calculated relative to the first order, (described under 4.6.2 - Phase reference).

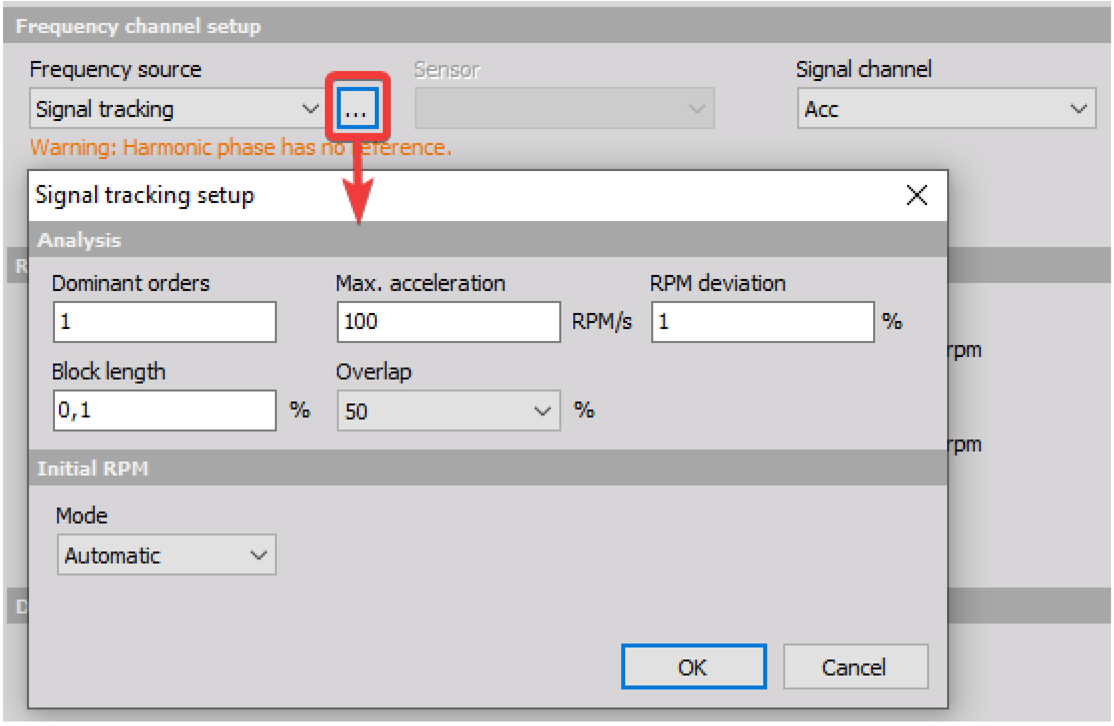
Following example shows an RPM signal from a CAN bus inside a vehicle (red line). Note that the sampling points are asynchronous. The blue line is the output signal of an acceleration sensor.



RPM signal

4.2.5 Signal tracking

In measurement scenarios where it is difficult to mount angle sensors, one of the measured analog input channels can be used to estimate RPM (speed) information.
In order to achieve optimal speed estimations the used analog channel should have at least one dominant order to use for tracking and additional parameters should be set. Below the signal tracking settings are shown:

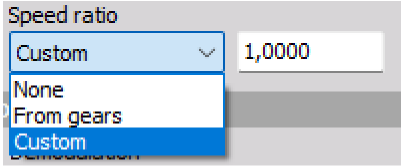


- **Dominant orders** - is the orders that will be used to estimate the RPM information.
- **Max. acceleration** - is the maximum change in speed per second that will be included for the speed estimation.
- **RPM deviation** - indicate how stable the rotational speed is. Depending on this parameter, the search range for the RPM estimate will be broader or narrower.
- **Block length** - is the time block duration in seconds used for each estimated RPM value The estimator assumes the speed is quasi-stationary within each time block.
- **Overlap** - is the overlap of time blocks used for RPM estimations. With increased overlap more RPM values are estimated.

Next to the Analysis parameters the speed estimator requires a relation to the physical setup by knowing the **Initial RPM**. The initial RPM is used to determine how the dominant vibration patterns are related to the Dominant orders.
For example, if two orders are dominant, then the Initial RPM helps determine how these orders relate to the 1st order and hereby to the rotational frequency.
The Initial RPM **Mode** can be set to Manual or Automatic. When Mode is set to Automatic the initial speed is estimated by the software.

Since Signal tracking will estimate speed, it will work similar to using an RPM channel; the phase relation to the zero-angle is missing and instead the phase information should be set relative to the 1st. order phase (described under 4.6.2 - Phase reference).

4.2.6 Speed ratio



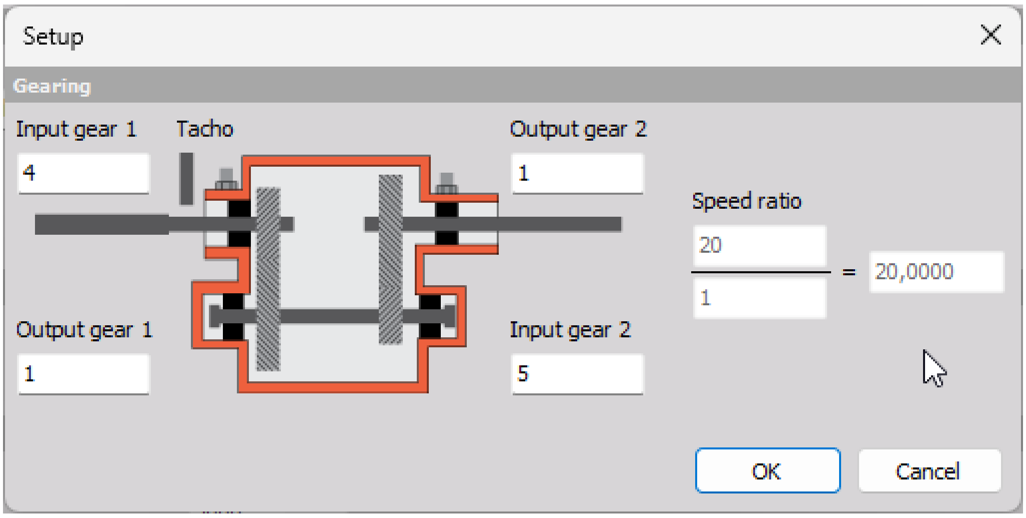
Speed ratio settings

With speed ratio settings it is possible to account for gearing ratios between a fundamental rotation source and the rotation at another component, where the frequency channel sensor might be located.

For example, for practical reasons it might be necessary to perform the frequency channel measurement on a machine component different from the main crankshaft. By using the speed ratio settings the frequency channel can be converted to represent the speed of another component like e.g. the crankshaft.

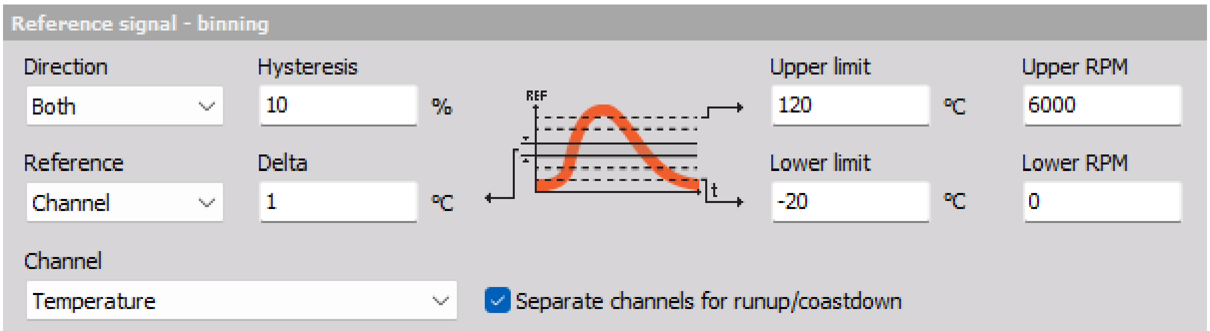
If the measured frequency channel is measured on an output shaft of a system and the RPM should refer to the input shaft of that system, then the speed ratio should be set to input/output.

You can type in a Custom speed ratio value factor, or you can select From gears which will provide an assisting gearing ratio interface after clicking in the [...] button.



Speed ratio setting when selecting From gears.

4.3. Reference signal - binning



Reference signal - binning settings. In this example the reference channel and hereby the bins are set to be related to a temperature channel.

To cover the whole frequency spectrum, a runup or coastdown of the engine has to be performed.

As the Reference channel the speed calculated from the Frequency source is used by default, but can be changed to tag another channel as a bin axis instead.
Select the Reference channel limits, the RPM limits related to the Frequency source, and whether you want to calculate output data while the **Direction** is runup, coastdown, both or the First detected direction.

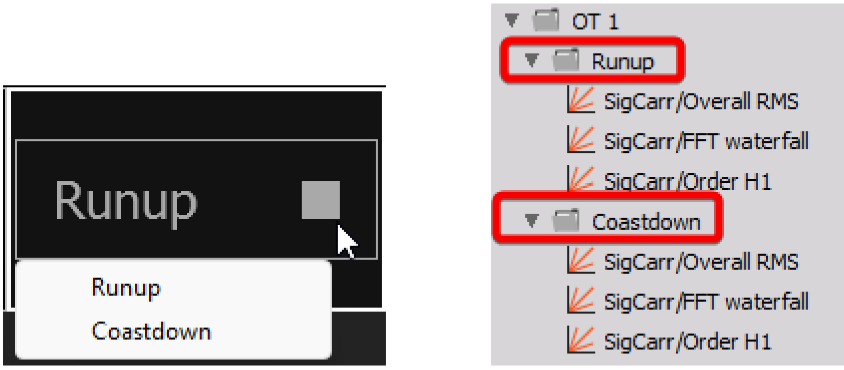
Hint
Upper and lower **RPM limits** are used to correctly set up the resampling algorithm, depending on the max orders extracted.

Delta defines the bin width of the REF axis in waterfall spectra and in extracted order domain harmonics.

Hysteresis is used to determine when measured data is assigned to another bin. Hysteresis is described in percentage of the Delta bin width. Assigning data to another bin will only be considered if the reference value crosses the bin edge by more than the hysteresis percentage.

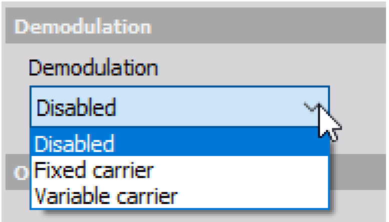
Reference determines which channel the REF axis relates to. By default it is set to RPM where the speed (RPM) of the Frequency source will be used. Alternatively a user-defined reference **Channel** can be selected. By using a user-defined reference channel the order spectra can relate to other channels. For example if a temperature channel is used as a reference channel, then waterfall spectra will be vs temperature - relating order analyzed signals to another physical quantity. In this case the Upper- and Lower **REF limits** should be set to cover the measured temperature range.

Separate channels for runup/coastdown can be enabled only when the **Direction** is set to Both.
In that case, when you are measuring you will be able to determine if data currently belong to a runup or a coastdown scenario.
While Runup is selected under Measure using the control widget, data will be added to channels under the Runup channels folder. When Coastdown is selected, then data will be added to separate channels under the Coastdown channel folder:



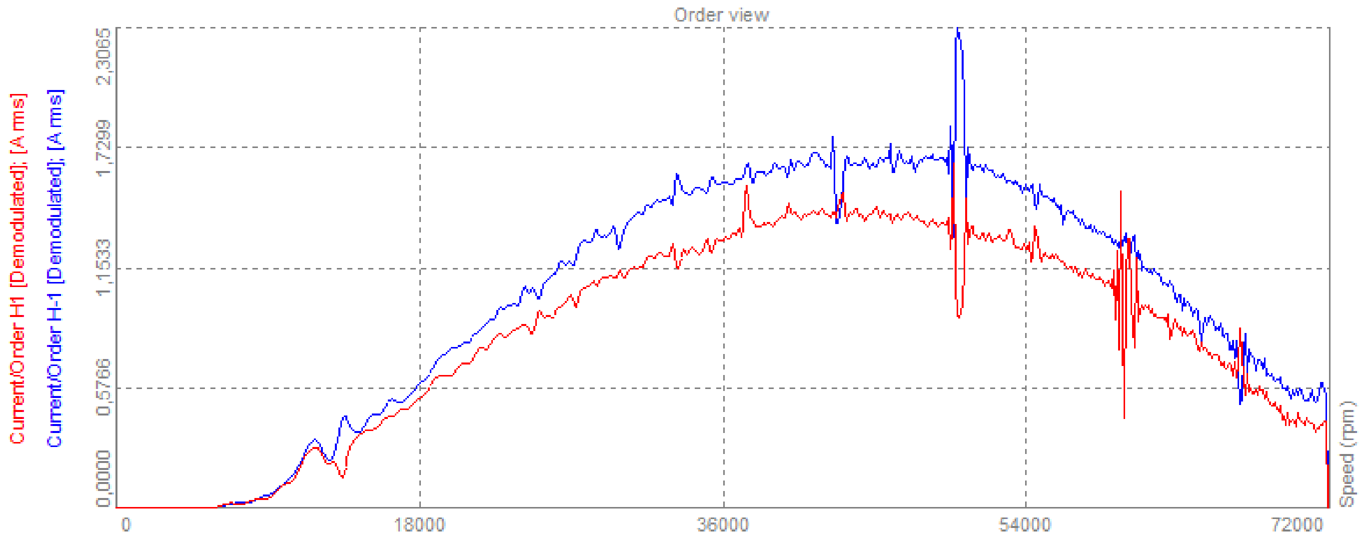
Under Measure the current direction can be selected if Direction Both has been selected under Ch. setup together with Separate channels for Runup/coastdown. If you can't see the control widget then try Rebuild the display layout.

4.4. Demodulation



Demodulation settings

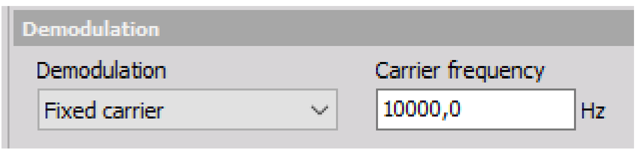
Demodulation can be enabled to analyze e.g. electrical Pulse Width Modulated (PWM) signals and related effects. By demodulating signals the modulating carrier frequency is shifted to DC (0 Hz) and the Order FFT results show the energy content of harmonic components that relate to modulation effects.



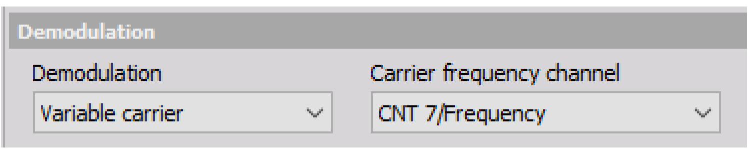
Extracted positive (red) and negative (blue) 1st. order of a demodulated current signal over a speed range.

Dewesoft Order analysis supports demodulation based on either a **Fixed carrier** frequency or a **Variable carrier** frequency.

When selecting Fixed carrier you manually type in the **Carrier frequency**:



When selecting Variable carrier you have to select a **Carrier frequency channel**::

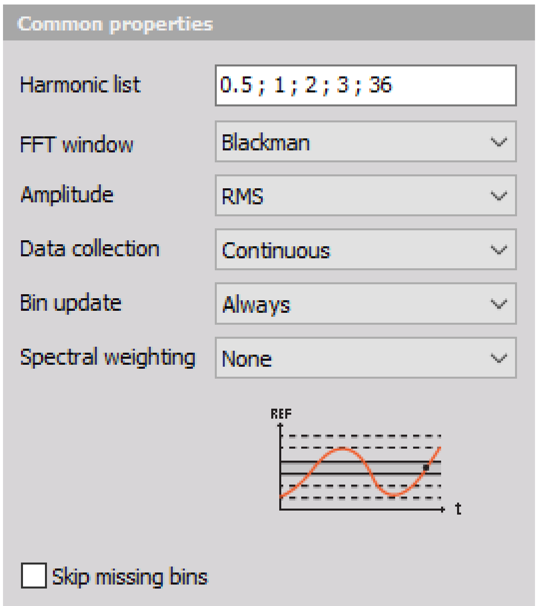


Demodulation will only affect order outputs which are selectable under the Order FFT setup section, see 4.6. Order FFT setup.

When using demodulation, order spectra will span from (negative) - Maximum order to (positive) + Maximum order, and it is possible to extract negative harmonic components by typing negative values in the Harmonic list under 4.5. Common properties.

The difference between negative and positive order components are related to the phase differences between the specific orders and the PWM carrier signal component.

4.5. Common properties



Common properties settings

Harmonic list
To extract harmonic orders simply enter the wanted number in the Harmonics list field. Separate multiple entries with the semicolon (;). In the example above the 1st, 2nd and the 8½ orders are selected. If the extracted order falls between discrete order resolution steps ($\Delta order$), the closest fitting resolution will be taken. E.g. if the resolution is 1 order per spectral line and 1.8 order is selected to be extracted, then the 2nd order will be used.

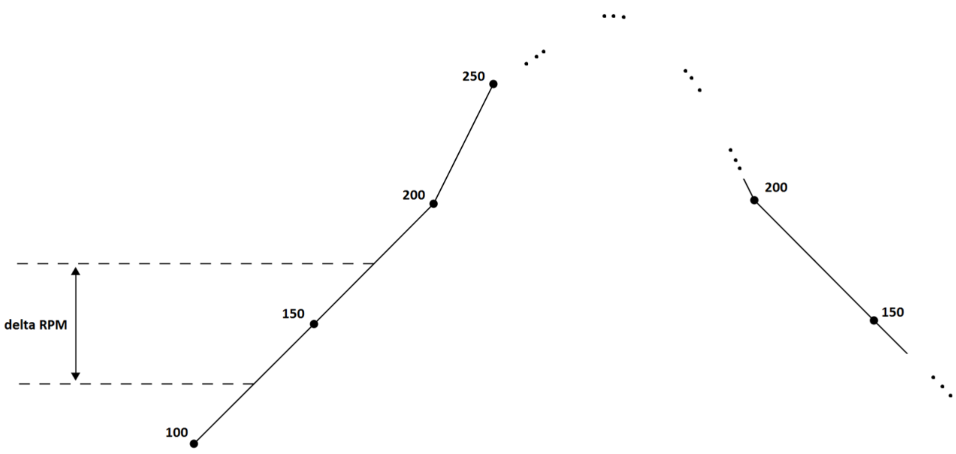
FFT window
In order to reduce spectral leakage a window function can be applied on the FFT time blocks of the resampled angle domain data. In most cases using order analysis the rectangular window can be used since the energy content can be configured to be located mainly at distinct spectral order lines, and not in between the lines. In cases where remarkable amounts of energy are located between spectral lines, a window function should be used.

Amplitude
The amplitude parameter determines how the collected data is scaled. The user can select between rms, peak and peak-to-peak.

Data collection

Data can be collected in two ways:

- *On center of bin:* collects data when the reference channel crosses the center of the bins only
- *Continuous:* collects data through the entire bins



On center of bin collection presentation

Bin update

The collected data will be processed based on the Bin update parameter setting. It defines if the waterfall should be updated:

- *Always:* if you have more run-ups or coast-downs, only the newest bin values will be used in the output array.
- *First time:* if you have more run-ups or coast-downs, only the first run bin values will be used in the output array.
- *Average*: if you have more run-ups or coast-downs, the element of the output array will be calculated as an average between old and new bin values for each individual bin.
- *Maximum:* if you have more run-ups or coast-downs, the elements of the output array will contain the maximum bin values for each individual bin.

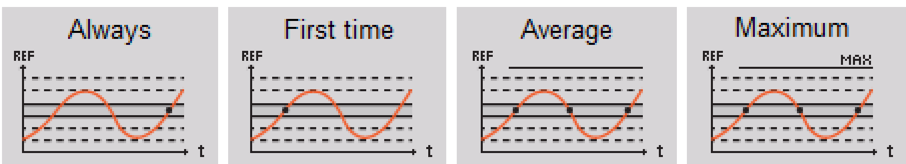
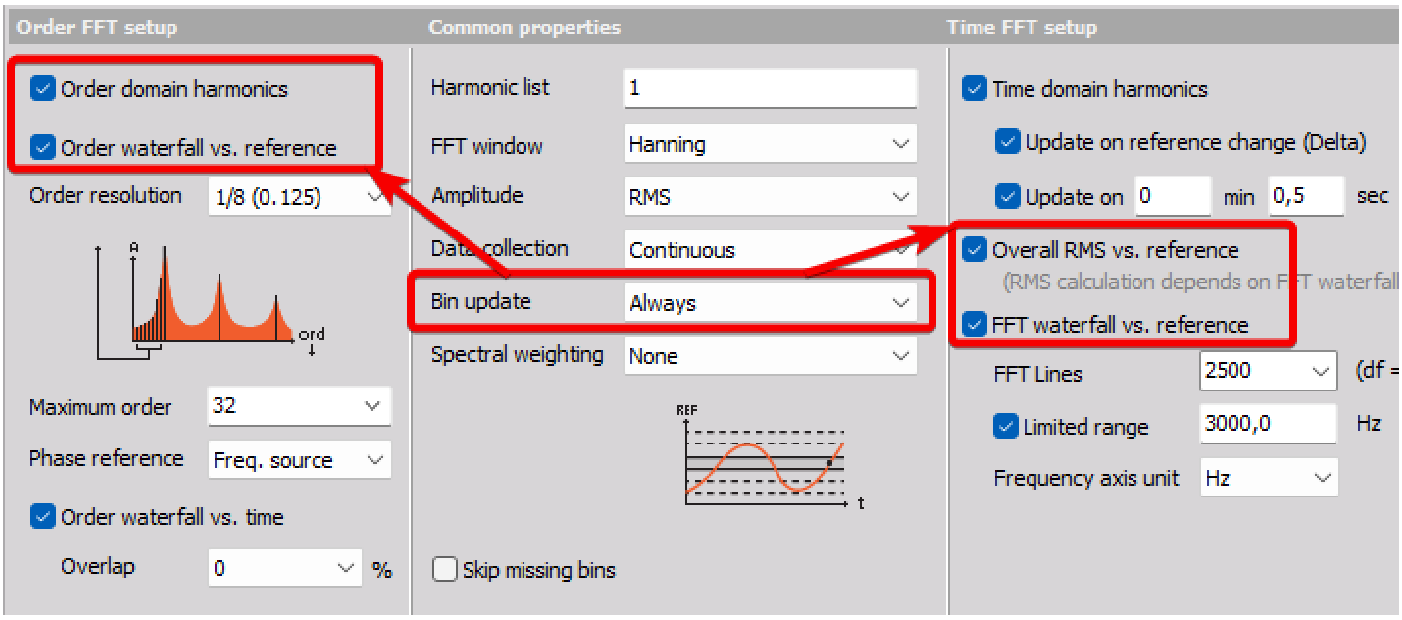


Illustration of the available Bin update types.

Note:
Bin update only apply to the array output channels that relate to the Reference Channel Binning, which is:

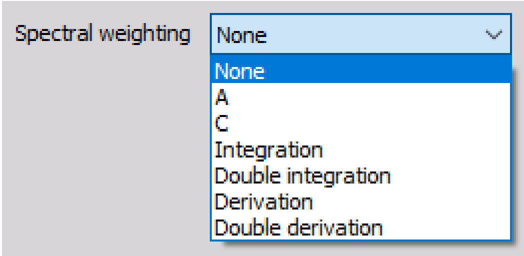
- Order domain harmonics
- Order waterfall vs. reference
- FFT waterfall vs. reference
- Overall RMS vs. reference



Bin update settings and the dependent output channels.

Spectral weighting

Following spectral weighting functions are supported:



- Acoustic weighting - A- and C-weighting are used for sound pressure signals. When analyzing sound and noise signals acoustic weighting filters can be applied in order to take audible human perception into consideration.

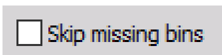
- Integration/Differentiation - Integration/Differentiation functions are used mainly for vibration signals to change the physical quantity. A typical scenario for this is when transforming data from the acceleration domain to the displacement domain. The table below illustrates how integration and differentiation functions can be used to transform vibration related physical quantities:

Physical quantity / Output Type / Input	Acceleration	Velocity	Displacement
Acceleration	None	Integration	Double Integration
Velocity	Derivation	None	Integration
Displacement	Double Derivation	Derivation	None

Illustration of how vibration quantities are transformed with use of integration and differentiation functions.

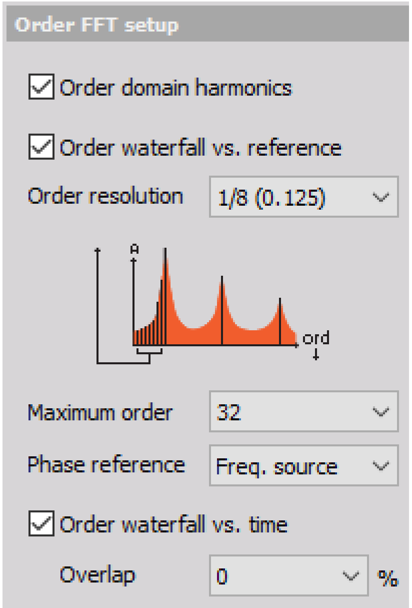
Skip missing bins

Empty bins typically appear when the Delta bin width is too narrow to capture the number of cyclic revolutions required to produce a spectrum. The required number of revolutions for each spectrum is determined by the Order resolution.



- If 'Skip missing bins' is enabled, all reference (REF) bins that miss revolutions of data for producing a spectrum will stay empty.
- If 'Skip missing bins' is disabled, all REF bins that miss revolutions for producing a spectrum will use an overlapping amount of revolutions from previous REF bins that match the missing part required for producing a spectrum.

4.6. Order FFT setup



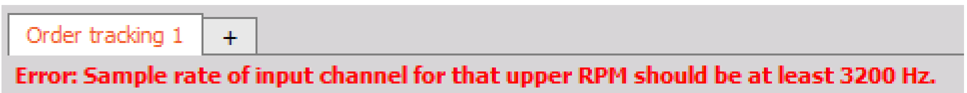
Order FFT setup

In this section, you define the order domain spectral properties, and properties for order extraction. In the Order FFT setup section the following data results can be selected as output channels:

- Order domain harmonics - Complex output values with magnitude and phase information of the defined harmonics over the reference channel axis. In the Harmonics list you define the harmonics that you want to extract.
- Order waterfall vs. reference - Order spectra over the defined range for the Reference Channel.
- Order waterfall vs. time - Order spectra over a time axis.

In the Order FFT setup, we can define the maximum number of orders to be extracted, and the order resolution (the number of lines between two orders).

Depending on the Upper RPM limit and the Maximum order used, the OT (Order Tracking) module will output a warning if the used sample rate is too low.



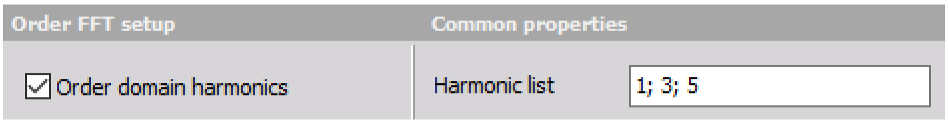
Warning if the sample rate is to low

In this example, we have set Upper RPM limit = 6000 and Maximum order = 64, so the minimum required sample rate is calculated like this:

First order at max speed: 6000 rpm / 60 = 100 Hz; so the highest order would be 100Hz * 64 = 6400 Hz
Because for FFT analysis minimum the double sampling frequency has to be used (Nyquist criteria): 2 * 6400 = 12800 Hz.

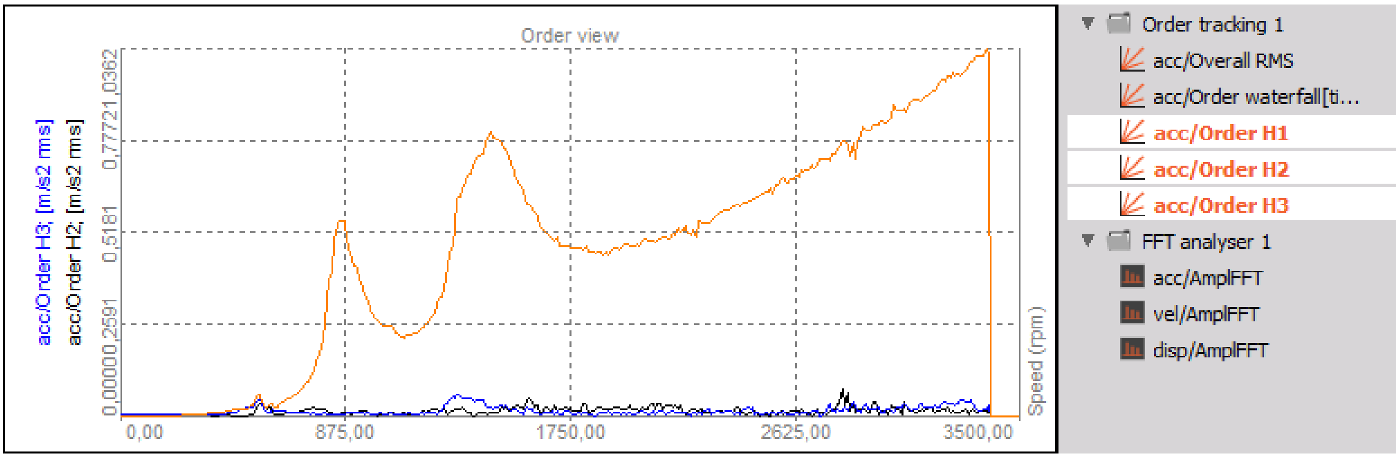
Hint
In an FFT, if the line resolution is 0.5 Hz, the required data window must be 2s. The same is true for the ordered resolution: If the resolution is set to 0,25 orders, 4 revolutions are required for one data block. The higher the required order resolution, the more cyclic periods must be included in the FFT time blocks.

4.6.1. Order domain harmonics



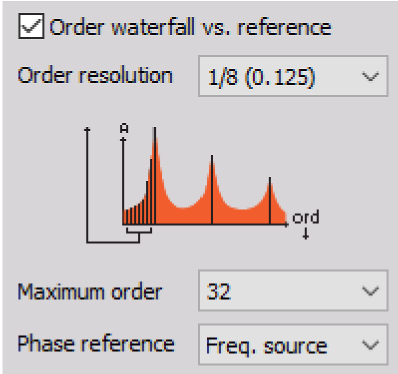
Order domain harmonics

Order domain harmonics are complex channels displayed on 2D graphs. In the harmonic list section, we define which harmonics we want to extract.



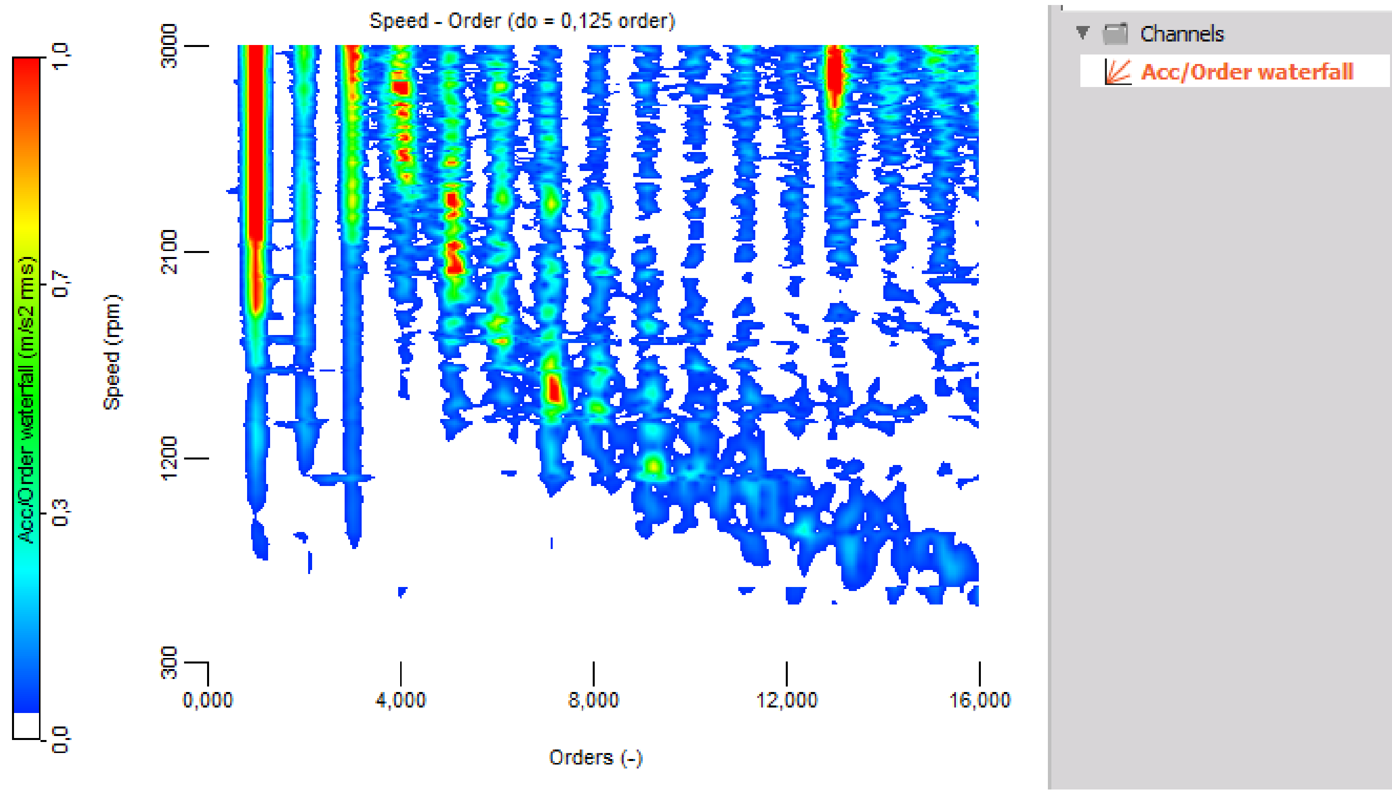
Extracted harmonics

4.6.2. Order waterfall vs. reference



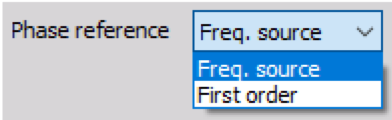
Order vs reference

Order waterfall vs. reference monitors current values of orders. We define the order resolution (the line spacing) and the maximum order that will be shown on a 3D graph.



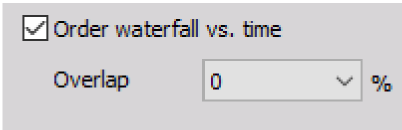
Order waterfall vs reference. In this case the reference signal - binning is related to speed (RPM).

Phase reference
Also, the Phase reference can be selected to be either:



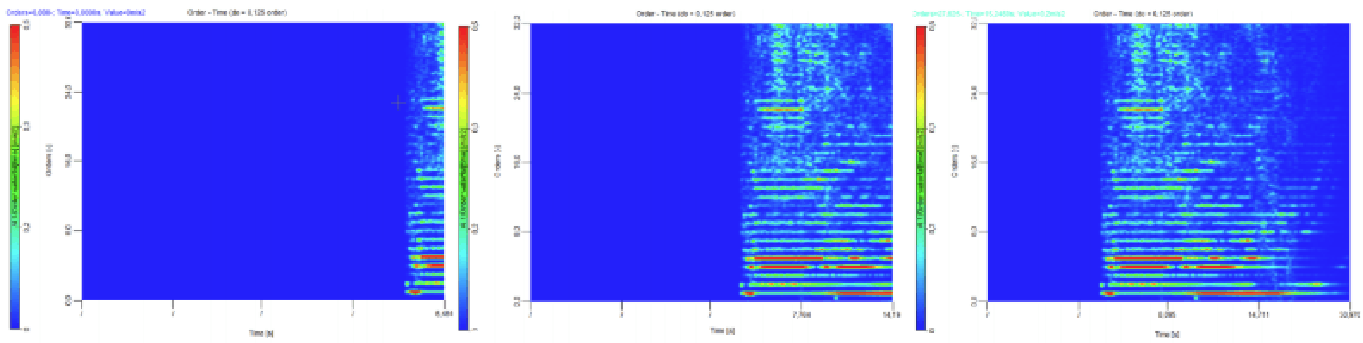
- *Freq. source:* which is the default setting, used when Analog pulses or Counters is selected as the Frequency source. The phase information will be calculated relative to the keyphasor position of the Frequency source.
- *First order:* which can be used e.g. when an RPM channel is selected as the Frequency source. First order is used when the Frequency source does not directly relate to the rotation angle. In such cases the phase calculation is missing a phase reference, but it can be determined relative to the First order.

4.6.3. Order waterfall vs. time



Order waterfall vs. time channel setup, with possible FFT time block overlap.

Order waterfall vs. time monitors orders through time and not only the current values. The channel is updated when every new FFT is being calculated. The **Overlap** parameter can be used to increase the rate of FFT calculations by setting an FFT time block overlap percentage.

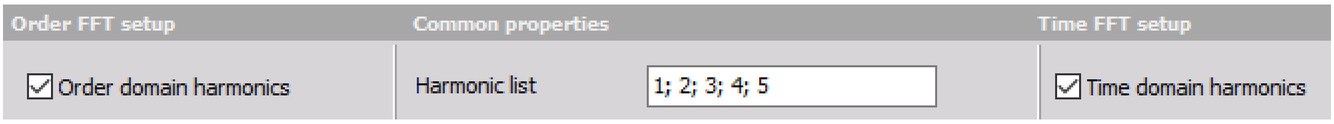


Updated values

4.7. Output extracted harmonics as channels

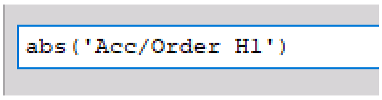
This will extract specific orders from the order waterfall plot to be used as channels. So it is possible to draw a specific order over time, or over engine speed.

To extract the orders simply enter the wanted number in the Harmonics list field. Separate multiple entries with a semicolon (;). In the example below the 1st, 2nd and 3rd, 4th and 5th orders are selected. If the extracted order falls between discrete order resolution steps, the closest fitting resolution will be taken.



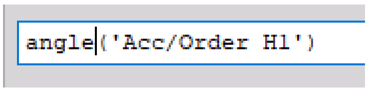
Harmonic list

Time domain and order domain harmonics are both complex channels. To get the amplitude from the complex number, use the ABS function in math.



Formula settings

To get the phase angles from complex numbers use the ANGLE function in math (only available when using an RPM sensor with zero-angle information).



Formula settings

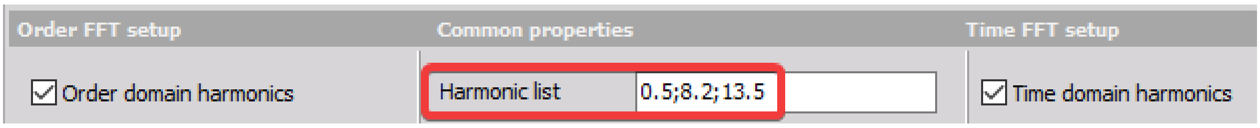
To get the real and imaginary part as separate channels out of the complex number, use two math formulas:

- real = real('acc/Time domain'[0])
- imag = imag('acc/Time domain'[0])

In the example above, the index [0] will show 1st harmonic, index [1] will show 2nd, and [2] the 3rd harmonic.

4.7.1. Extracting the interharmonics

In the order tracking module there is an option to extract interharmonics (order fractions). Enter the number in the harmonic list section.



Harmonic list of interharmonic components.

Order domain harmonics and interharmonics are complex channels displayed on the 2D graph.

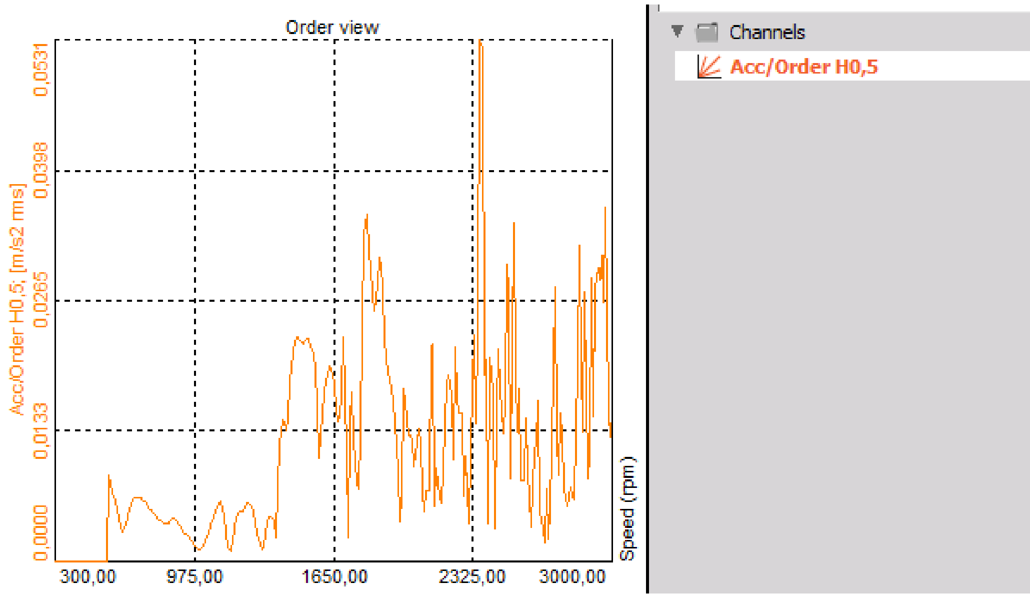
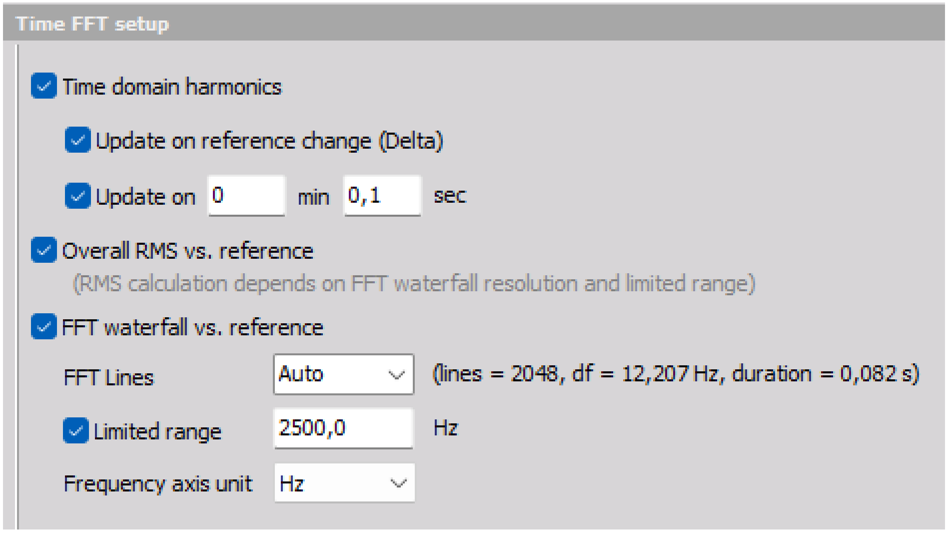


Image 32: 2D graph presentation

4.8. Time FFT setup



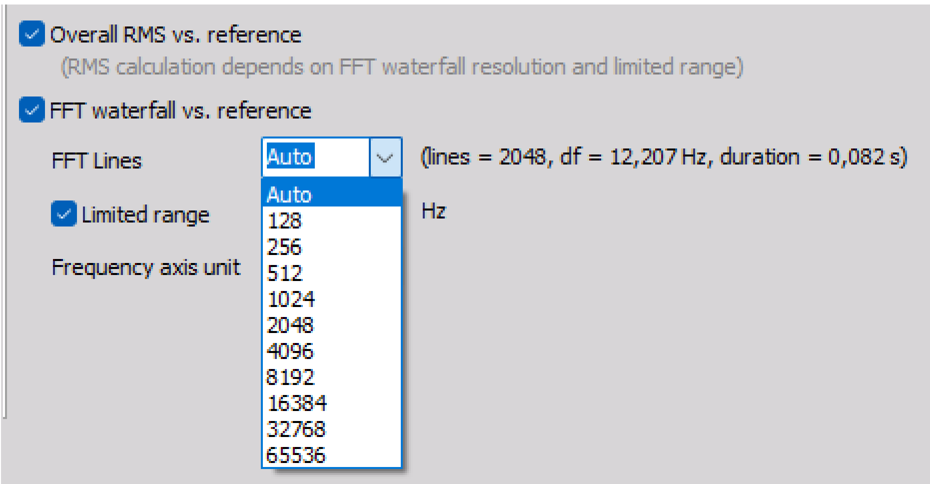
Time FFT setup

In this section, you define the frequency domain spectral properties, and properties for harmonic extraction in the time domain.

In the Time FFT setup section the following data results can be selected as output channels:

- **Time domain harmonics** - Complex output values with magnitude and phase information of the defined harmonics over a time axis. In the Harmonics list you define the harmonics that you want to extract.
- **Overall RMS vs. reference** - Overall RMS values over the defined range for the Reference Channel.
- **FFT waterfall vs. reference** - Frequency spectra over the defined range for the Reference Channel.

The FFT resolution, lines, and data block length is per default automatically calculated out of sampling rate, order resolution and maximum order



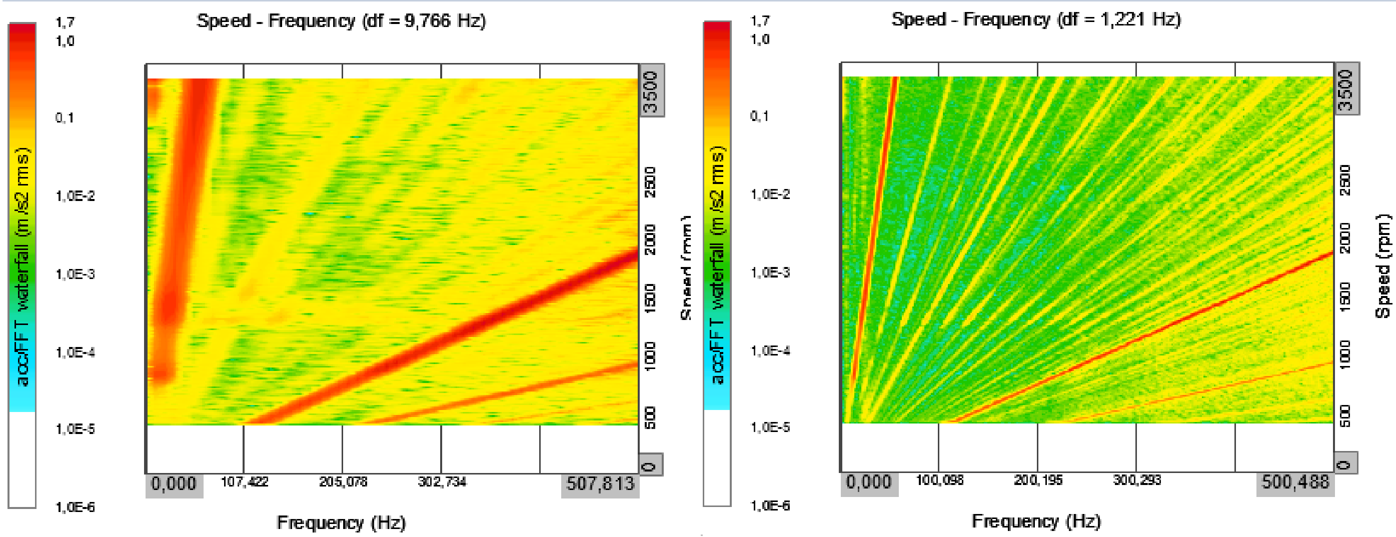
Possible options

FFT Lines settings determine the number of lines in the Time FFT waterfall diagram. This can be user-defined - So we manually change the FFT resolution in the FFT waterfall diagram with this setting. The number of FFT Lines are spread equidistantly from 0 Hz and up to the Nyquist frequency of the input channel's sample rate.
If Limited range is enabled, then the frequency resolution (df) will be kept and instead only the fraction of lines included up to the Limited range frequency will be outputted.

Limited range can be enabled if the used frequency range should be reduced to a fraction of the original range based on the acquisition sample rate.
This can be useful if the input channels are acquired with a much greater sample rate than relevant for the order analysis part. Such channels might have been acquired with higher sample rates due to other types of analysis that are performed in parallel to the order analysis.

Note:
Both the parameter **FFT Lines** and **Limited range** are used for the outputs:
Overall RMS vs. reference and **FFT waterfall vs. reference**.

Below you see the difference (left: Df = 9,766 Hz; right: Df = 1,221 Hz):

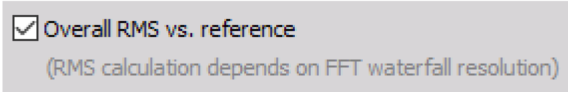


Different Line resolutions

The second picture shows much sharper lines, and separates much clearer into single frequencies.

If Time domain harmonics is checked, the extracted orders are calculated for the resampled data over time. By using the resampled data the time harmonics have no smearing across rotational speed ranges, and provide clear phase relations.

4.8.1. Overall RMS vs. reference



Overall RMS vs. reference

This channel shows the overall RMS amplitude over the defined range of reference channel values.

Overall RMS

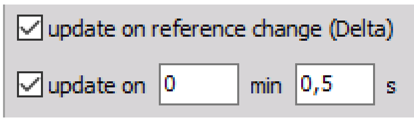
4.8.2. Time domain harmonics

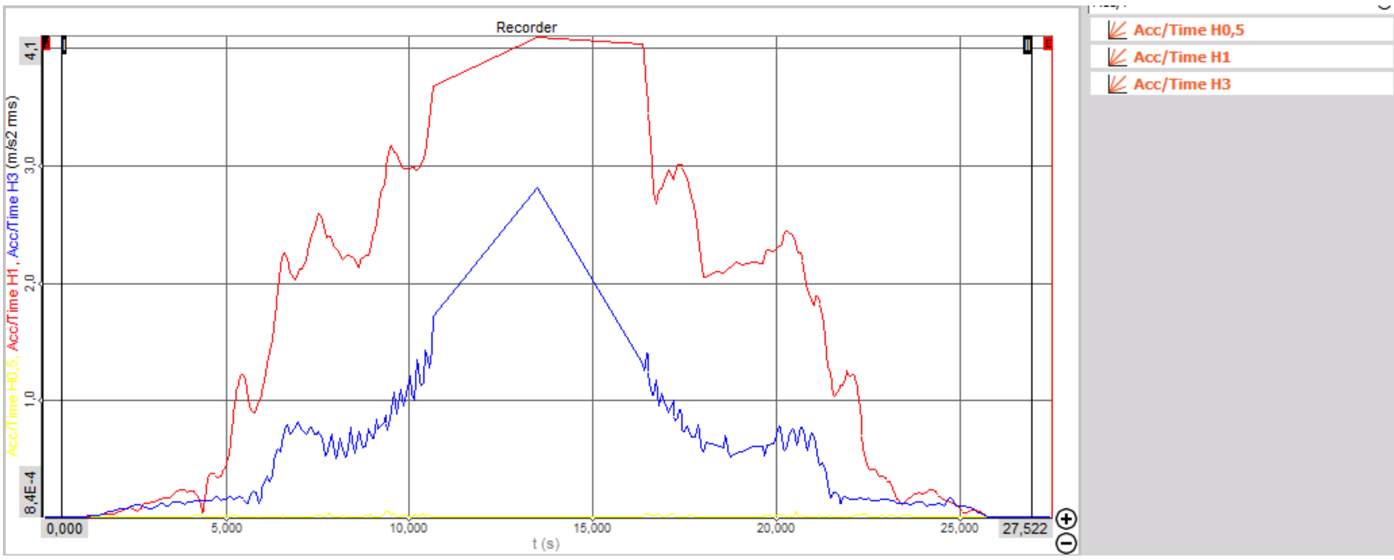
Time domain harmonics

This is a complex output channel showing the amplitude of harmonics in a time domain. In the harmonics list section, we define the harmonics that we want to extract.

Update on reference change (Delta) and **Update on**

These parameters are used to define when new harmonic values are extracted on the time axis.





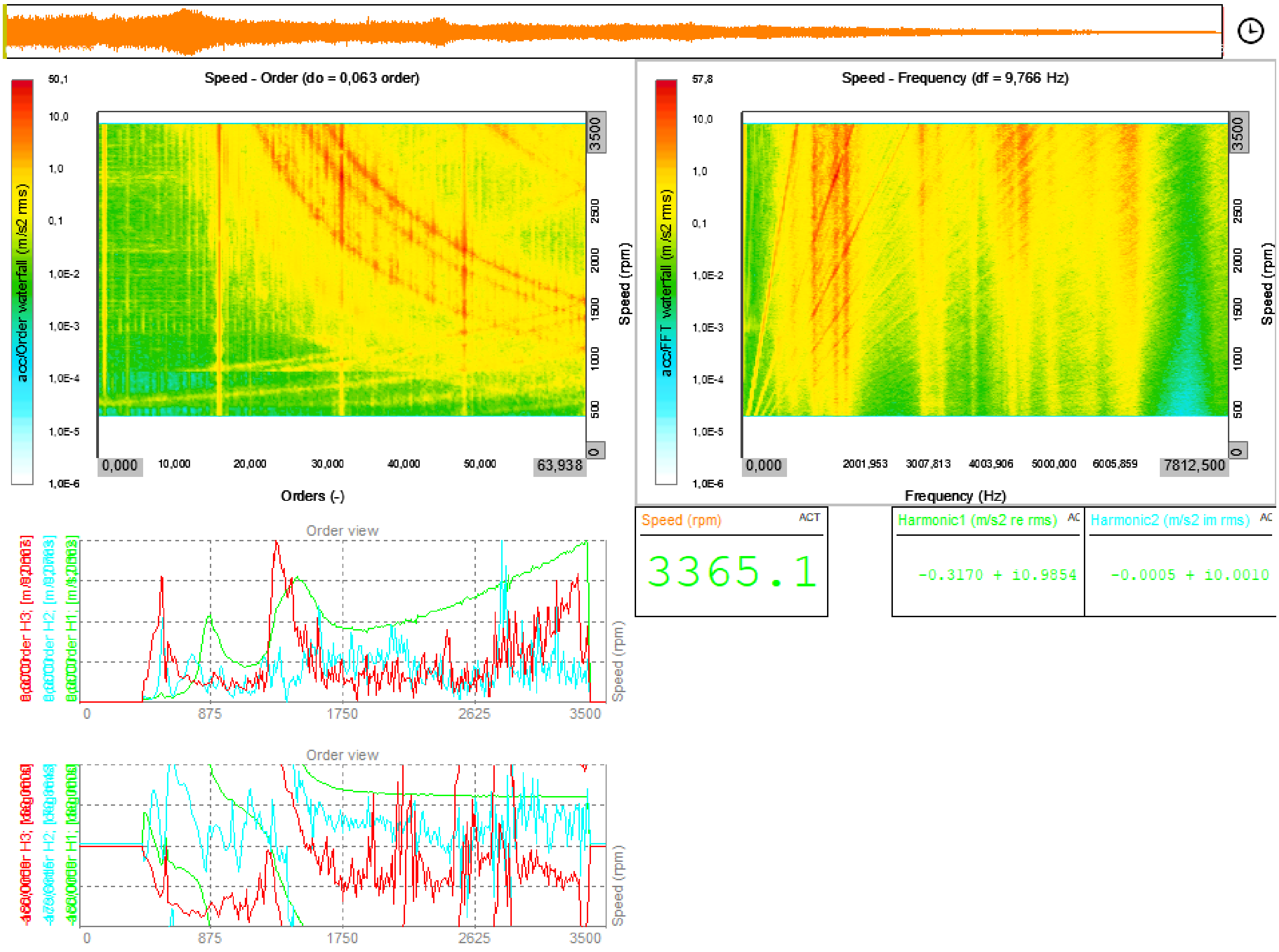
Presented Harmonics

5. Measurement and visualization

As the order tracking is done during a run up or coast down, the visualization instruments show the vibration spectrum (and orders) over RPM, frequency or other REF quantities. Single order lines can additionally be extracted.

5.1. Automatic display mode

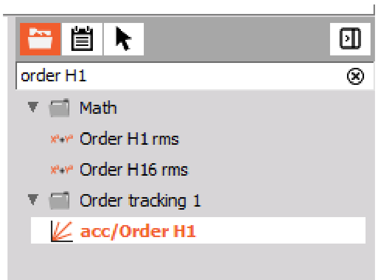
With the order tracking module enabled, when you start the measurement, DewesoftX® will automatically generate a display setup showing the major signals for a quick start.



Automatic Display

The handling of all visuals follows the same concept. For the selected visuals, the properties are shown on the left side. The channel selector for this visual is shown on the right side. Only channel types suitable for the selected visual are shown. E.g. you can't select statistical channels of a visual holding angle based data. Already selected are shown in bold.

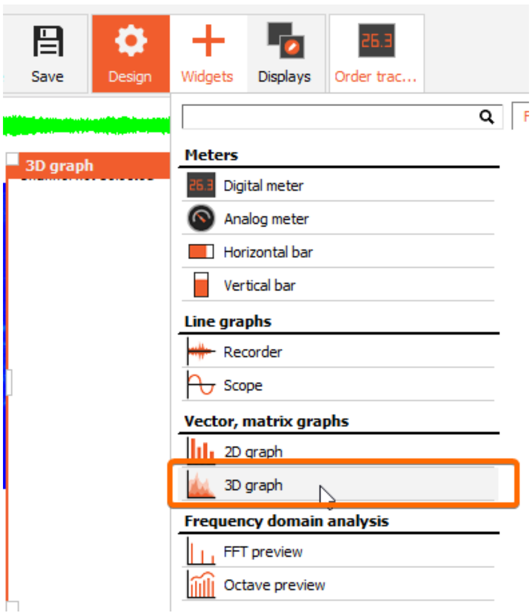
We can use the channel filter for quickly finding the wanted channels on top of the channel list.



Search option

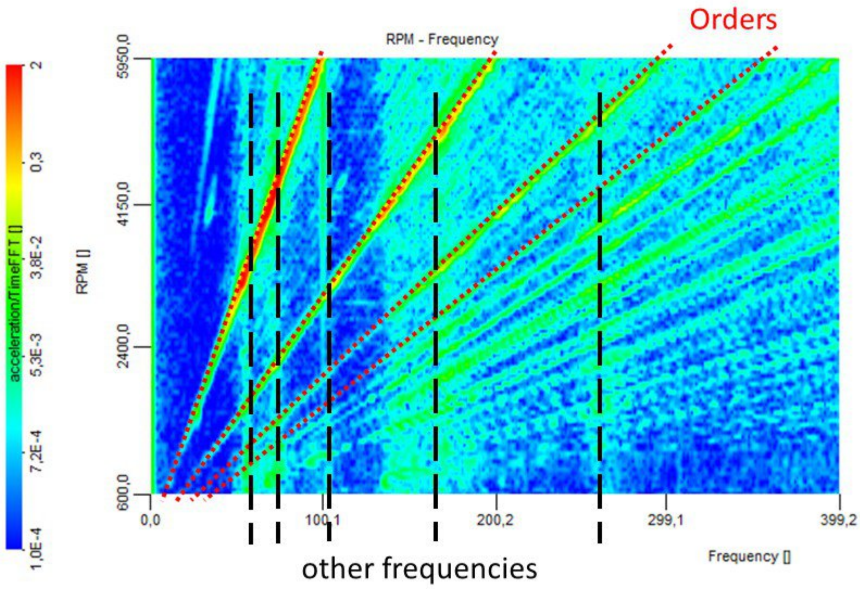
5.2. Time FFT waterfall

The most important instrument for order tracking is the 3D graph.



Adding new 3D Graph widget

When you pick it in design mode, assign the signal/TimeFFT from the channel list to it.

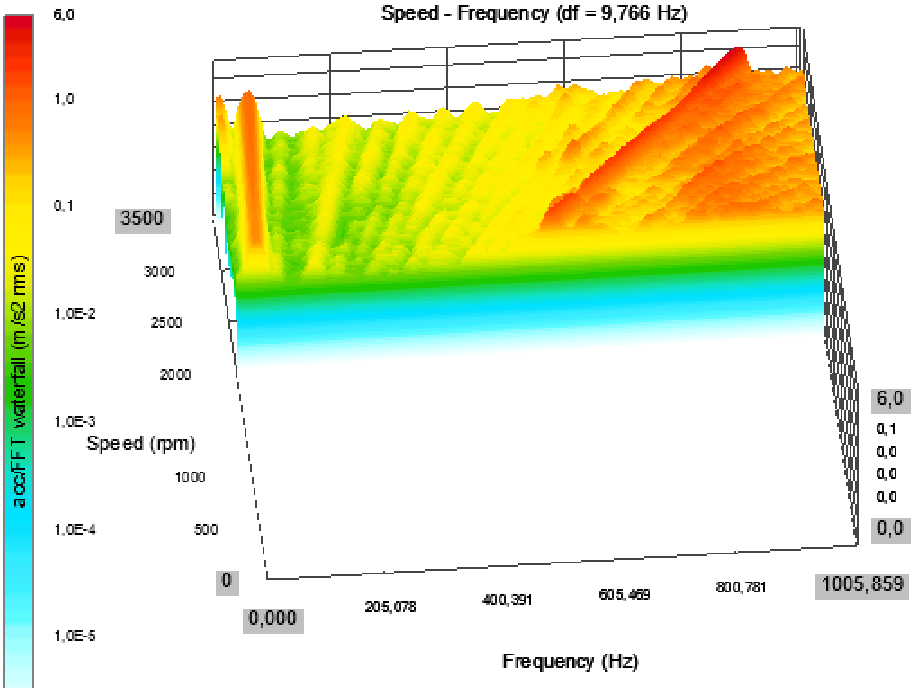


Signal/TimeFFT channel, showing both straight structural frequency components and rotation related order components.

The waterfall plot shows a number of FFTs plotted across the REF range (y axis), where the vibration amplitude is shown as color (up-direction in 3D mode).

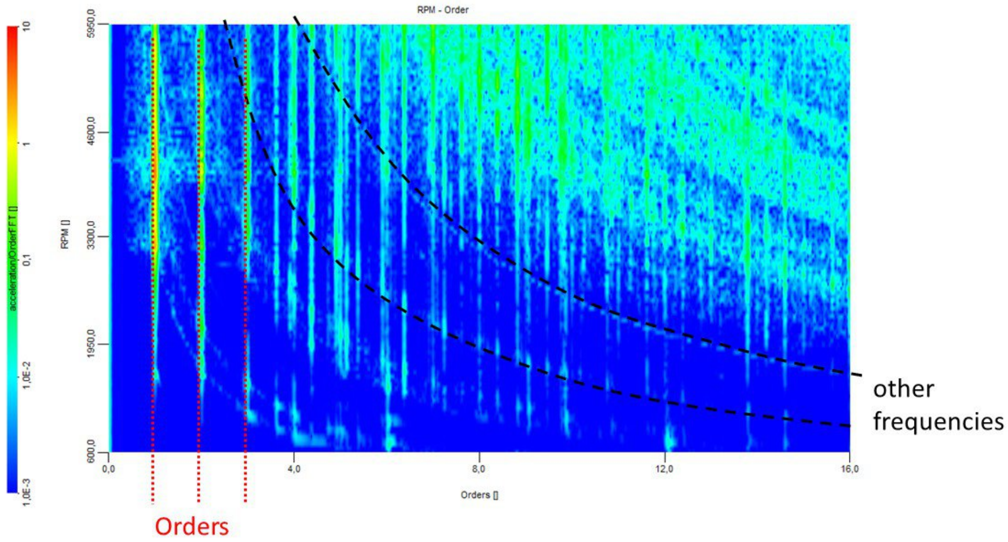
With this instrument, you can separate the spectrum into frequency components related to RPM (= orders) and other straight frequency line components (e.g. resonances of the mechanical structure, noise from the electrical grid, ...).

The 3D FFT instrument is updated in real-time during measurement, it will grow during runup / coast down, already showing the end result.



3D graph visualization

5.3. Order FFT waterfall



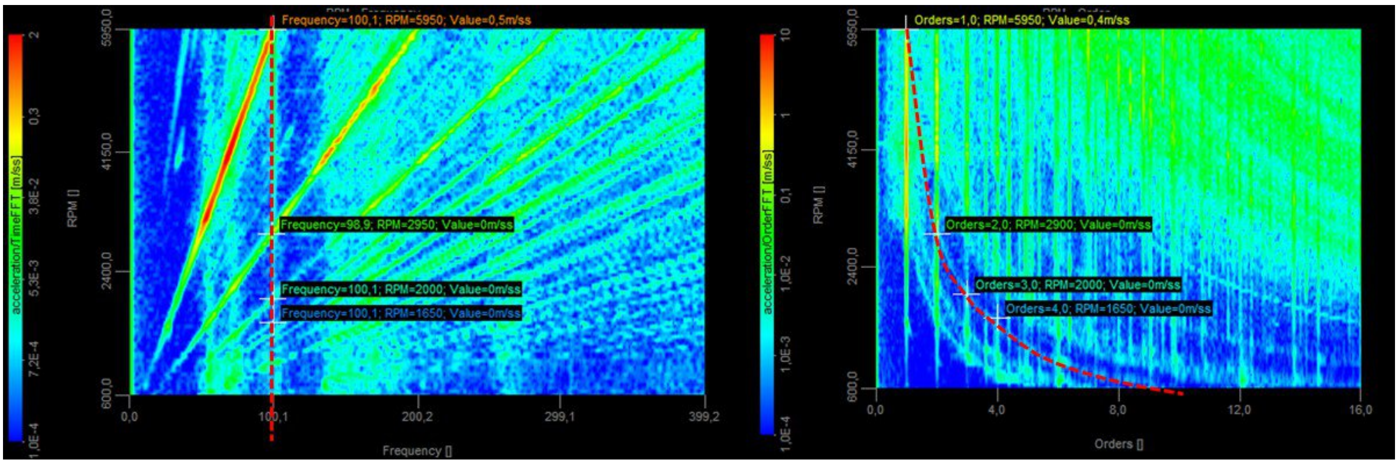
Order FFT waterfall, showing both straight rotation related order components and other structural frequency components.

Also with the 3D graph instrument, the order FFT can be shown. Orders are plot versus RPM or another reference quantity. Again, the color shows the vibration amplitude.
The straight lines parallel to the y axis are the orders. This is very helpful, because the frequencies of the orders change with rpm, and sometimes it is difficult to trace them.

Example: frequency change of the first order with rpm:

- 1st order at 600 rpm → 600/60 = 10 Hz
- 1st order at 4600 rpm → 4600/60 = 76,7 Hz

Below you see the comparison: Time FFT (left) and Order FFT (right). The straight 100 Hz noise line in the Time FFT appears as a curve in the Order FFT; marked with a red dotted line in the two graphs.

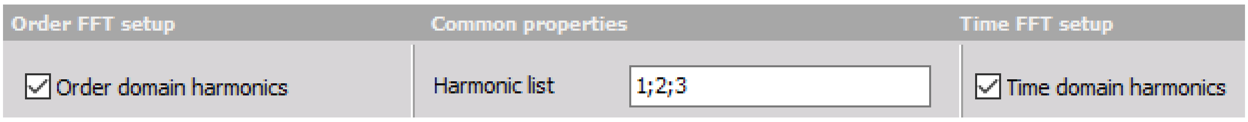


Time FFT (left) and Order FFT(right)

6. Polar diagram / Nyquist plot

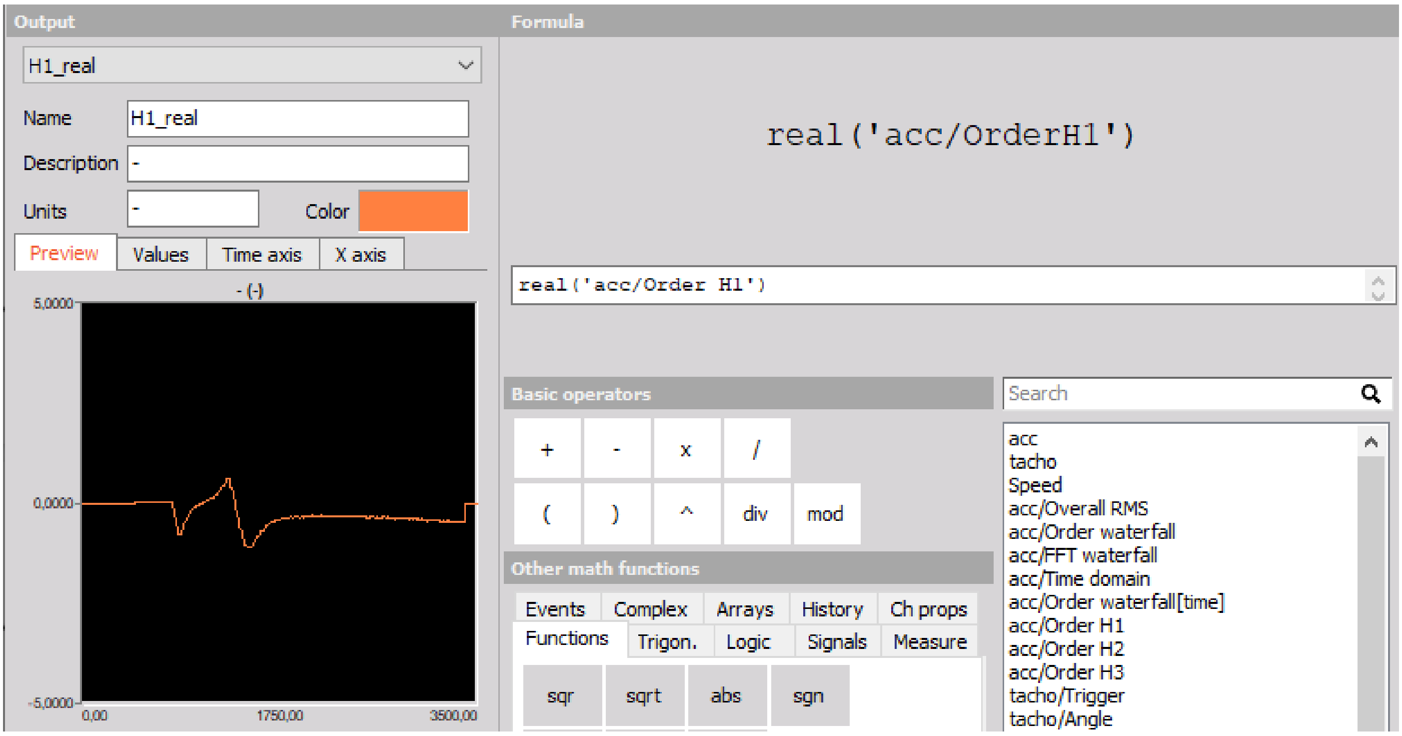
For this functionality, you have to enable the “Time domain harmonics” checkbox in the order tracking setup. It is also possible to draw a Polar diagram with Order domain harmonics.

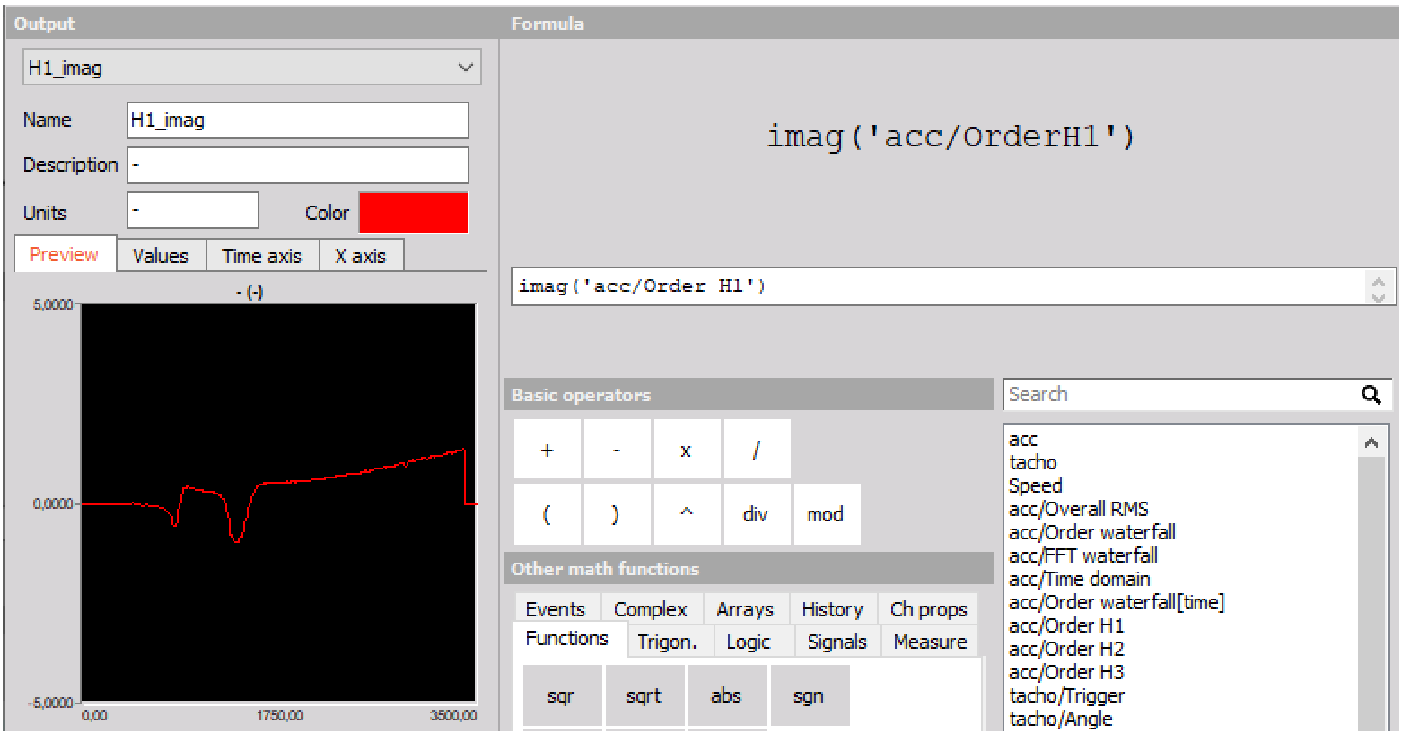
In the example with the scooter motor the strongest orders are relatively high, so we selected 1; 16; 32.



Selected 1; 16; 32. harminics

The Complex output (Re + jIm) has to be split up into real and imaginary parts using Math. Create a new formula and add one the beginning “real()” and “imag()” to the signal/Complex channel. This can also be done “offline” on the data file, after the measurement. Go to Recalculate and take a look at the Math preview again.

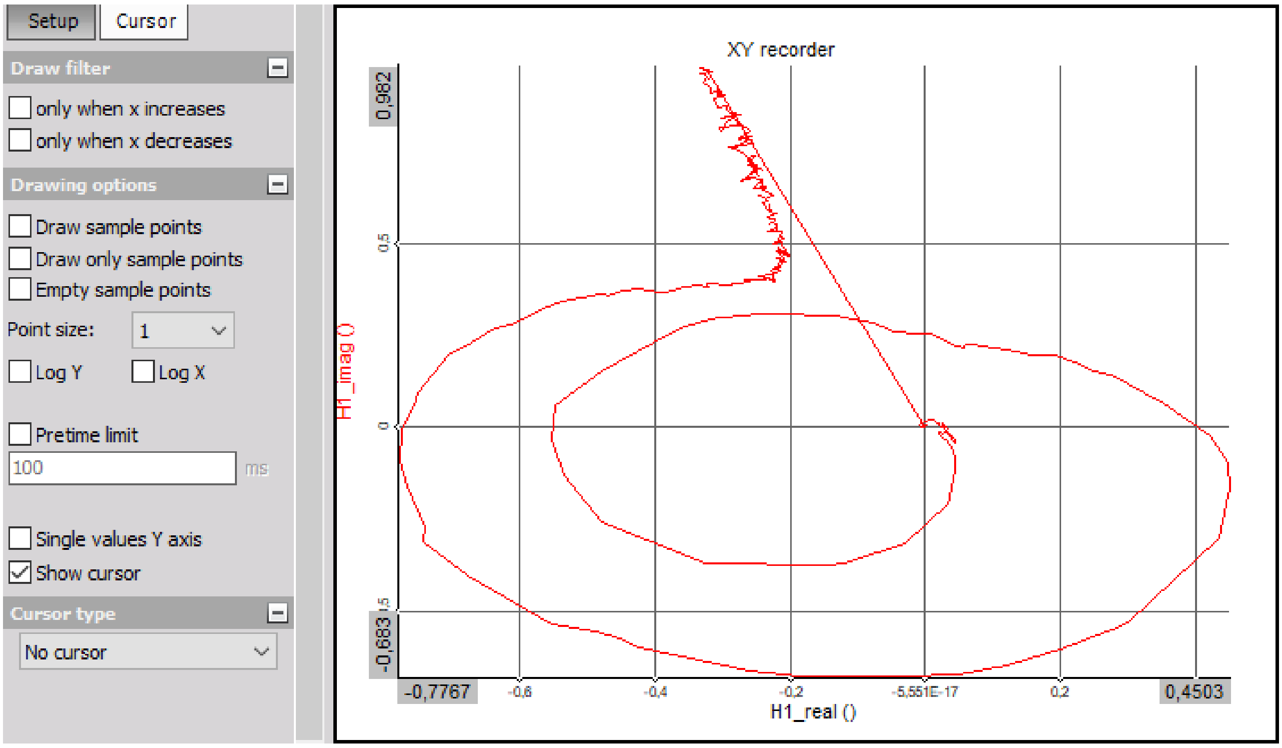




Formula setup for real and imaginary part of the signal

The x and y axis were manually scaled to the same min/max value to show the angle proportion correctly.

On the left side, in the properties you can select if you want to display all data, only the current data, or over a specified window with the Pre time limit option.



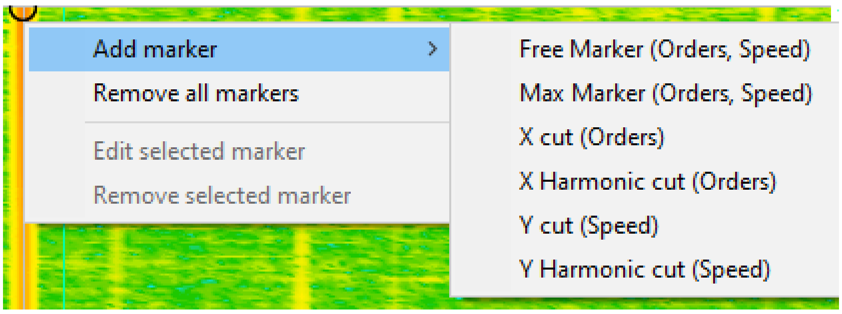
Polar plot shown on XY recorder widget

7. Processing markers on 3D graph

To learn more about processing markers take a look at the dedicated marker manual.

These are the markers that are available on 3D graph:

- Free marker
- Max marker
- X and Y cut
- X and Y Harmonic cut

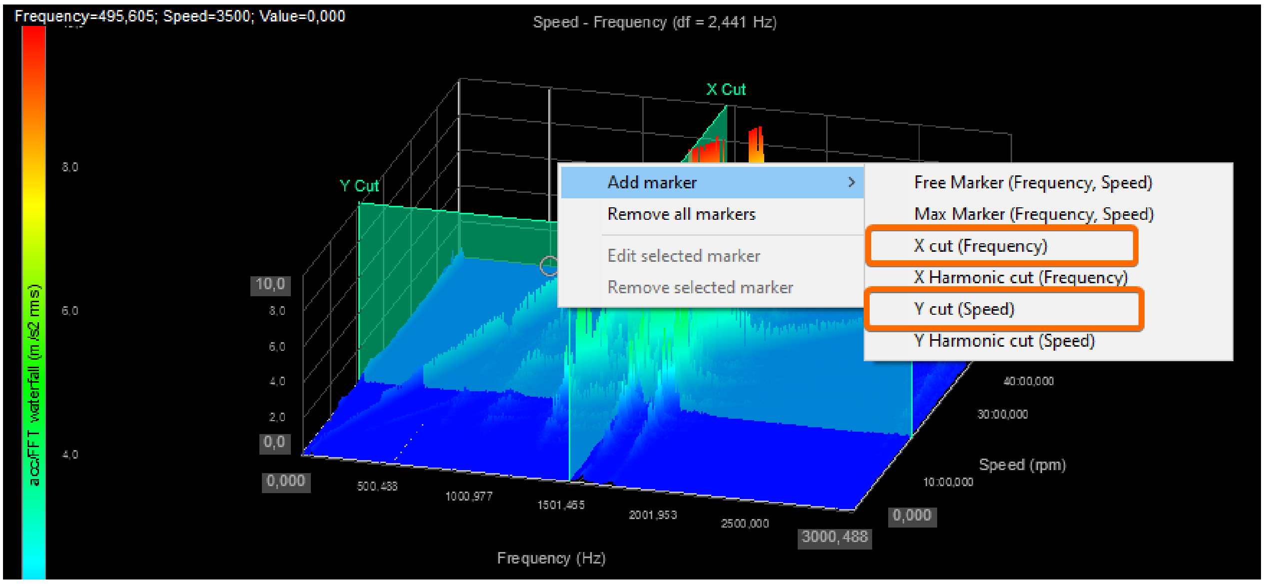


All the markers have two modes, showing only current value or full history.

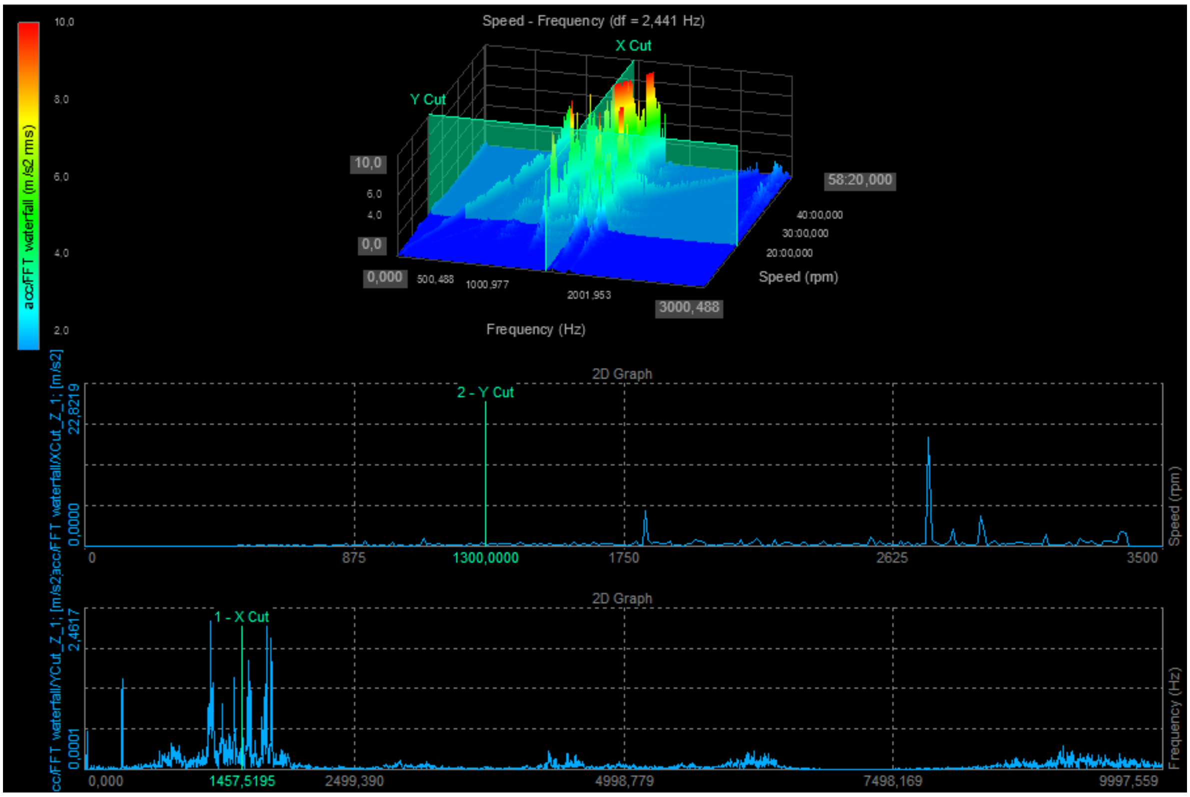
- Current value - shows only a current value of the marker and can be interacted while storing
- Full history - stores calculated values in output channels and can be used as input in other modules

Take a look at the FFT waterfall again. As discussed before, it consists of a lot of FFT's (one for each delta REF) and it might be interesting to extract a single FFT for a user-defined REF value.

Right-click on the 3D graph and add X cut (frequency) or Y cut (speed).



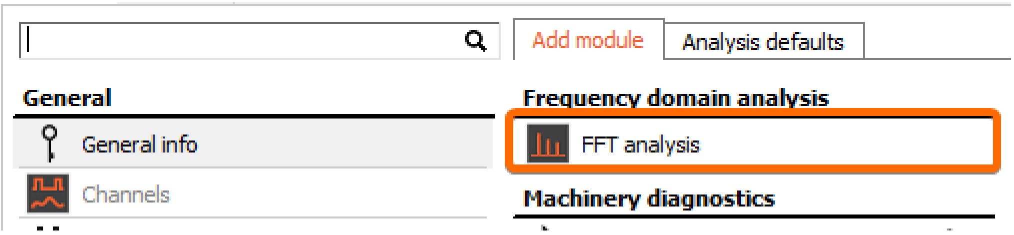
The cut in X and Y direction can be displayed on the 2D graph.


Speed - Frequency (df = 2,441 Hz)
X Cut
Y Cut
acc/FFT waterfall (m/s2 rms)
Frequency (Hz)
Speed (rpm)
58:20,000
3000,488
2D Graph
2 - Y Cut
1300,0000
2D Graph
1 - X Cut
1457,5195
Speed (rpm)
Frequency (Hz)

8. FFT peak calculation

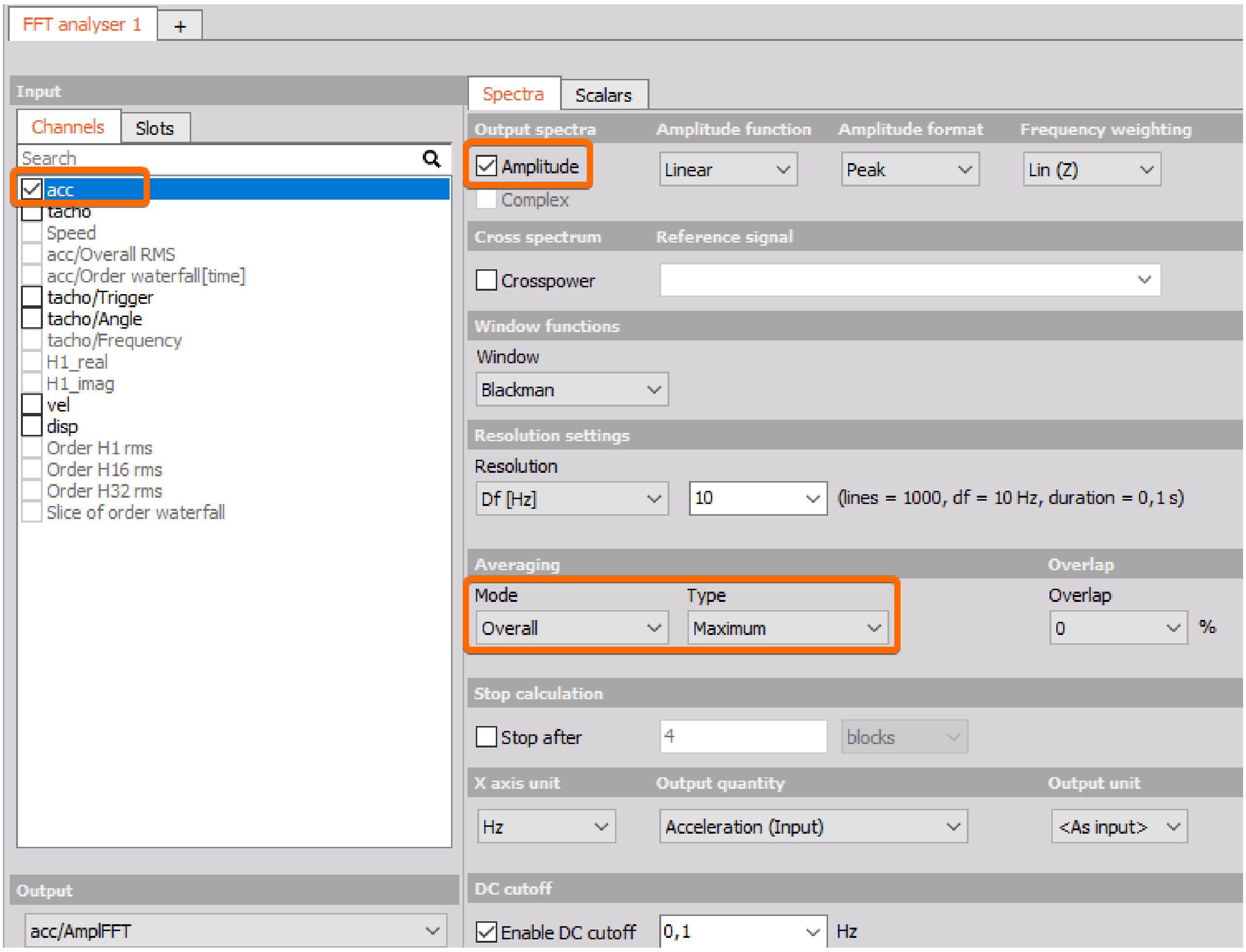
One of the standard measurements to do for example, is the run up of the machine and then calculate the max amplitude over the FFT.

Add the FFT analysis module.



Add FFT analysis module

Then select the input channel, in this example, an acceleration sensor. Set the output to Amplitude, calculation mode to Overall, and averaging type as maximum.

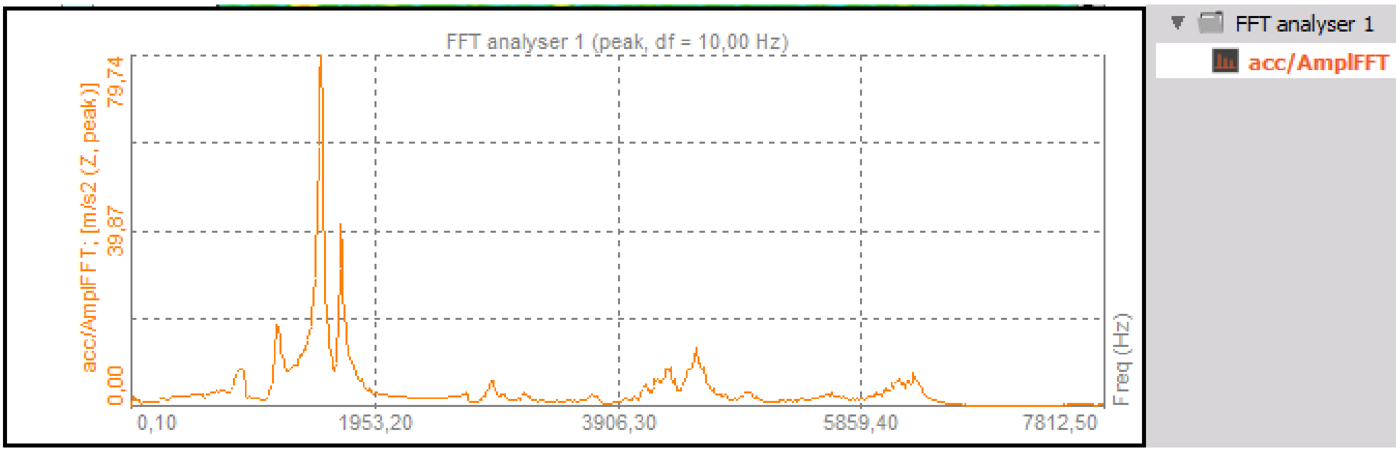


FFT analysis setup

This example was done “offline”, on a data file after the measurement. You can also do it during the measurement.

Then a 2D graph was added (see instrument bar, red box) and the AmplFFT math channel assigned.

In 2D graph display options, the type of Y-axis can be set to logarithmic.

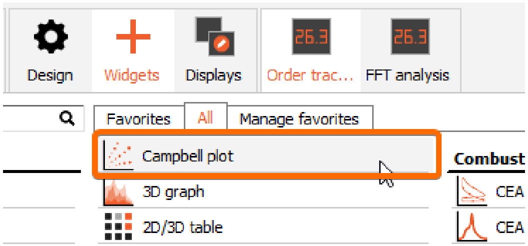


FFT spectrum displayed on the 2D graph

Hint
In the recorder you can select only one section of the data file, to perform the PeakFFT over a specific RPM range. After that the calculated math data can be exported.

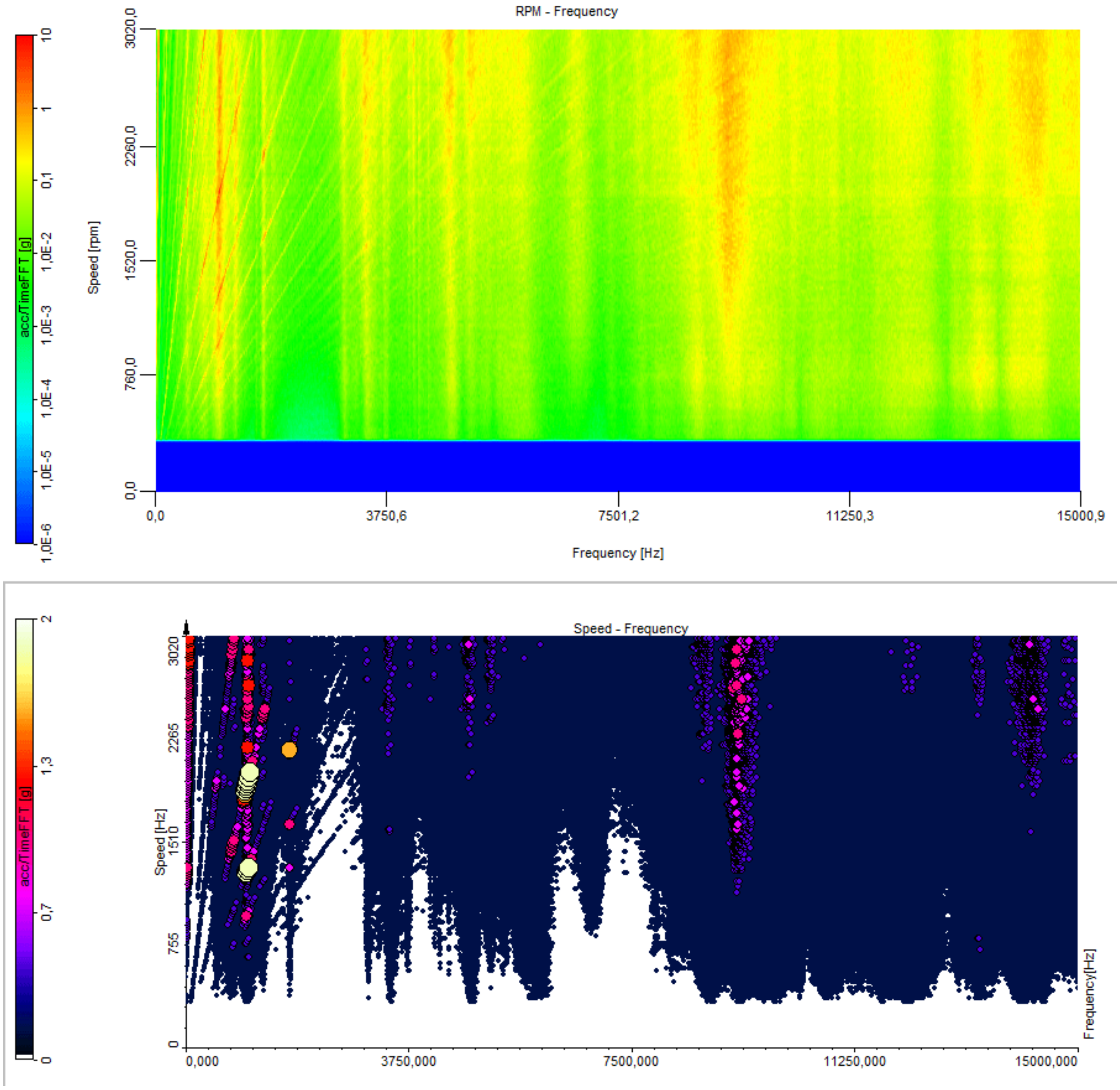
9. Campbell plot

You can also display TimeFFT or Order FFT on Campbell plot. Click on the Design button and add Campbell plot.



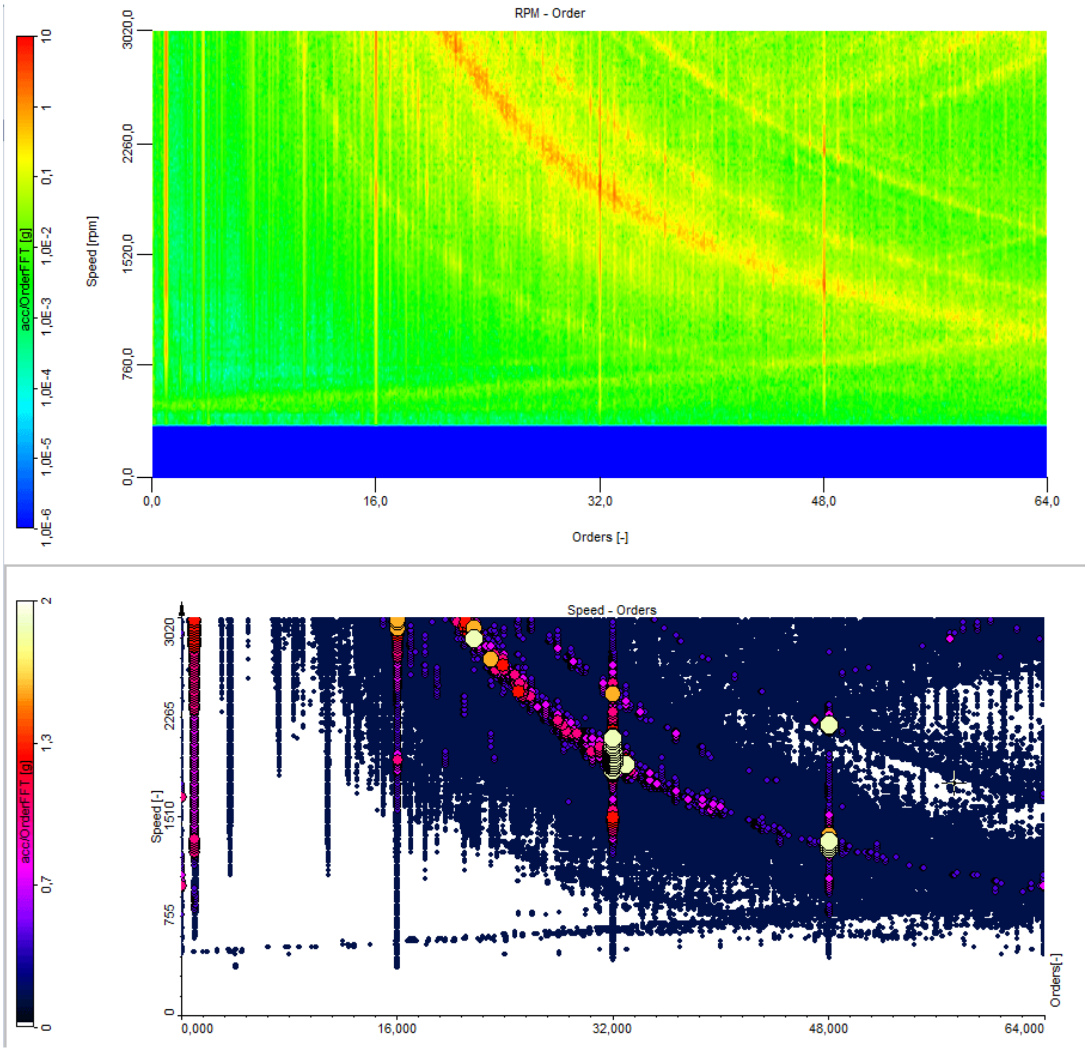
Add Cambell plot

On the upper picture an ordinary 3D graph is shown and the lower one is a Campbell plot.



Campbell plot

Also, the Order FFT can be displayed on the Campbel plot.



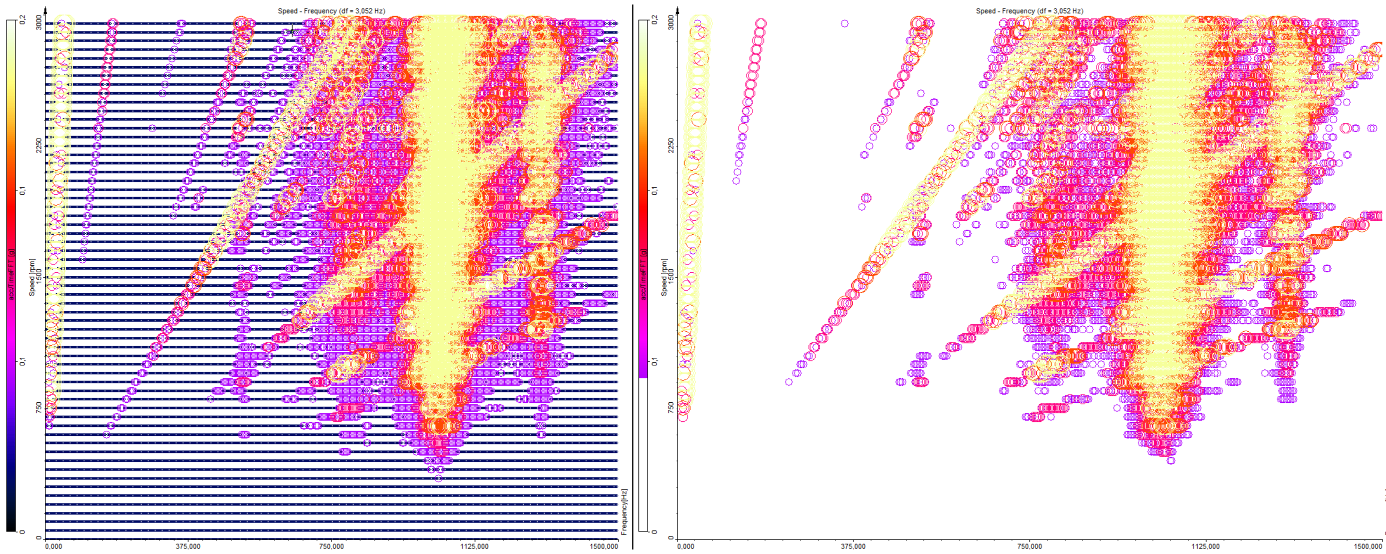
Campbell plot

Campbell plot presents multiple options to manipulate its design.

Minimal and maximal value on the diagram's scale (on the left side of Campbell plot visual control) represents the range of values which will be segmented into levels. Values, bigger than maximal value, belong to the highest level and values, smaller than minimal values fall into the lowest level. In the picture below we can see an example, how the value's range is segmented into levels, where the number of levels is set to 5. Number of levels can be changed within the Levels edit field on the Options tab.

Campbell plot Levels

Cutoff is given in percent. It determines the size of the portion that will be cut out from the range of shown values. Diagram's scale shows which values will not be shown by hiding the scale's color map. Next picture shows an example with no cutoff (0%) on the left side and the right side cutoff was equal to 30%. Scale's color maps are changed accordingly.

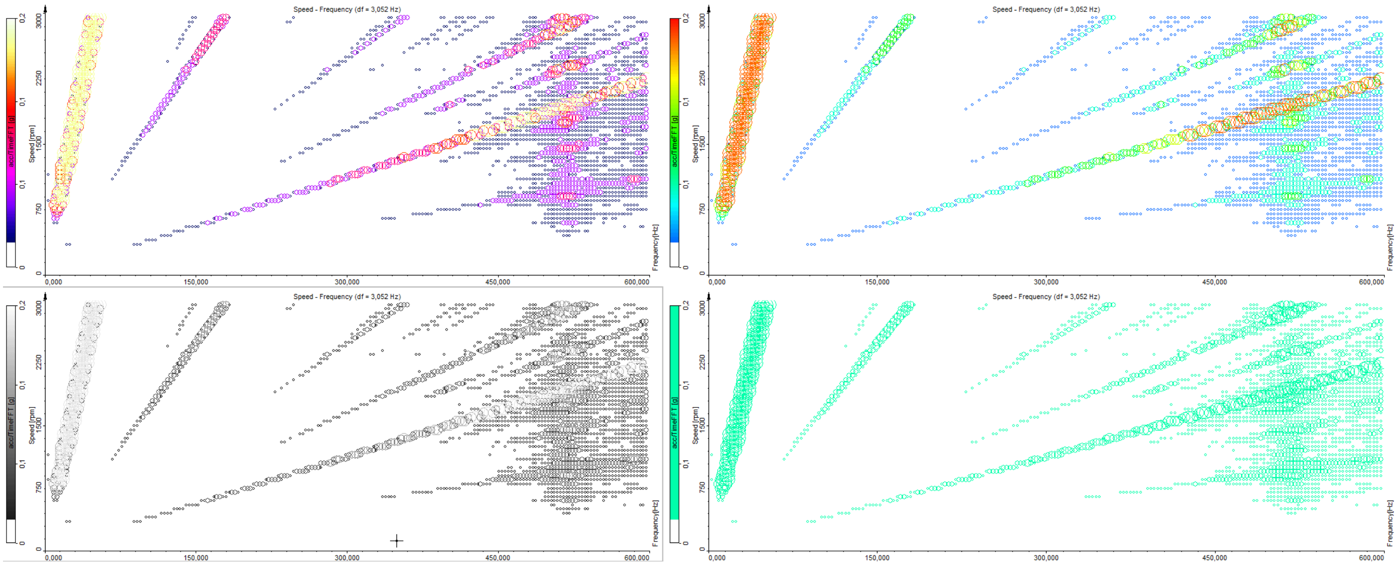


Campbell plot

Hint
By clicking on the diagram and hovering over the scale with your mouse, you can easily define your Cutoff by scrolling up and down.

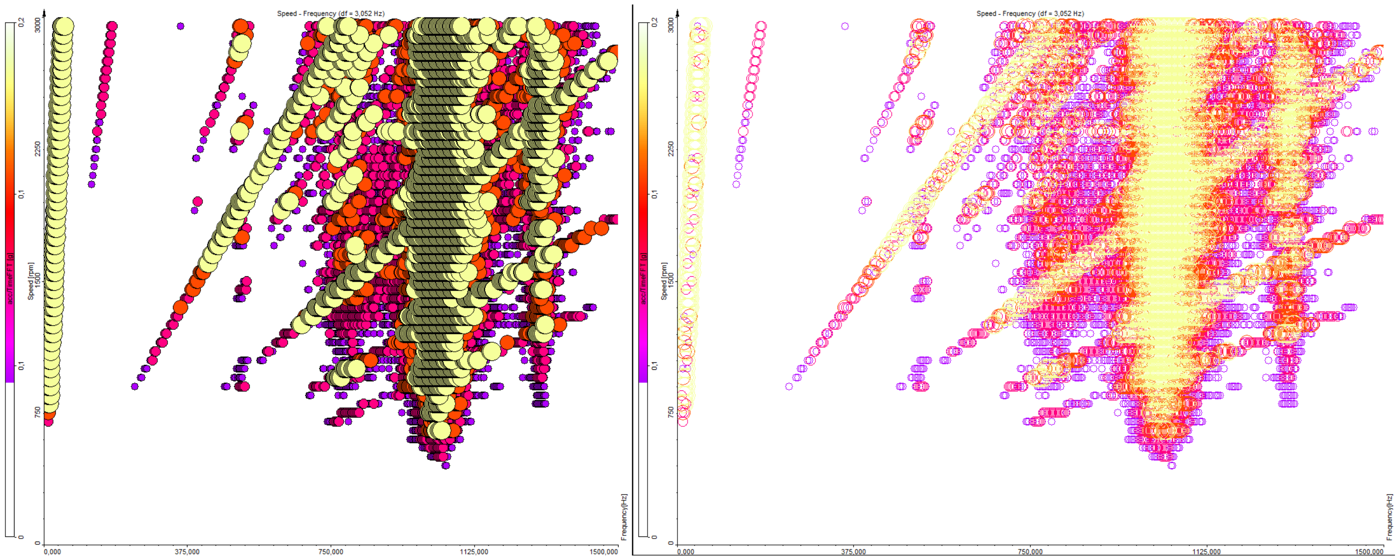
High and low value amplitudes correspond to the diameters of circles from largest to smallest. Diameters of circles from levels in between increases linearly from lowest to highest diameter with respect to the number of levels. Each level has its own diameter.

Scale's colour map can be generated from different palettes (Palette drop-down). Below you can see examples of all of them; Rainbow (warm), Rainbow, Grayscale and single colour, which is colour from the channel on the diagram.



Campbell plot

There are two possible circle styles; outline (by default) and fill. On the left "filled" circle style is shown and on the right only "outlined" circle style is displayed.

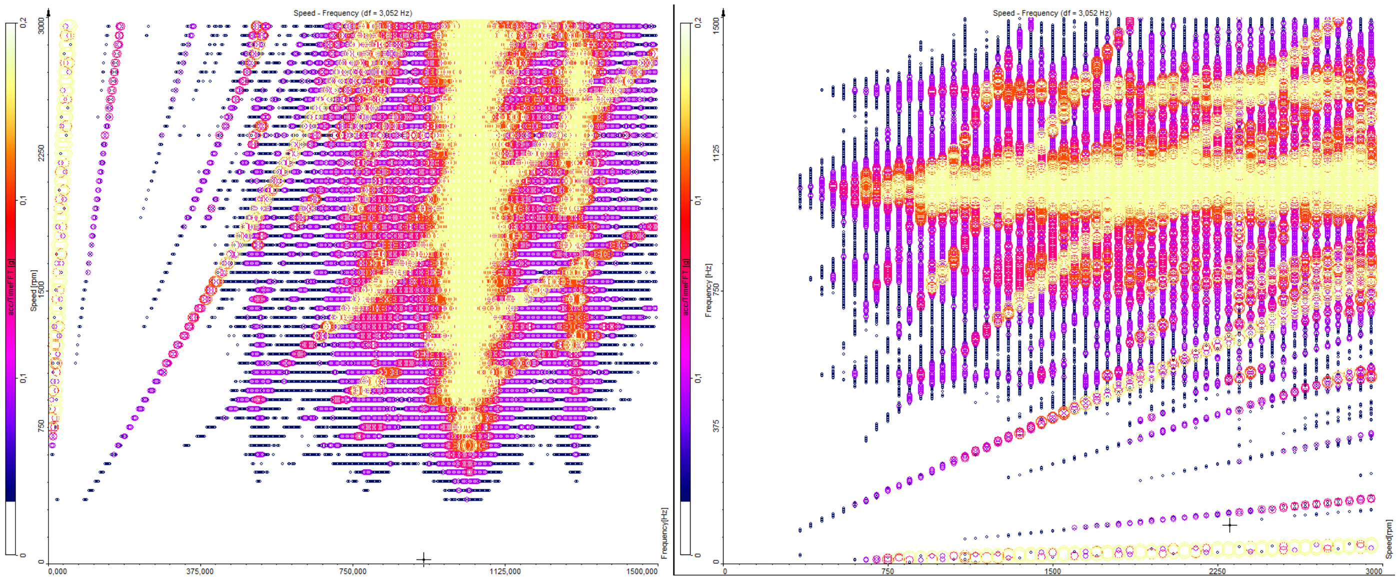


Campbell plot

Campbell plot lets you choose between XY and YX projections. XY has x axis horizontal and y axis vertical, YX projection has it the other way around; X vertical and Y horizontal.

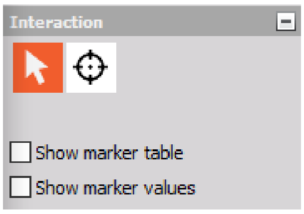
Projection

Positions of x and y axes are set as on the selected icon. Left we have XY projection and YX on the right.



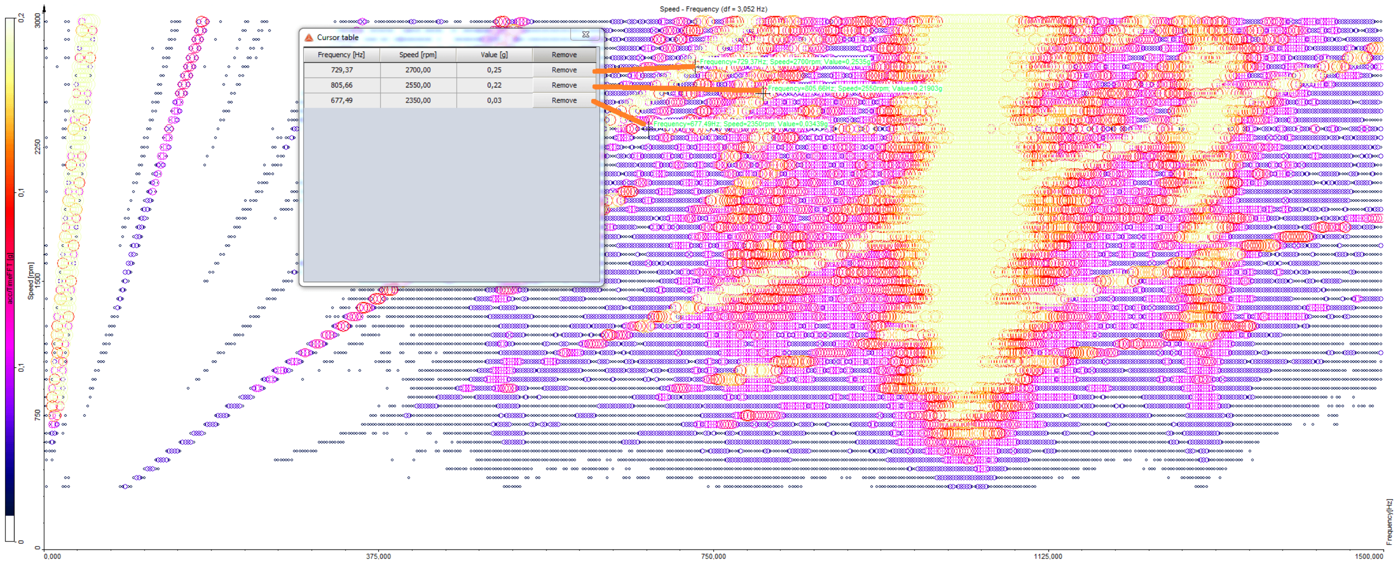
Campbell plot

Selection marker (selected on the image below), shows you the value of the area where your mouse cursor is currently positioned on the diagram. Value is shown in the upper left corner of visual control.



Interaction

Free marker (not selected above), allows you to mark the position with one left click of the mouse on the wanted area. You cannot click on the area where there are no values (cut out levels). Little crosses will be drawn, to show the marker's position with its index written on the side. If Show marker values are checked, value on the marker will be shown instead of its index. In the picture there is also a marker table, which has all marker values collected. Only for demonstration reasons on the picture below, the line connects markers and their values in the table.

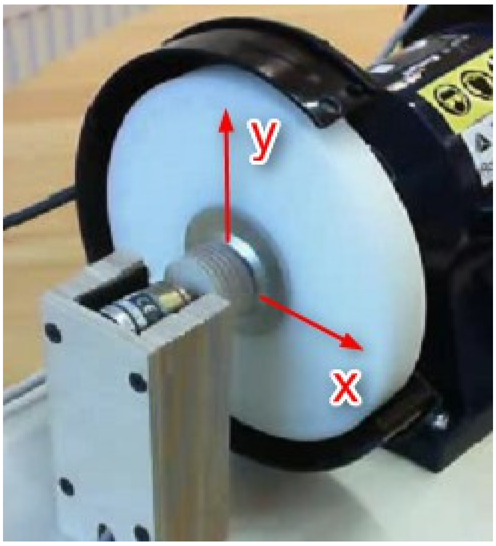


Campbell plot

10. Orbit graph

To learn more about Orbit analysis please take a look at the Orbit analysis manual.
Dedicated Orbit analysis and measurements of journal bearings using displacement / proximity probes are supported using the Orbit analysis module, as specified in the linked manual above.

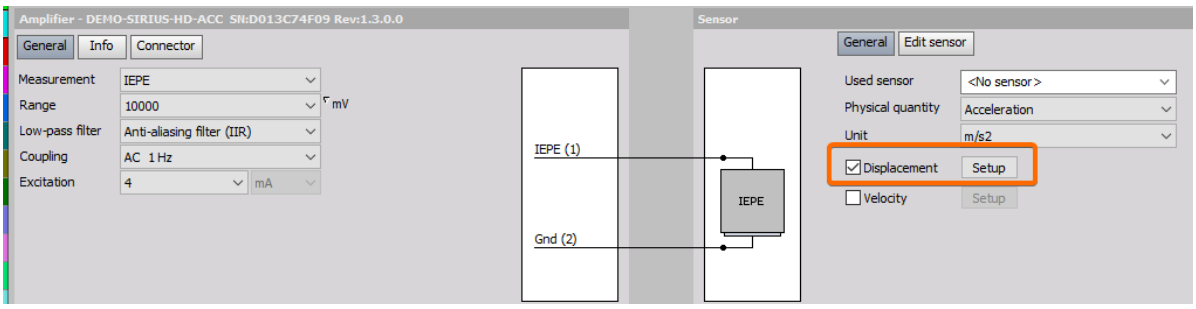
In this example, we want to visualize the movement of a rotating disc. To have a high angular resolution we use an encoder with 1024 pulses per revolution. A 2-axis acceleration sensor is mounted on the metal frame holding the motor. The axis orientation is shown as below.



2-axis acceleration sensor positioning

The output of the sensor is an acceleration in m/s². If we use double integration on it, we can calculate the displacement in µm.

This can be done directly in the channel setup for the accelerometer or using Derivation/Integration math.

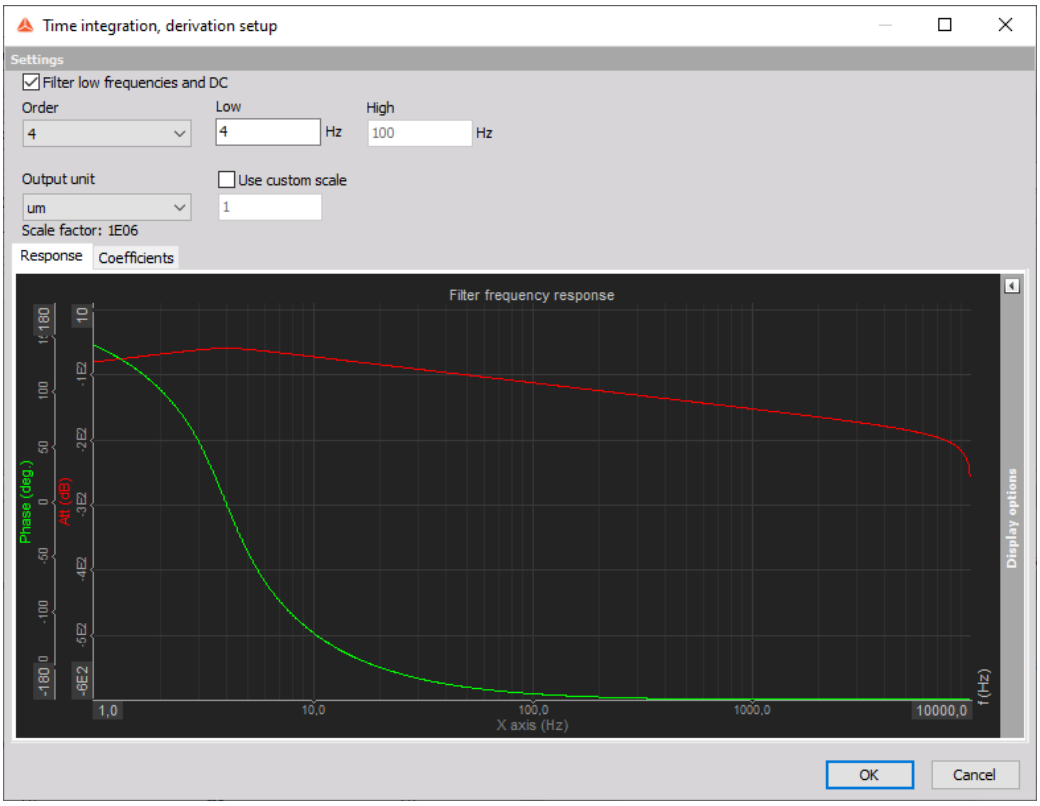


Channel setup

The filter order and low-pass frequency have to be chosen carefully in order not to create an unwanted and unstable output signal.

To determine the filter frequency, make an FFT spectrum on the acceleration sensor and look for the lowest dominant frequency. 4th order 4 Hz is a good starting point (signals below 4Hz * 60 = 240 rpm will be cut).

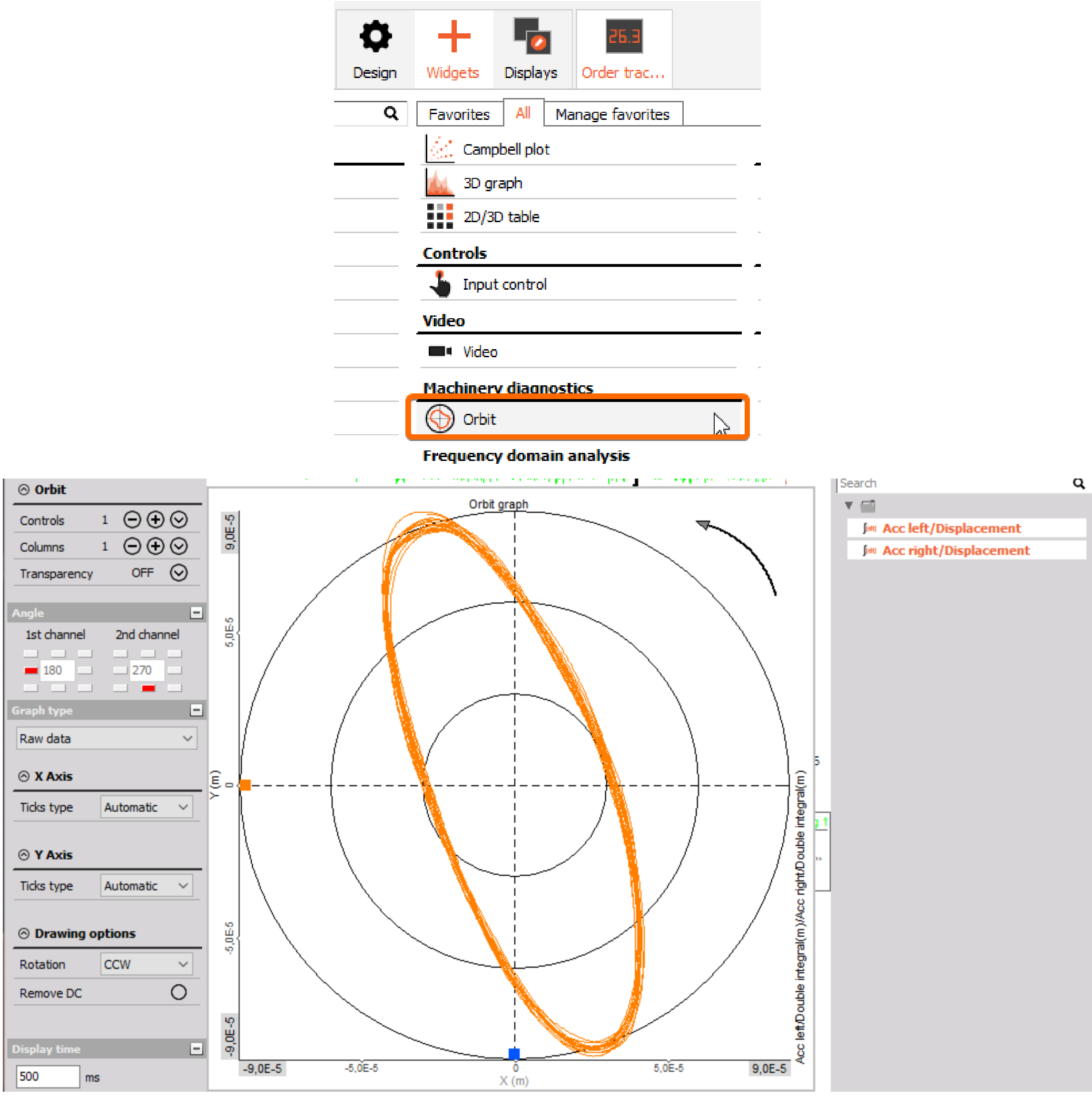
If you use lower frequencies / higher orders the filter can start slowly bouncing due to integral math DC output.



Time integration/derivation setup

The visual instrument for that operation is the “Orbit graph”.

Assign first x, then y displacement output. Both axes are scaled with the same min/max values automatically.



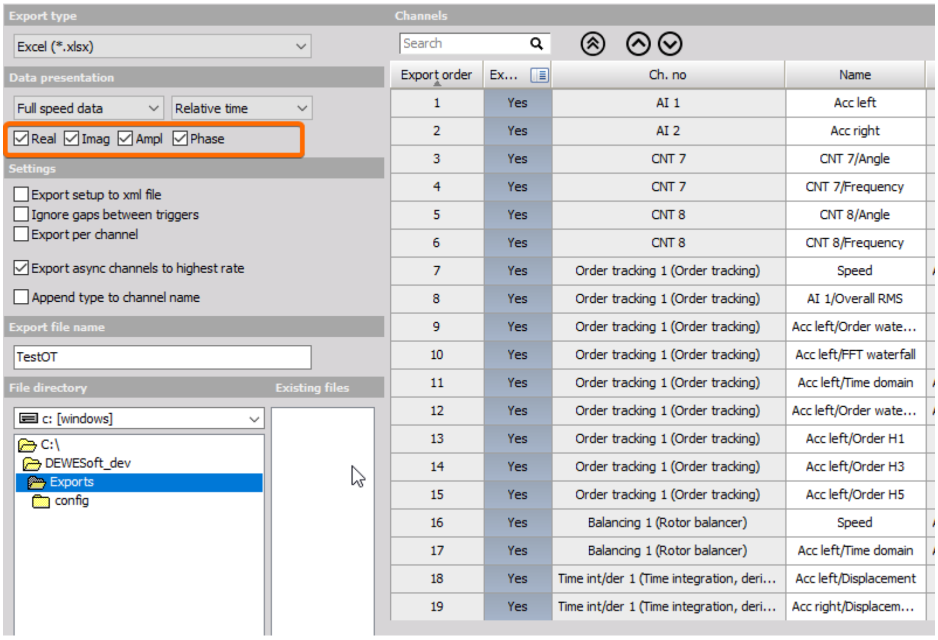
Add Orbit graph

11. Analyze and export

In the Analysis mode, DewesoftX® provides data review, modifying or adding Math-Modules and printing the complete screen for generating your report as well. Similar to the Measurement mode you can modify or add new Visuals or Displays. All these modifications can be stored in the data file with Store Settings and Events. This display layout and formulas can also be loaded on other data files with Load Display & Math Setup or with the multi-file operation Apply action.

11.1. Export of complex data

Go to the Export section, on top you see the “Complex export” box, check e.g. Real and Imag. Then select the signal/Complex channel. If you additionally select other channels, they will not be affected. This setting is only applied to the Complex dataset.



Exporting Real, Imag, Ampl and Phase data

For each order, we selected for calculation in the order tracking setup (1st, 16th, 32nd, 48th) two columns (real, imag) are exported.

	A	B (1st Re)	C (16th Re)	D	E	F (1st Im)	G (16th Im)	H	I
1	Time	OT0/acc/Complex1_Real	OT0/acc/Complex16_Real	OT0/acc/Complex32_Real	OT0/acc/Complex48_Real	OT0/acc/Complex1_Imag	OT0/acc/Complex16_Imag	OT0/acc/Complex32_Imag	OT0/acc/Complex48_Imag
2	s	g	g	g	g	g	g	g	g
3	0,3264	-1,8924294	-1,8670999	-0,59492481	0,6226669	0,14801131	1,7072728	0,94815034	0,06560488
4	0,75022	-1,8914028	-1,8645577	-0,55500567	0,59901708	0,14439532	1,8958366	0,88525283	-0,072931036
5	1,25028	-1,8891592	-1,8219287	-0,62545186	0,65623963	0,14190185	1,9010379	0,88075542	-0,04811614
6	1,74996	-1,8803375	-1,8647492	-0,92975509	0,39908624	0,14533	1,6848087	0,82456315	-0,17070429
7	2,2495	-1,8445768	-1,8487459	-0,59679049	0,2546649	0,13915473	1,6384701	-0,32637334	-0,13139677
8	2,64898	-1,8192401	-1,7474957	0,089906305	0,30932945	0,13957092	1,5865844	-0,22803432	-0,12118319
9	2,88808	-1,7965913	-1,8009541	0,34905559	0,24165301	0,13829747	1,1569586	-0,10071415	-0,1797888
10	3,11764	-1,7796891	-1,7358172	0,40260845	0,20808092	0,13395816	1,0943856	-0,1503956	-0,15445612
11	3,40938	-1,7544181	-1,8534465	0,39726961	0,21079053	0,12718414	0,75417137	-0,14476593	-0,19174594
12	3,697	-1,7382498	-1,8810842	0,38627684	0,15772793	0,12542617	0,85215962	-0,13470529	-0,16696268

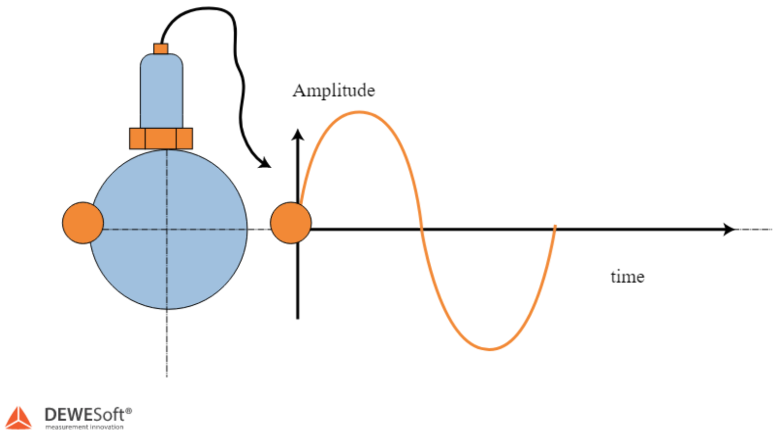
Exported data

12. Additional information

After we have shown how to extract orders and visualize them in DewesoftX®, this page should give a rough idea what 1st, 2nd ... order means and what might be their possible source.

12.1. 1st order = unbalance

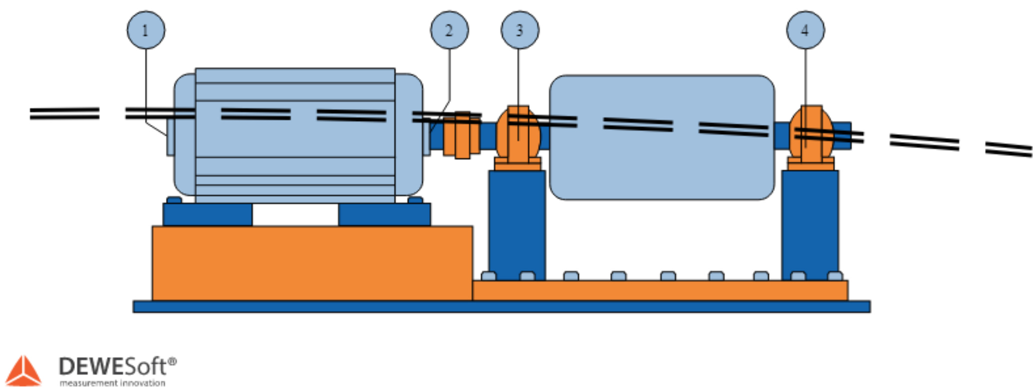
The first order is the shaft frequency, so if the first order is the main reason for high vibration, this is related to an unbalanced shaft or blade.



Unbalance

Imagine a blade or shaft or any rotating part that has a higher weight at one side. This weight will rotate with exactly the rotational speed (1st order), create a force and, therefore, a vibration frequency which is exactly the rotation speed or first order. So high amplitudes of first orders indicate an unbalanced system.

12.2. 1st and 2nd order = misalignment



Misalignment

If a high second order is observed in the vibration spectrum of a machine, it often indicates a misalignment of two coupled engines. So, two times per revolution (2nd order) the shaft is bent and causes a vibration force, which is transmitted to the mechanical structure and creates a vibration.

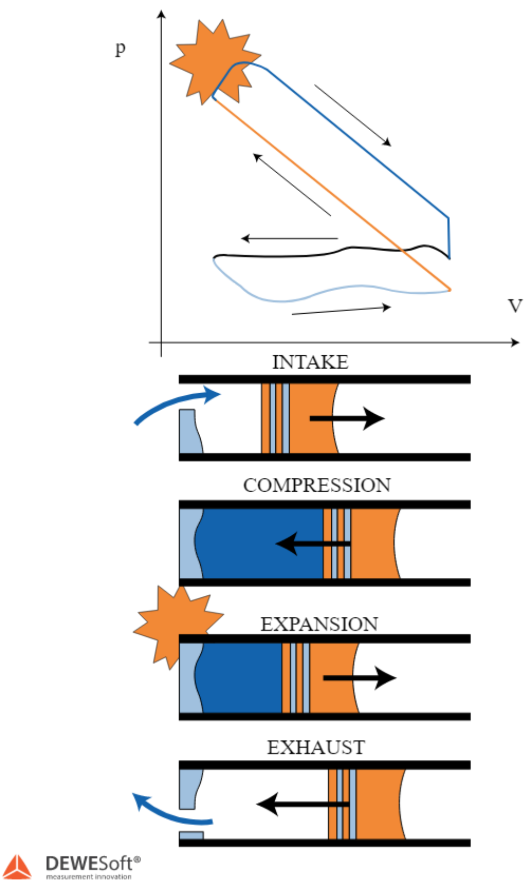
12.3. Diesel and gasoline engines

In diesel and gasoline engines, we can observe that the 2nd, 3rd or 6th order are almost all the time dominant.

It depends on the cylinder count of the engine. Let's assume we have a 4 cylinder 4 stroke engine. One cylinder is fired every 2 revolutions, so we would get 0.5 order vibration if we would have a 1 cylinder engine.

With a 4 cylinder engine the firing of the 4 cylinders is distributed over 4 revolutions, 2 rev/4 = 0,5 rev so one of the 4 cylinders will fire every 0,5 revolutions. This will lead to high second order vibration.

A 6 cylinder 4 stroke engine will produce high 2 rev/6 = 0.33rev → 3rd order.



Diesel and gasoline engines

13. Annex I: Order resolution and maximum order settings

Results from the order tracking module are dependent from calculation block size (FFT block). This block is calculated from order resolution and maximum order. Order FFT and Time domain harmonics data are also dependent from filters applied during resampling.

Order resolution defines how many periods will be taken for calculation. With order resolution 1/8 we take 8 periods, with order resolution 1/16, we take 16 periods, etc. The order resolution and number of required rotations/periods are related by:

$$\Delta order = 1/\#rev.$$

When smaller resolution is used, calculated curves become smoother. At 1/8 order resolution, curves are still a little rough on the edges, but with order resolution 1/64, curves are smoother. It's like averaging, bigger FFT blocks provide a smoother curve. With the examples below, the maximum order for calculation was the same all the time.

Different Resolution

Block for calculation (FFT block) is calculated from the wanted number of periods (=1/order resolution) and samples (resampled) needed for calculation of maximum order harmonic.

We want that maximum order harmonic to have at least 2 samples per period -> first harmonic will have 2*maximum order samples per period and whole calculation block will have (1/order resolution * 2 * max order) samples. Smaller the order resolution bigger the calculation blocks.

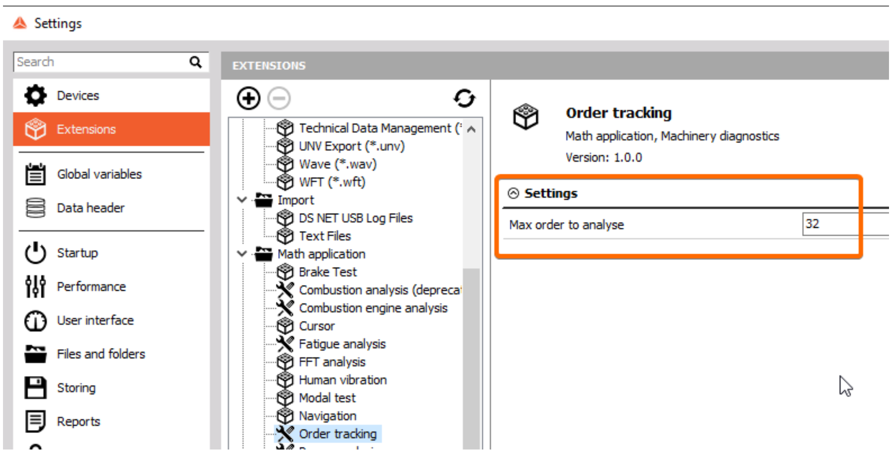
Order FFT block size = 2 * 1/Order resolution * Maximum Order

Important
In an FFT, if the line resolution is 0.5 Hz, the required data window must be 2s. The same is true for the order resolution: If the resolution is set to 0,25 orders, 4 revolutions are required for one data block.

Maximum Order	Order resolution	FFT block size
8	1/8	128
16	1/8	256
32	1/8	512
64	1/8	1024
8	1/32	128
16	1/32	512
32	1/32	1024
64	1/32	2048
8	1/64	1024
16	1/64	2048
32	1/64	4096
64	1/64	8192

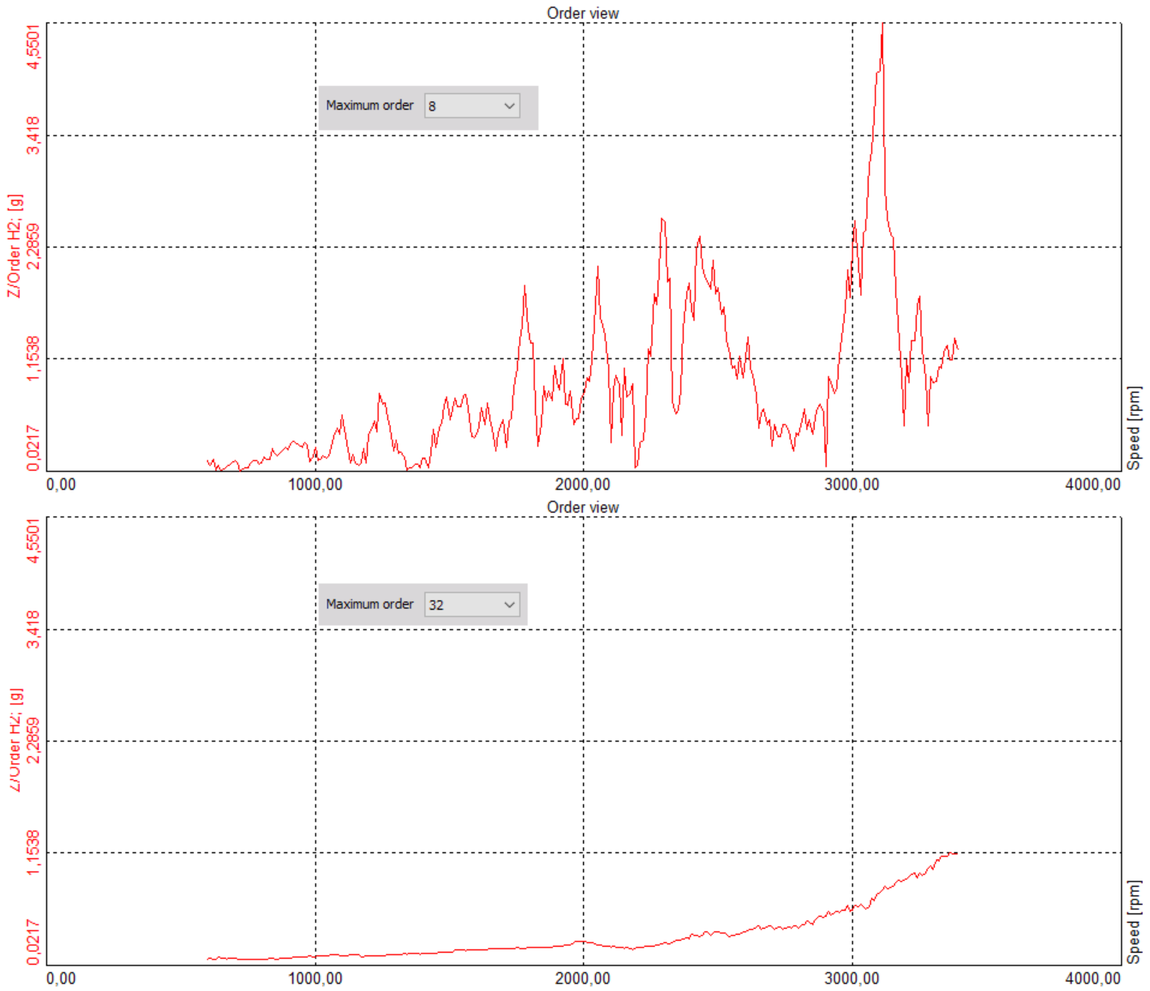
When we choose a maximum order of 64, it is logical that the filter in calculation will need to have a higher cut-off frequency than for maximum order 32, since we don't want to cut out orders smaller than 64.

A Major factor on final appearance of results from order tracking is also filtering, that is used while data are resampled. This filter is dependent on maximum order. For calculation, cut-off frequency and steepness of this filter are set according to maximum order or maximum order to analyze, whichever is greater. Max order to analyze is an advanced setting, which tells us, how many orders we still want to take into consideration at resampling (how we set filter's cut-off frequency), independent from maximum order setting directly in order tracking setup.



Order tracking settings

For calculating one block, order tracking will take 8 periods (if order resolution is 1/8), but it will have more samples for analysis with 64^{th} order, hence more accurate results. We need more samples if we want to analyze higher orders. For example, if we have 1024 (= FFT size) samples per block with 64^{th} order and 512 samples with 32^{nd} order, we have 8 periods in one block in both cases.

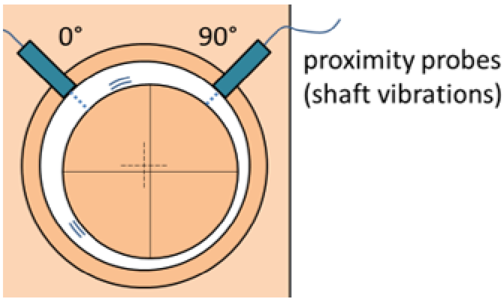


Max order settings

14. Annex II: Orbit plot

To learn more about Orbit analysis please take a look at the Orbit analysis manual.

To display the movement of the shaft on an orbit plot you need two proximity probes (eddy current sensors at 0° and 90°) that measure the shaft movement.



Proximity probes

To be able to set the Orbit plot in the properties to “Order tracking” mode, both channels where the proximity probes are connected must be selected as the input!

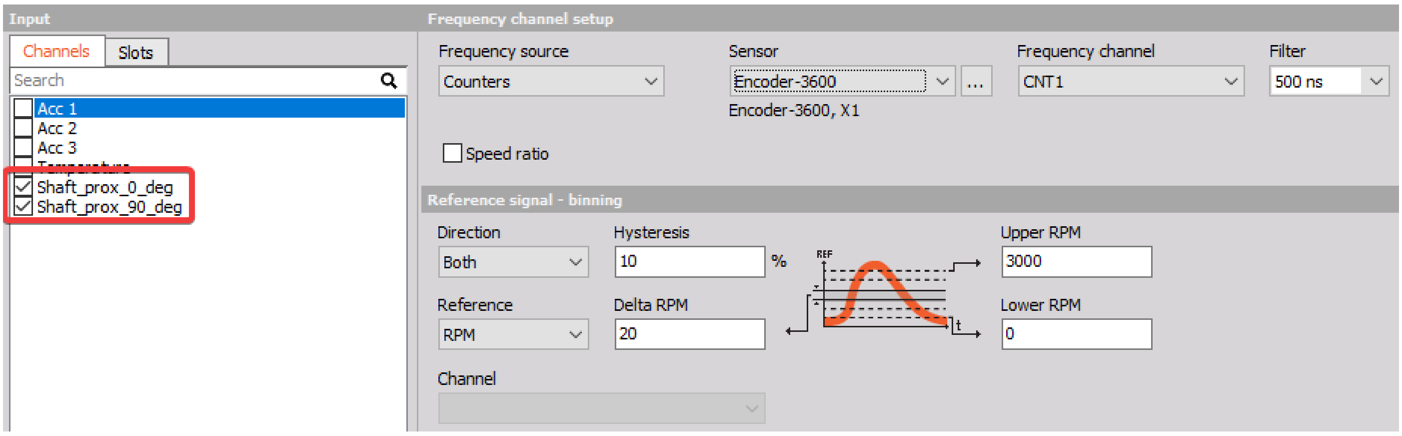
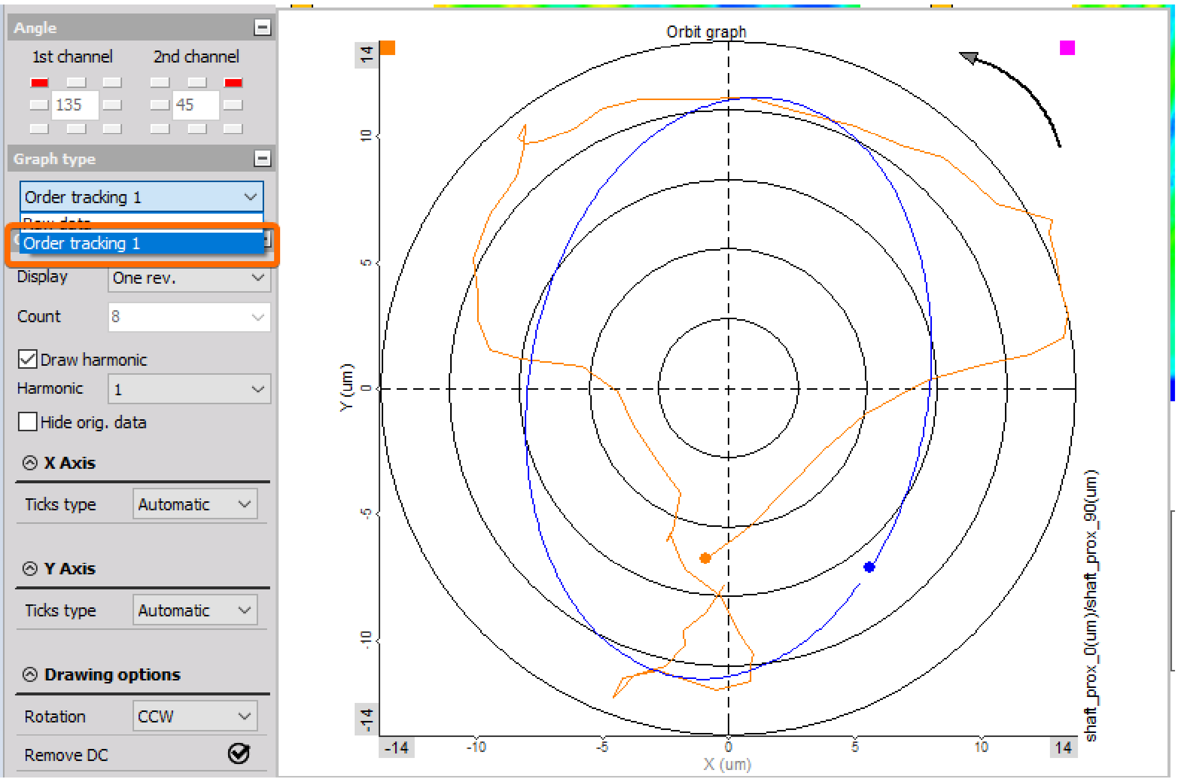


Image 84: Select channels used for order tracked orbit plots

The “shaft orbit” plots the proximity raw signals against each other, but you can select from the properties to “remove DC”. So, it is like high-pass-filtered, we only see the high-frequency vibrations of the shaft.

With the orbit plot set to “Order tracking” mode, you get additional options:

- display adjustable number of revolutions
- average over a number of revolutions
- draw the harmonics (extracted by the order tracking module before)



Presenting data on Orbit graph

15. Warranty information

Notice:
The information contained in this document is subject to change without notice.

Note:
Dewesoft d.o.o. shall not be liable for any errors contained in this document. Dewesoft MAKES NO WARRANTIES OF ANY KIND WITH REGARD TO THIS DOCUMENT, WHETHER EXPRESS OR IMPLIED. DEWESOFT SPECIFICALLY DISCLAIMS THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE. Dewesoft shall not be liable for any direct, indirect, special, incidental, or consequential damages, whether based on contract, tort, or any other legal theory, in connection with the furnishing of this document or the use of the information in this document.

The copy of the specific warranty terms applicable to your Dewesoft product and replacement parts can be obtained from your local sales and service office. To find a local dealer for your country, please visit https://dewesoft.com/support/distributors.

15.1. Calibration

Every instrument needs to be calibrated at regular intervals. The standard norm across nearly every industry is annual calibration. Before your Dewesoft data acquisition system is delivered, it is calibrated. Detailed calibration reports for your Dewesoft system can be requested. We retain them for at least one year, after system delivery.

15.2. Support

Dewesoft has a team of people ready to assist you if you have any questions or any technical difficulties regarding the system. For any support please contact your local distributor first or Dewesoft directly.

Dewesoft d.o.o.
Gabrsko 11a
1420 Trbovlje Slovenia

Europe Tel.: +386 356 25 300
Web: http://www.dewesoft.com
Email: Support@dewesoft.com
The telephone hotline is available Monday to Friday from 07:00 to 16:00 CET (GMT +1:00)

15.3. Service/repair

The team of Dewesoft also performs any kinds of repairs to your system to assure a safe and proper operation in the future. For information regarding service and repairs please contact your local distributor first or Dewesoft directly on https://dewesoft.com/support/rma-service.

15.4. Restricted Rights

15.6. Copyright

15.7. Trademarks

We take pride in our products and we take care that all key products and technologies are registered as trademarks all over the world. The Dewesoft name is a registered trademark. Product families (KRYPTON, SIRIUS, DSI, DS-NET) and technologies (DualCoreADC, SuperCounter, GrandView) are registered trademarks as well. When used as the logo or as part of any graphic material, the registered trademark sign is used as a part of the logo. When used in text representing the company, product or technology name, the ® sign is not used. The Dewesoft triangle logo is a registered trademark but the ® sign is not used in the visual representation of the triangle logo.

16. Safety instructions

Your safety is our primary concern! Please be safe!

16.1. Safety symbols in the manual

Warning
Calls attention to a procedure, practice, or condition that could cause the body injury or death

Caution
Calls attention to a procedure, practice, or condition that could possibly cause damage to equipment or permanent loss of data.

16.2. General Safety Instructions

Warning

The following general safety precautions must be observed during all phases of operation, service, and repair of this product. Failure to comply with these precautions or with specific warnings elsewhere in this manual violates safety standards of design, manufacture, and intended use of the product. Dewesoft d.o.o. assumes no liability for the customer's failure to comply with these requirements.

All accessories shown in this document are available as an option and will not be shipped as standard parts.

16.2.1. Environmental Considerations

Information about the environmental impact of the product.

16.2.2. Product End-of-Life Handling

Observe the following guidelines when recycling a Dewesoft system:

16.2.3. System and Components Recycling

Production of these components required the extraction and use of natural resources. The substances contained in the system could be harmful to your health and to the environment if the system is improperly handled at its end of life! Please recycle this product in an appropriate way to avoid unnecessary pollution of the environment and to keep natural resources.

This symbol indicates that this system complies with the European Union's requirements according to Directive 2002/96/EC on waste electrical and electronic equipment (WEEE). Please find further information about recycling on the Dewesoft web site www.dewesoft.com

Restriction of Hazardous Substances
This product has been classified as Monitoring and Control equipment and is outside the scope of the 2002/95/EC RoHS Directive. However, we take care of our environment and the product is lead-free.

16.2.4. General safety and hazard warnings for all Dewesoft systems

Safety of the operator and the unit depend on following these rules.

- Use this system under the terms of the specifications only to avoid any possible danger.

- Read your manual before operating the system.
- Observe local laws when using the instrument.
- DO NOT touch internal wiring!
- DO NOT use higher supply voltage than specified!
- Use only original plugs and cables for harnessing.
- You may not connect higher voltages than rated to any connectors.
- The power cable and connector serve as Power-Breaker. The cable must not exceed 3 meters, the disconnect function must be possible without tools.
- Maintenance must be executed by qualified staff only.
- During the use of the system, it might be possible to access other parts of a more comprehensive system. Please read and follow the safety instructions provided in the manuals of all other components regarding warning and security advice for using the system.
- With this product, only use the power cable delivered or defined for the host country.
- DO NOT connect or disconnect sensors, probes or test leads, as these parts are connected to a voltage supply unit.
- Ground the equipment: For Safety Class 1 equipment (equipment having a protective earth terminal), a non-interruptible safety earth ground must be provided from the mains power source to the product input wiring terminals.
- Please note the characteristics and indicators on the system to avoid fire or electric shocks. Before connecting the system, please read the corresponding specifications in the product manual carefully.
- The inputs must not, unless otherwise noted (CATx identification), be connected to the main circuit of category II, III and IV.
- The power cord separates the system from the power supply. Do not block the power cord, since it has to be accessible for the users.
- DO NOT use the system if equipment covers or shields are removed.
- If you assume the system is damaged, get it examined by authorized personnel only.
- Adverse environmental conditions are Moisture or high humidity Dust, flammable gases, fumes or dissolver Thunderstorm or thunderstorm conditions (except assembly PNA) Electrostatic fields, etc.
- The measurement category can be adjusted depending on module configuration.
- Any other use than described above may damage your system and is accompanied with dangers like short-circuiting, fire or electric shocks.
- The whole system must not be changed, rebuilt or opened.
- DO NOT operate damaged equipment: Whenever it is possible that the safety protection features built into this product have been impaired, either through physical damage, excessive moisture, or any other reason, REMOVE POWER and do not use the product until the safe operation can be verified by service-trained personnel. If necessary, return the product to Dewesoft sales and service office for service and repair to ensure that safety features are maintained.
- If you assume a more riskless use is not provided anymore, the system has to be rendered inoperative and should be protected against inadvertent operation. It is assumed that a more riskless operation is not possible anymore if the system is damaged obviously or causes strange noises. The system does not work anymore. The system has been exposed to long storage in adverse environments. The system has been exposed to heavy shipment strain.
- Warranty void if damages caused by disregarding this manual. For consequential damages, NO liability will be assumed!
- Warranty void if damage to property or persons caused by improper use or disregarding the safety instructions.

- Unauthorized changing or rebuilding the system is prohibited due to safety and permission reasons (CE).
- Be careful with voltages >25 VAC or >35 VDC! These voltages are already high enough in order to get a perilous electric shock by touching the wiring.
- The product heats during operation. Make sure there is adequate ventilation. Ventilation slots must not be covered!
- Only fuses of the specified type and nominal current may be used. The use of patched fuses is prohibited.
- Prevent using metal bare wires! Risk of short circuit and fire hazard!
- DO NOT use the system before, during or shortly after a thunderstorm (risk of lightning and high energy over-voltage). An advanced range of application under certain conditions is allowed with therefore designed products only. For details please refer to the specifications.
- Make sure that your hands, shoes, clothes, the floor, the system or measuring leads, integrated circuits and so on, are dry.
- DO NOT use the system in rooms with flammable gases, fumes or dust or in adverse environmental conditions.
- Avoid operation in the immediate vicinity of high magnetic or electromagnetic fields, transmitting antennas or high-frequency generators, for exact values please refer to enclosed specifications.
- Use measurement leads or measurement accessories aligned with the specification of the system only. Fire hazard in case of overload!
- Do not switch on the system after transporting it from a cold into a warm room and vice versa. The thereby created condensation may damage your system. Acclimatise the system unpowered to room temperature.
- Do not disassemble the system! There is a high risk of getting a perilous electric shock. Capacitors still might be charged, even if the system has been removed from the power supply.
- The electrical installations and equipment in industrial facilities must be observed by the security regulations and insurance institutions.
- The use of the measuring system in schools and other training facilities must be observed by skilled personnel.
- The measuring systems are not designed for use in humans and animals.
- Please contact a professional if you have doubts about the method of operation, safety or the connection of the system.
- Please be careful with the product. Shocks, hits and dropping it from already- lower level may damage your system.
- Please also consider the detailed technical reference manual as well as the security advice of the connected systems.
- This product has left the factory in safety-related flawlessness and in proper condition. In order to maintain this condition and guarantee safety use, the user has to consider the security advice and warnings in this manual.

EN 61326-3-1:2008
IEC 61326-1 applies to this part of IEC 61326 but is limited to systems and equipment for industrial applications intended to perform safety functions as defined in IEC 61508 with SIL 1-3.

The electromagnetic environments encompassed by this product family standard are industrial, both indoor and outdoor, as described for industrial locations in IEC 61000-6-2 or defined in 3.7 of IEC 61326-1.

Equipment and systems intended for use in other electromagnetic environments, for example, in the process industry or in environments with potentially explosive atmospheres, are excluded from the scope of this product family standard, IEC 61326-3-1.

Devices and systems according to IEC 61508 or IEC 61511 which are considered as “operationally well-tried”, are excluded from the scope of IEC 61326-3-1.

Fire-alarm and safety-alarm systems, intended for the protection of buildings, are excluded from the scope of IEC 61326-3-1.

17. Documentation version history

Version	Date [dd.mm.yyyy]	Notes
1.4	7.11.2019	Updated template
1.3	5.1.2018	Added description for max order and order resolution, added description for orbit plot
1.2	27.7.2015	Added Annex I, updated template and Dewesoft logo
1.1	10.6.2014	Added missing pictures
1.0	14.2.2014	Initial revision
V20-1	31.8.2020	New Template
V21-1	15.10.2021	Updated screenshots of the software to match the UI in the software, updated images in the Introduction section, Added description for Speed ratio, Added description for binning and bin update, Updated description for extracting interharmonics, Added description for Processing markers on 2D graph, added link to the manual, Updated description for Orbit graph
V21-2	26.11.2021	Updated screenshots for the OT setup UI to match SW V. 2021.5. Keyphasor parameter changed to Phase reference. Bin update related outputs are specified. Added info for Spectral weighting and Skip missing bins. Common properties are set to Heading 2.
V21-3	30.12.2021	Added section for Signal tracking. Added section for Demodulation. Updated screenshots for the OT setup UI to match SW V. 2021.6.
V23-1	15.06.2023	Changed manual name from Order tracking to Order analysis. Updated module screenshots Added info for Phase channel as Frequency source. Extended Speed ratio section Added info about separate channels for runup and coastdown Minor text corrections in the manual.