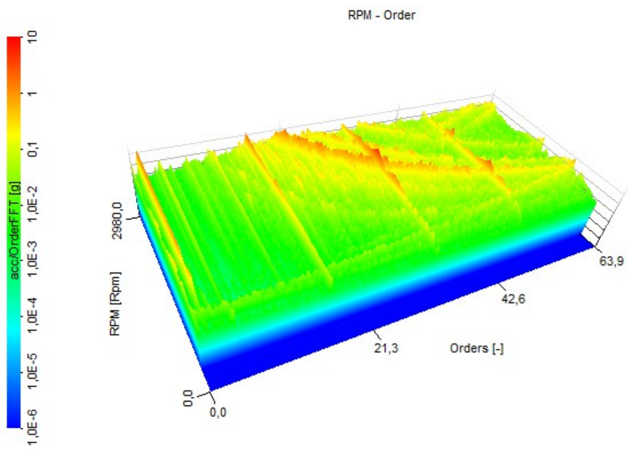
Ordertracking

Users Manual

Version: 1.0



Thank you!

Thank you very much for your investment in our unique data acquisition systems. These are top-quality instruments which are designed to provide you years of reliable service. This guide has been prepared to help you get the most from your investment, starting from the day you take it out of the box, and extending for years into the future.

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1.1 Safety instructions

Your safety is our primary concern! Please be safe!

Safety symbols in the manual

WARNING	Calls attention to a procedure, practice, or condition that could cause 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.

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 GmbH assumes no liability for the customer's failure to comply with these requirements.

1.2 About this document

This is the Users Manual for Ordertracking Version 1.0.

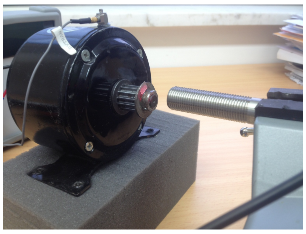
1.3 Legend

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

IMPORTANT	Gives you an important information about a subject. Please read carefully!
HINT	Gives you a hint or provides additional information about a subject.
EXAMPLE	Gives you an example to a specific subject.

2 Introduction

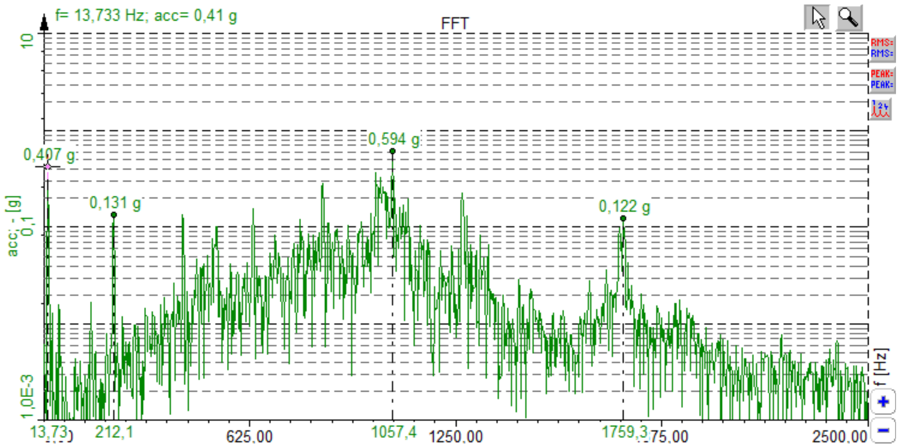
2.1 Basic theory



Before we start explaining all the different options of the setup, let's check at first why we need the Ordertracking module inside DEWESoft 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.

2.1.1 FFT spectrum @ 800 rpm

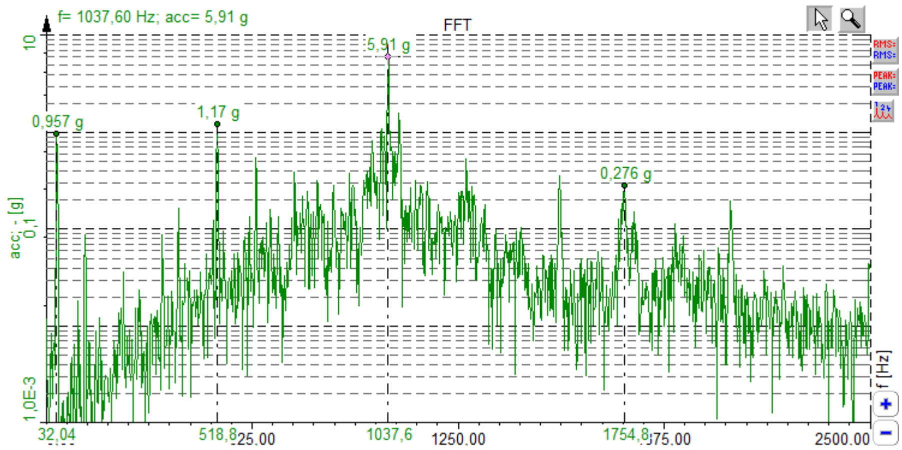


In the first example the engine is running at a constant speed of 800 rpm.

When we look at the vibration spectrum, the lowest frequency with the highest peak is 13,73 Hz (*60 = 823 rpm), which is most likely the first order. The next peak could be the 16th order (13,73 * 16 = 219,7 Hz).

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.

2.1.2 FFT spectrum @ 1950 rpm



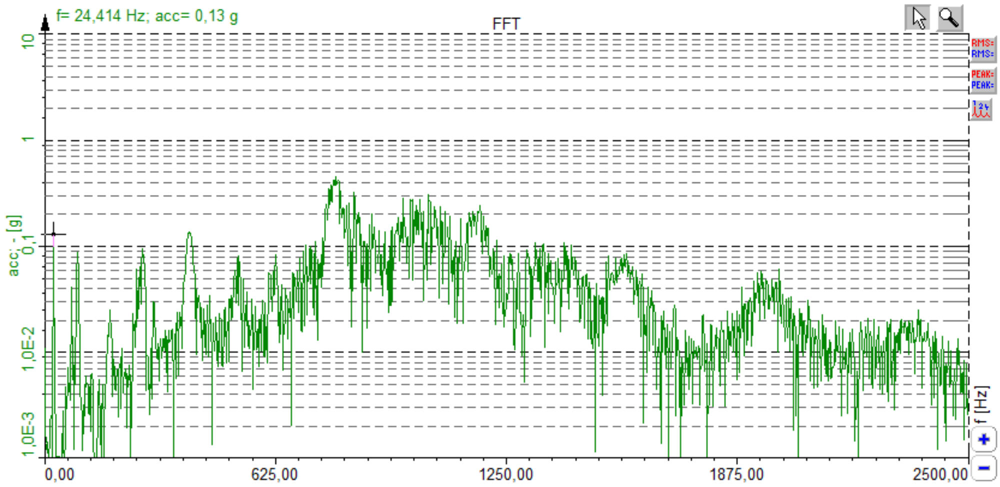
Then we run the engine at a constant speed of 1950 rpm.

The first order is again the lowest frequency peak (32,04 Hz * 60 = 1922 rpm). Around 518 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 (compare with 800 rpm measurement).

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

2.1.3 FFT spectrum during runup/coastdown

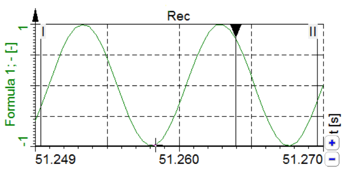
Of course it would take too much time to make a FFT for each RPM, so we can try to use the FFT during engine runup or coastdown. The following experiment shows the FFT while the engine is slowing down from 1700 to about 1400 rpm.



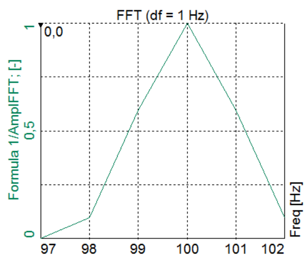
When you compare the spectrum with the ones before, you see that there are no sharp lines any more. The reason is, that the rpm is changing, while the FFT is still needs time for calculating. This effect is called "smearing".

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

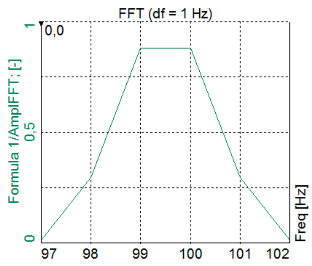
To demonstrate, we generate a simple 100 Hz sine wave using the DEWESoft mathematics (sine(100)). When we use a sampling frequency of 2048 Hz and a FFT with 1024 points we get (because of Nyquist criteria) a line resolution of exactly 1 Hz. Amplitude and frequency in the FFT are correct. Now we change the sine wave to 99.5 Hz. The energy of the peak is now distributed to both neighbour lines at 99 and 100 Hz, therefore the amplitude is also not exact any more.



sine wave



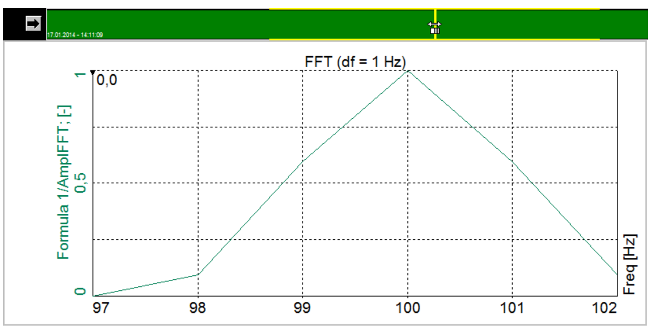
FFT spectrum for 100 Hz



FFT spectrum for 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).

Hint: In DEWESoft the FFT calculation time window is shown as a yellow frame in the overview instrument in Analyse mode, if you click on the FFT.



Please see also DEWESoft help for more infos about FFT.

2.1.4 Conclusion

Manual ordertracking 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 unprecise measurement because of smearing and other FFT disadvantages.

With the Ordertracking module of DEWESoft the order analysis is very easy to setup and easy to use, let's take a look at the different analysis options available.

2.2 Order tracking module

The DEWESoft™ Ordertracking module is used for e.g. vibration analysis on engines or other rotating machineries, both in development and optimization. With the small, handy form factor of the DEWESoft instruments (DEWE-43, SIRIUS*i*) it is also a smart portable solution for service engineers coping with failure detection.

The Ordertracking 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 ordertracking the frequencies can be seperated into those related to the RPM, and spurious ones. The powerful visualisation and mathematic options lead to a clear picture of the situation.

Furthermore calculations can also be done offline (after the measurement), like with most of 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 DEWESoft™ are not enough, you can even export the data to several different file formats.

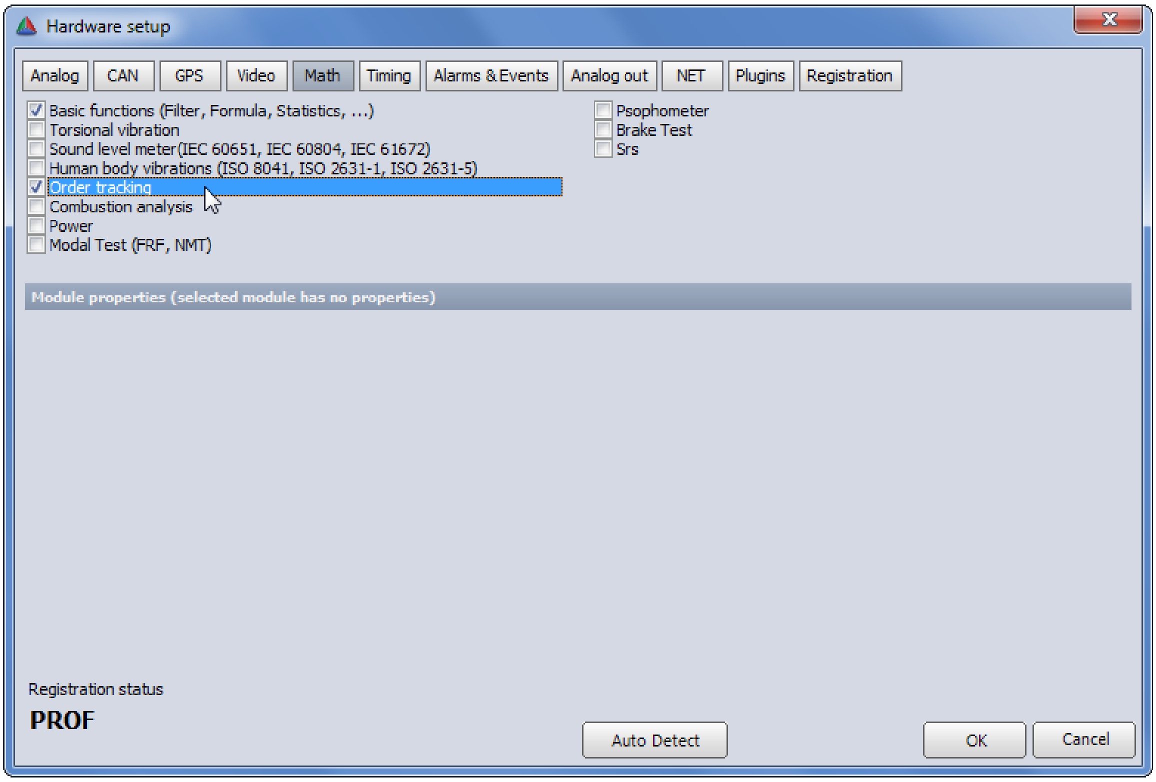
2.3 System Overview

Depending on what to analyse, 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...6000rpm) or data channel, e.g. the CAN bus of a car.

2.4 Enabling OT module

Like many additional mathematics modules also Order tracking is an option to the standard DEWESoft™ package and needs to be enabled in the Hardware setup: Enter <Settings> <Hardware Setup> and then <Math>.

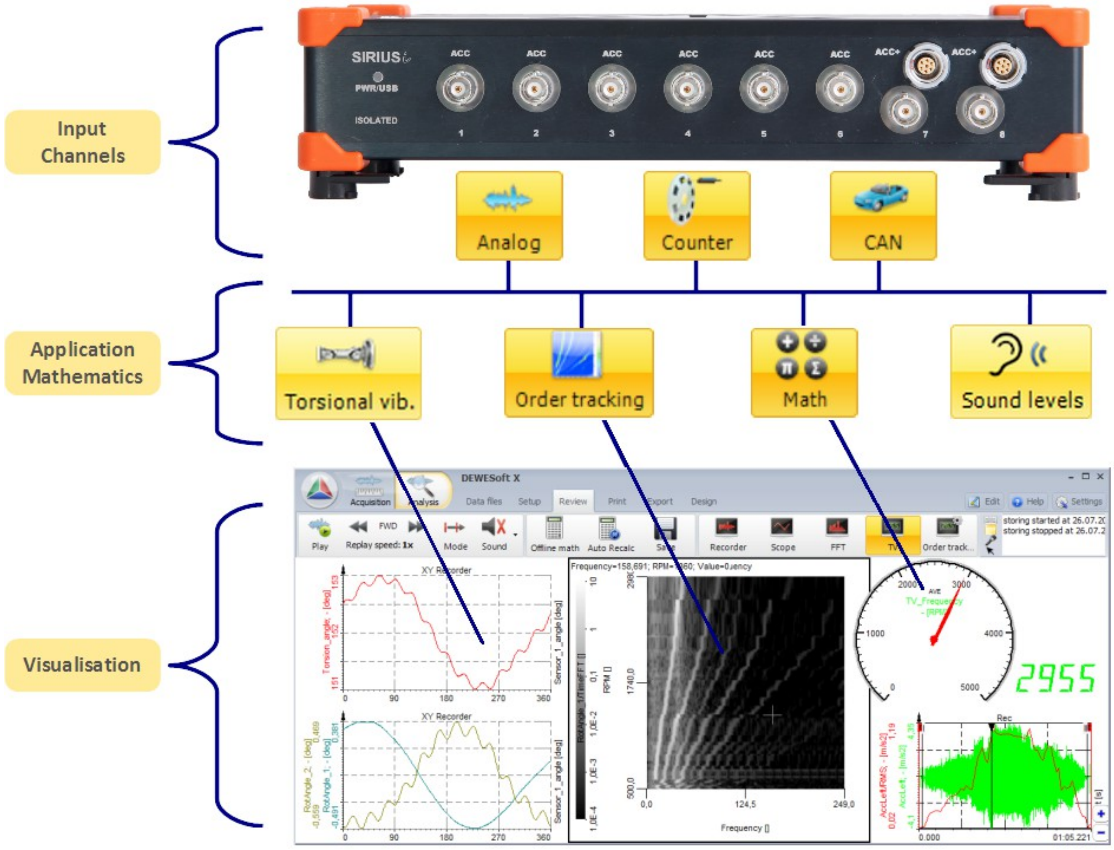


Usually this must not be done manually, since the license is already stored on your Dewesoft instrument.

Just click on the "Auto Detect" button and all options will be detected and enabled automatically.

2.5 Basic operating concept

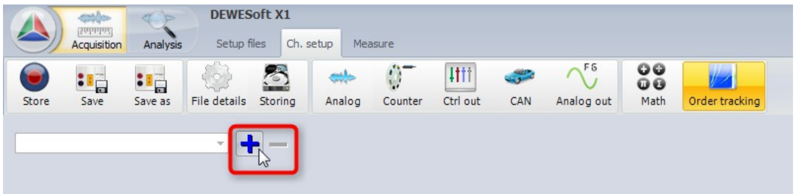
The Ordertracking module inside DEWESoft™ is just one out of several other application modules which offers dedicated mathematics and visual controls like angle based XY-diagram.



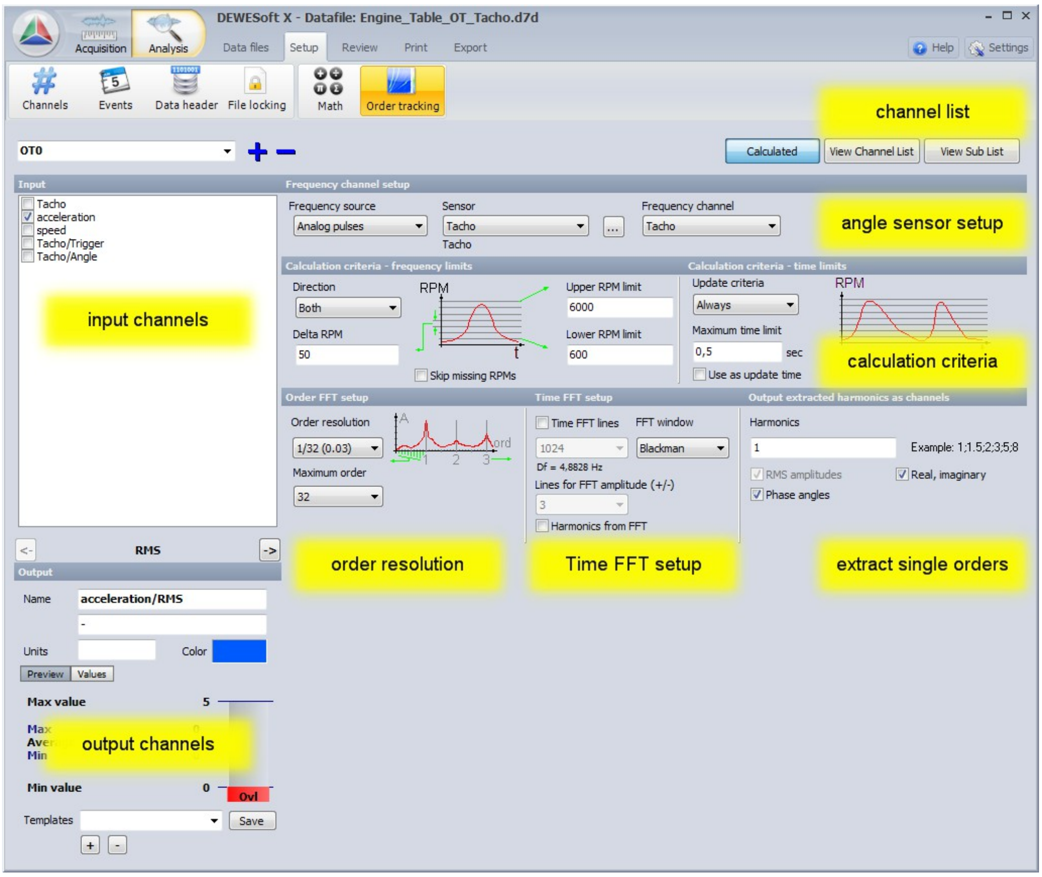
EXAMPLE	
	You can use the output of the Torsional vibration module as an input for the Ordertracking module, and then apply additional mathematics on it.

2.6 General setup

In the first step we add one module with the + button:



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



- channel list: change to channel list view
- input channels: define the input channels to perform the analysis on (e.g. acceleration sensor)
- output channels: switch through the output channels with arrow buttons and see preview values
- angle sensor setup: define type of angle sensor (e.g. Enc-512, Tacho)
- calculation criteria: set RPM limits, delta RPM, runup/coastdown/both, update settings
- order resolution: specify maximum orders and the resolution (e.g. 1/16th order)
- Time FFT setup: change calculation method from resampled data to FFT
- extract single orders: select specific orders and get amplitude and phase as separate channel

3 Setup

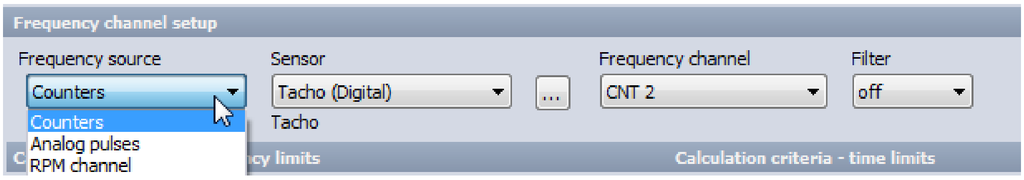
3.1 Analog input signal to analyze

In most of the cases the analysis will be done on a vibration sensor. Just enable the wanted 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

3.2 Frequency channel setup

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



- Tacho probe (1 pulse/revolution; connect to analog or digital input)
- 36-2 or 60-2 sensor (connect to 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 phase of the harmonics cannot be extracted, because there is no zero-angle information)

3.2.1 Counters

Select “Counters” if you connect an Encoder to the Dewesoft instrument Counter input (usually 7pin 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 background is then overtaken (locked) by the Ordertracking module, the counters will not be accessible (greyed out), to prevent double-usage.

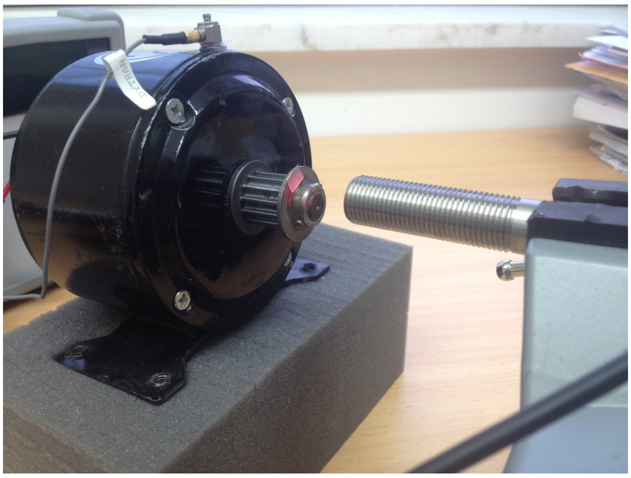
In Counter mode, you can optionally set the filter, to suppress glitches/spikes shorter than the shown value (100ns...5µs). The optimal setting is derived from following equation:

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

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

The biggest error is caused by inproper 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.

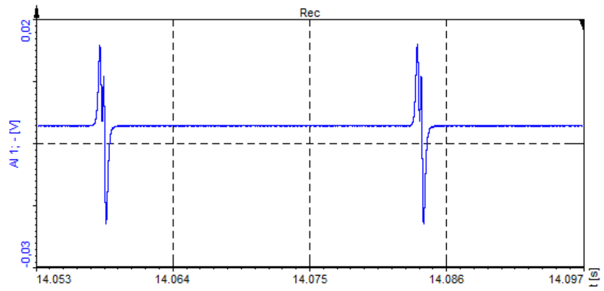
The easiest way is using a tacho probe with digital output. It can be directly connected to the Dewesoft instrument's counter input and is easy to mount. For example the optical tacho probe only requires a reflective sticker on the rotating part, see picture below.

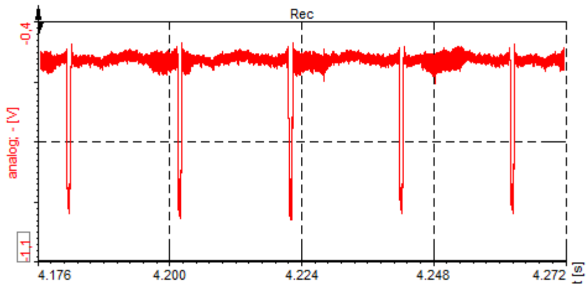


3.2.2 Analog pulses

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.

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

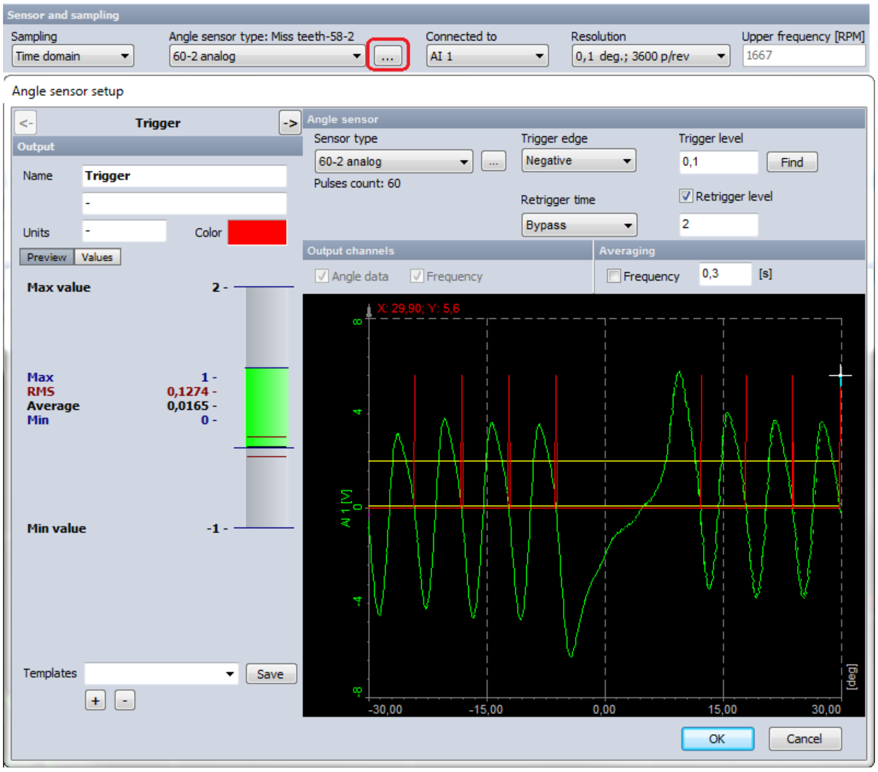




Beyond that, also 60-2 and 36-2 analog signals from crank sensor (inside nearly every vehicle) are supported.

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 for 60-2 analog sensor is shown.



HINT: If machines with high rpm dynamic, or with a high rotational vibration are analyzed (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.

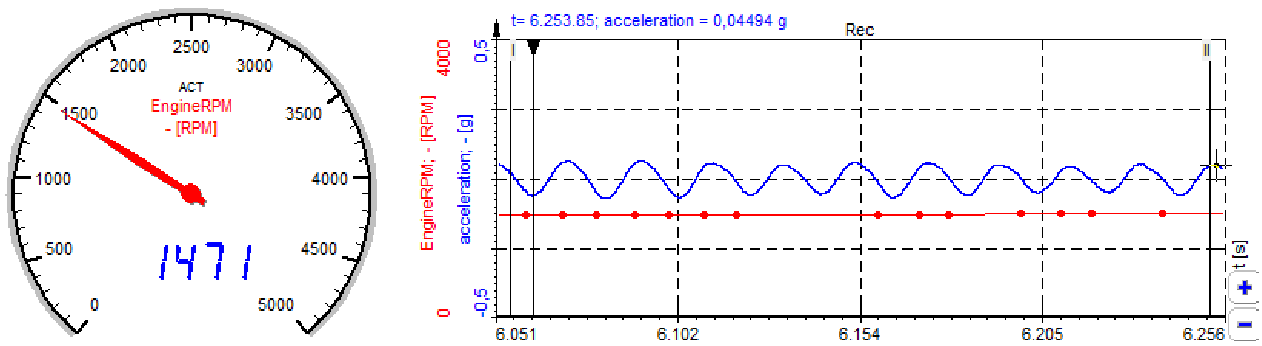
Reason: The order tracking algorithm resamples the time domain data into angle domain. If we get more information from the RPM probe, we have more pulses per revolution and the resampling to angle domain will be much more accurate!

3.2.3 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 extraction of the phase angles of the single orders is not possible.

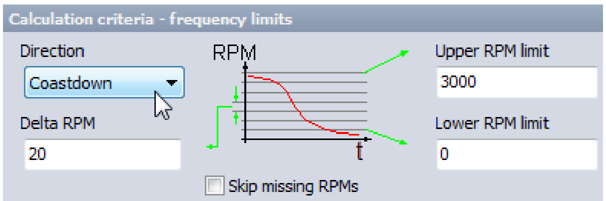
Following example shows an RPM signal from CAN bus inside a vehicle (red line). Note that the sampling points are asynchronous. The blue line is the output signal of an acceleration sensor.



3.3 Calculation criteria – time and frequency limits

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

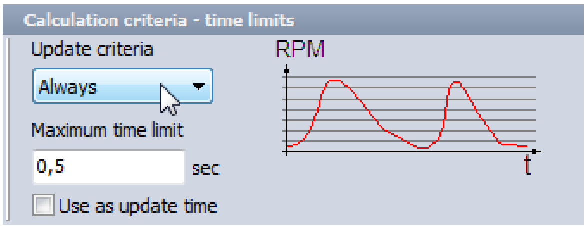
Select the RPM limits, and whether you want to calculate the waterfall spectrum and order extraction while runup, while rundown or always.



Upper and lower RPM limit define the range for calculation and are used to correctly set up the resampling algorithm, depending on the max orders extracted.

Delta RPM will define when a new update of the waterfall spectrum and also the extracted orders is calculated. In case the rpm is not changing the calculation is performed according to the **Maximum time limit** setting.

Skip missing RPMs is used if the runup/coastdown is very fast and not all rpm points can be calculated.



Update criteria defines if the waterfall should be updated always or only the first time. So, if you have more runup or coast downs, only the first run will be used, if selected.

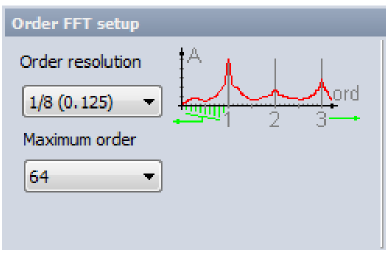
In this mode the update is done if the rpm changes bigger than the Delta RPM or if the Masimum time limit is reached.

Sometimes it is also necessary that the ordertracking calculation is done in a fixed time interval, independent of the rpm, e.g. when a car is driving a defined track or a machine is operated and observed during a working cycle.

If this is needed, **Use as update time** must be checked, so the calculation will be updated independently from the rpm every 0.5 sec (overwrites frequency limits – delta RPM setting).

3.4 Order FFT setup

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 module will output a warning if the used sample rate is too 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.

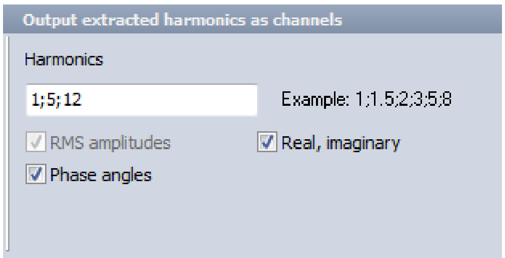
IMPORTANT	In an FFT, if the line resolution is 0.5 Hz, the required data window must be 2s. The same is true for the order resolution: If the resolution is set to 0,25 orders, 4 revolutions are required for one data block. The higher the required order resolution, the more slowly the rpm must change.

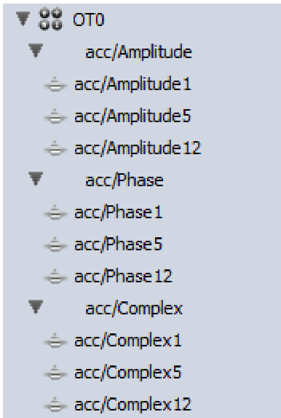
3.5 Output extracted harmonics as channels

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** field. Seperate multiple entries with the semicolon (;). In the example below the 1st, 5th and 12th order is selected. If the extracted order falls between discrete order resolution steps, the closest fitting resolution will be taken, so if the resolution is 1 order and 1.8 is extracted, 2nd order will be used.

For best visual instrument to use please also see page 22, chapter 4.2.3 Extract specific orders.





The **RMS amplitudes** are always calculated, they appear as /Amplitude1, /Amplitude5, …

Phase angles are shown as /Phase1, /Phase5, … (only available when using RPM sensor with zero-angle information!)

If a Nyquist plot is required, the **Real, imaginary** parts will appear as /Complex1, /Complex5, … To get the real and imaginary part as seperate channels out of the complex number, use two math formulas

- real = 'acc/Complex'.re[0]
- imag = 'acc/Complex'.im[0]

In our example above, the index [0] will show 1st harmonic, index [1] will show 5th, and [2] the 12th harmonic.

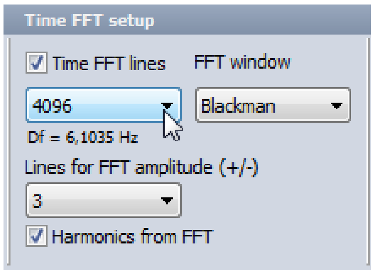
For further explanation and visualisation see also page 23, chapter 4.2.4 Draw Polar diagram / Nyquist plot.

3.6 Time FFT setup

The Order tracking module is creating a waterfall plot out of the rpm change. So everytime the rpm changes for the defined delta rpm, a FFT is calculated for that data block, and shown in the Time FFT diagram.

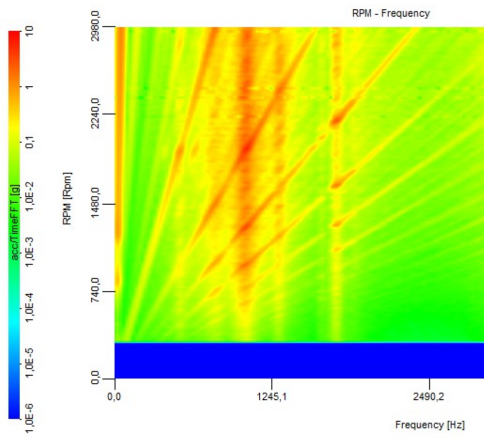
The FFT resolution and data block length is per default automatically calculated out of sampling rate, order resolution and maximum order.

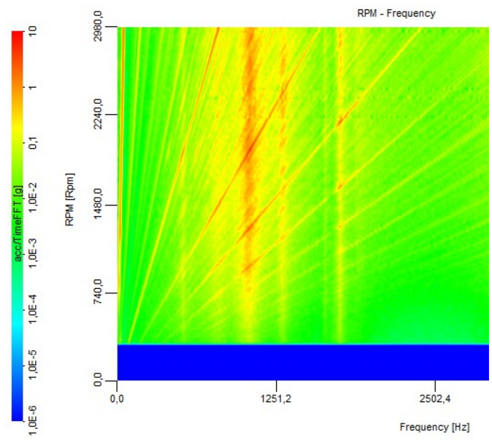
This data block is fed into a special mathematic algorithm, which resamples the data that we get exactly 2^x values during one revolution. Out of that we can get the order and phase spectrum without any leakage of FFT values. So FFT lines (=orders) will have exact amplitude (no smearing) and phase, almost no matter how fast we change the engine speed.



If **Time FFT lines** is checked, the Time FFT waterfall diagram will have a user defined number of lines for one rpm shot. So we manually change the FFT resolution in the FFT waterfall diagram with this setting.

Below you see the difference (left: Df = 24 Hz; right: Df = 6 Hz):





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

If **Harmonics from FFT** is checked, the extracted orders are calculated out of the FFT spectrum and not out of the resampled data. The lines for amplitude (+/-) will define how many FFT lines below/above the center line (=order) are averaged. So sidelobes are calculated back to the central line, and this is done to prevent leakage.

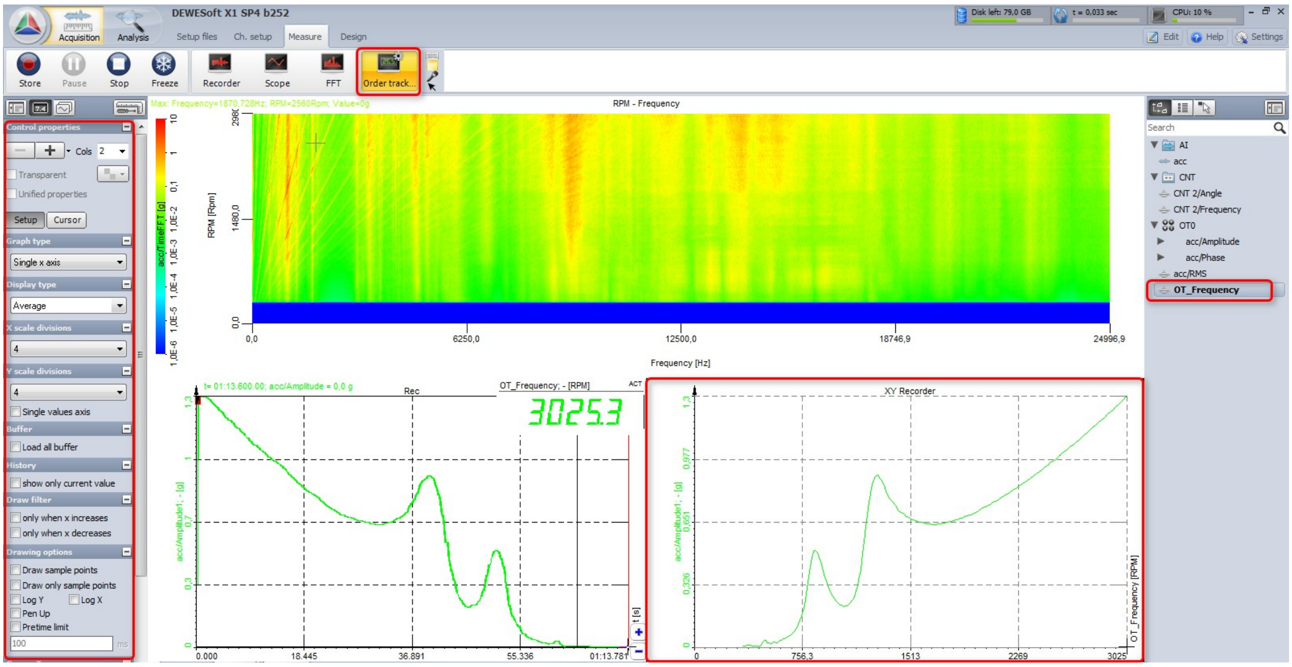
Therefore a smeared FFT with the right band around the center frequency will also give reliable results.

4 Measurement and visualisation

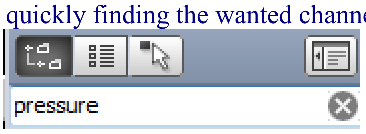
As the order tracking is done during a runup or coastdown, the visualisation instruments show the vibration spectrum (and the orders) over RPM and frequency. Single order lines can additionally be extracted.

4.1 Automatic display mode

With the order tracking module enabled, when you start the measurement, DEWESoft™ will automatically generate a display setup showing the major signals for a quick start. The tooth wheel symbol on the display icon indicates that this display is generated.
In the Illustration below, the automatic display configuration is shown. The selected visual control is a XY recorder, which can plot e.g. a channel against RPM.



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 statistic channels of a visual holding angle based data. Already selected are shown in bold.

HINT	Use the the channel filter for quickly finding the wanted channels on top of the channel list. 

The automatic display generation is activated by default and can be disabled in the project settings.

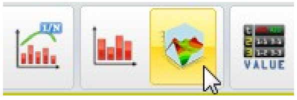
Once you modify the display in the design mode (e.g. adding an addition visual) the tooth wheel on the icon will disappear indicating the automatic mode is disabled.

4.2 Customizing displays

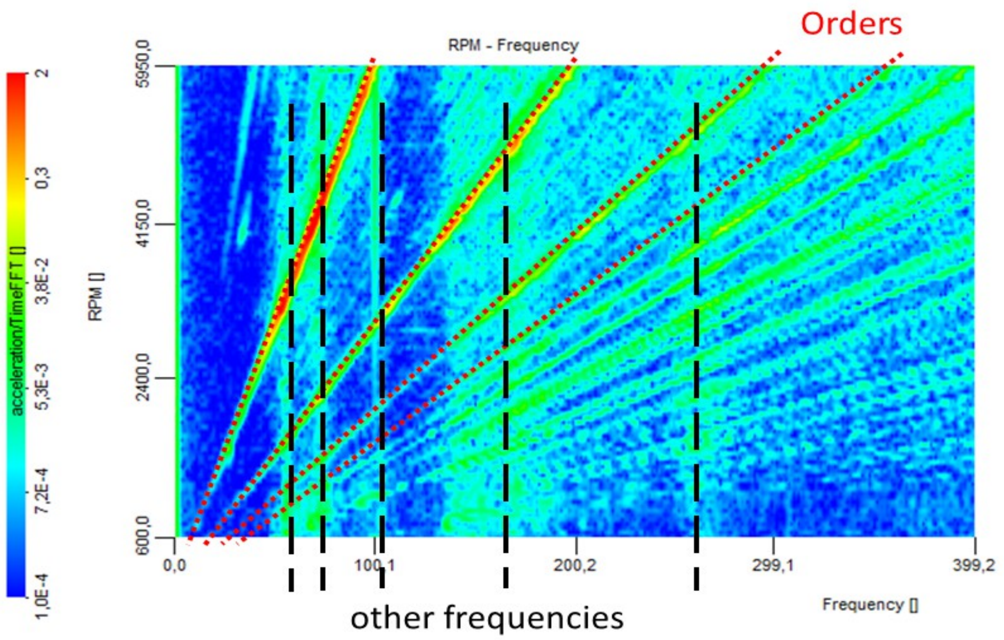
DEWESoft™ allows to arrange the displays completely flexible. The major displays for order tracking measurement are described below.

4.2.1 Time FFT waterfall

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



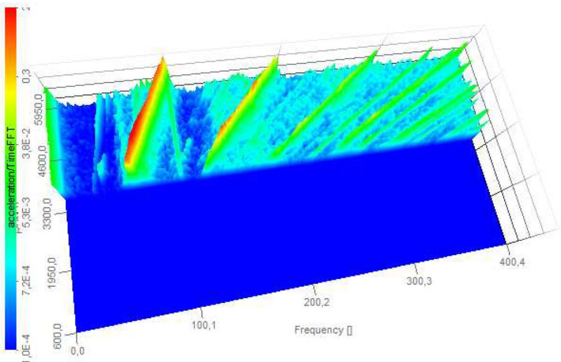
When you pick it in design mode, assign the *signal/TimeFFT* from the channel list to it.



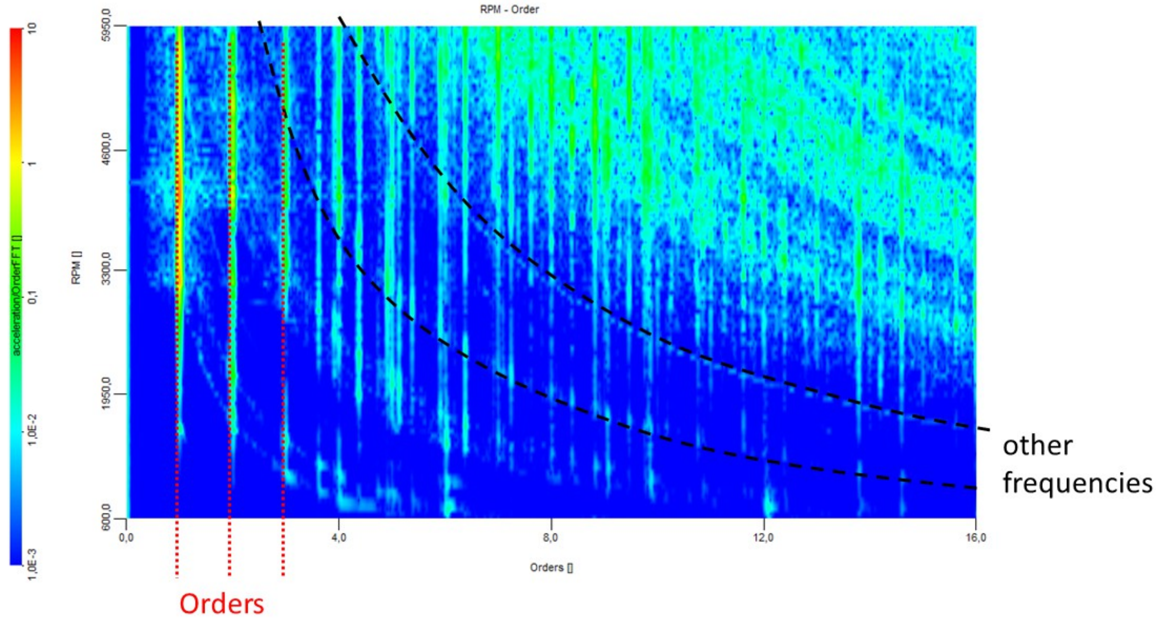
The waterfall plot shows a number of FFTs plotted across the RPM range (y axis), where the vibration amplitude is shown as color (up-direction in 3D mode).

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

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



4.2.2 Order FFT waterfall



Also with the 3D graph instrument, the order FFT can be shown.

Orders are plot versus rpm. Again, the color shows the vibration amplitude.

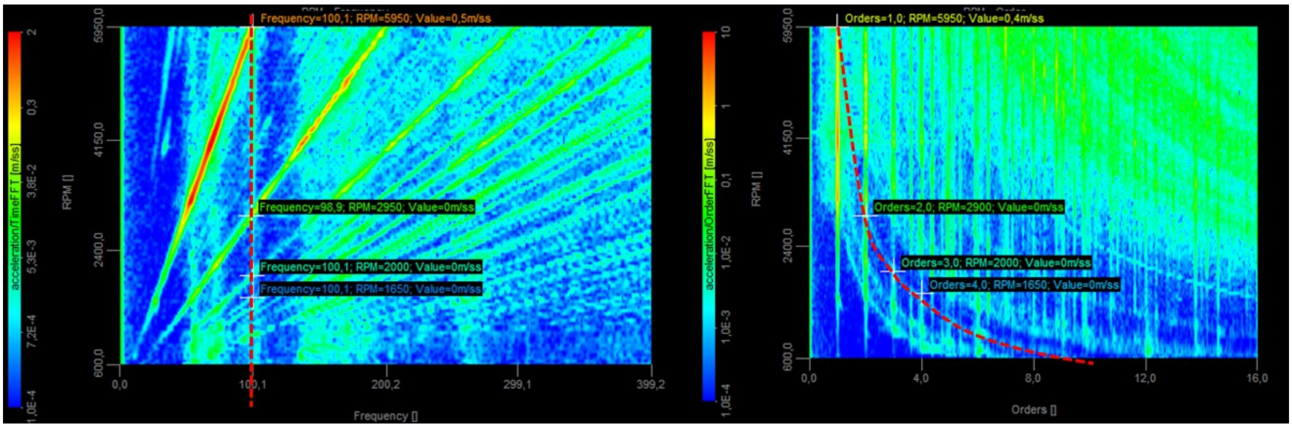
The straight lines parallel to the y axis are the orders. This is very helpful, because the frequencies of the orders change with rpm, and sometimes it is difficult to trace them.

Example: frequency change of the first order with rpm:

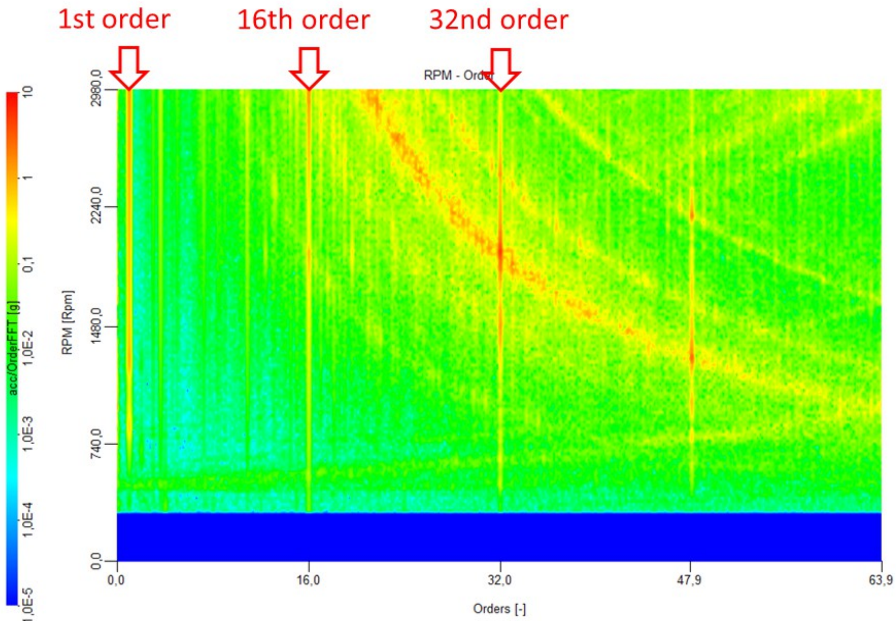
1st order at 600 rpm → 600/60 = 10 Hz

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.



4.2.3 Extract specific orders

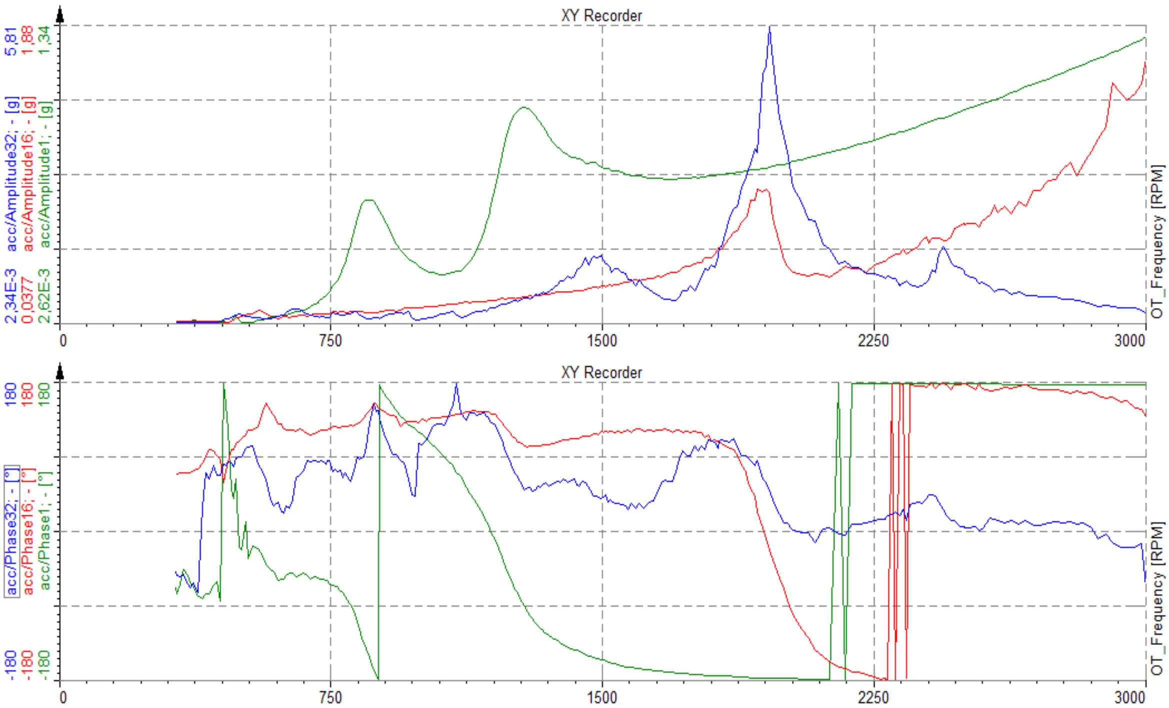


The graph above shows a vibration spectrum of an electrical scooter motor, standing on foamed rubber. The three major orders are marked (1st, 16th and 32th). It is also possible to extract them and see the amplitudes and phases over rpm.

Please also see page 17, chapter 3.5 Output extracted harmonics as channels.

Please use the XY recorder for displaying:

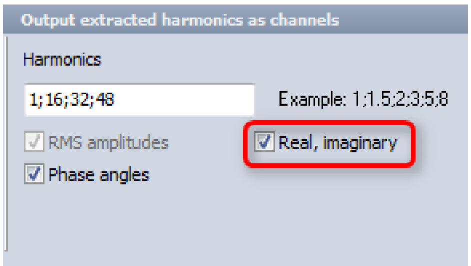
First pick the OT_Frequency channel from the channel list (x axis) on the right side, then assign the signal/Amplitude channel (y axis).



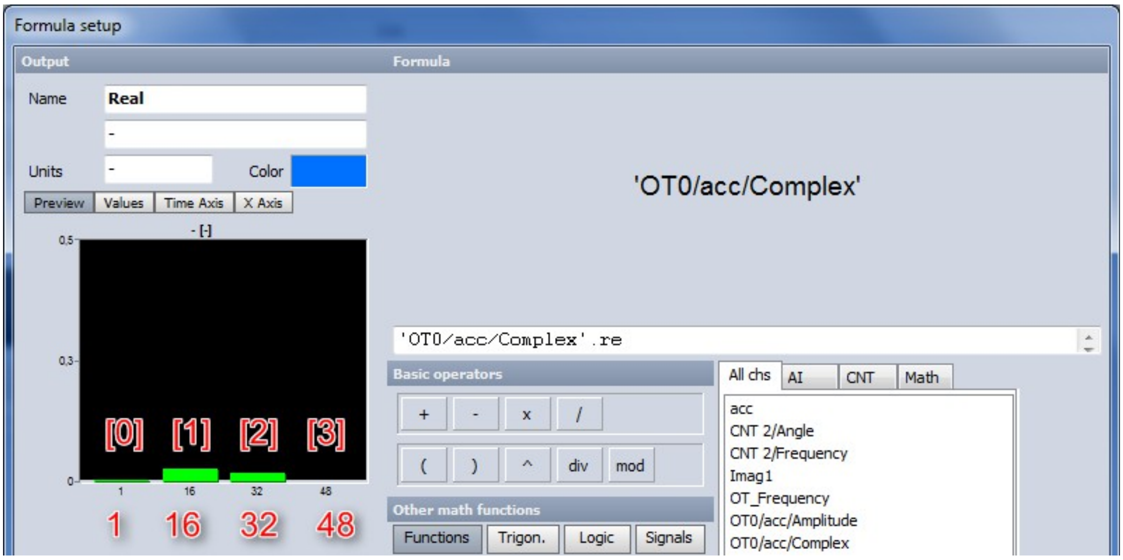
4.2.4 Draw Polar diagram / Nyquist plot

For this functionality you have to enable the "Real, imaginary" checkbox in the order tracking setup, please also see page 17, chapter 3.5 Output extracted harmonics as channels.

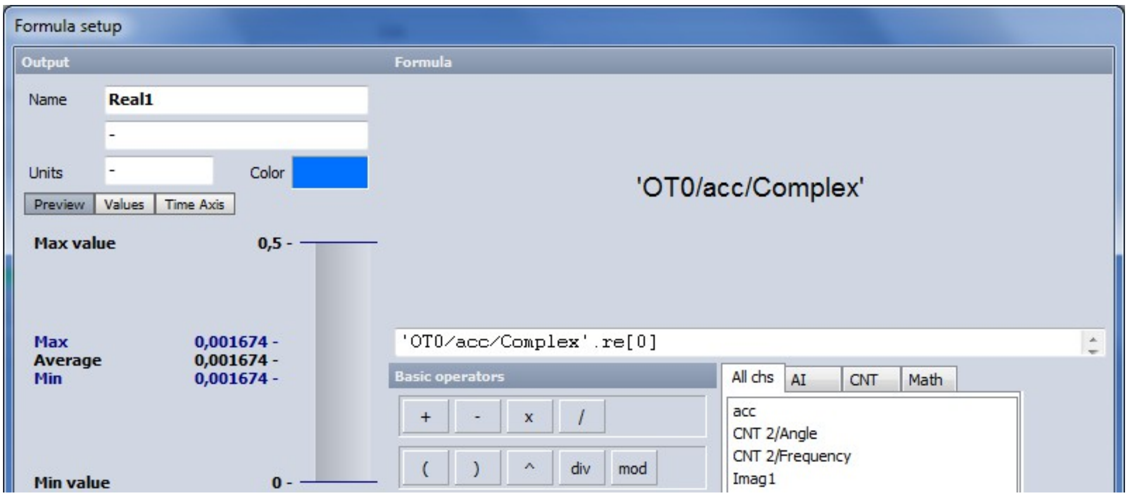
In the example with the scooter motor the strongest orders are relatively high, so we selected 1; 16; 32; 48.



The **Complex** output (Re + *j*Im) has to be split up into **real** and **imaginary** part using Math. Create a new formula and add the ending ".re" and ".im" to the signal/Complex channel. This can also be done "offline" on the datafile, after the measurement. Go to Recalculate and take a look at the Math preview again.



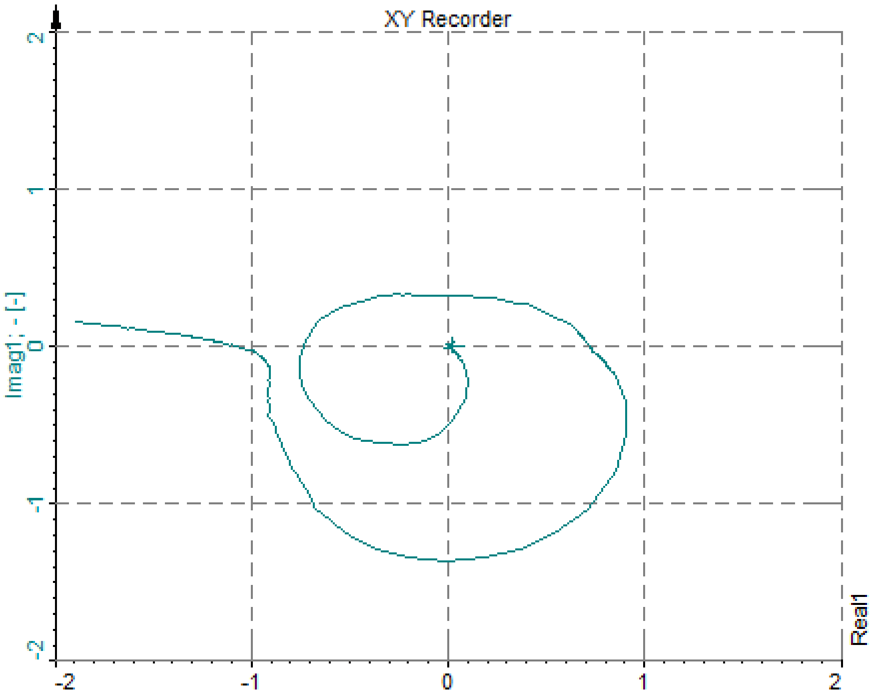
An array will be created, which is basically the four channels re1, re16, re32 and re48 combined into one multi-dimensional channel. If we want to access the components, we simply add "[i]", where i is the index {0,1,2,3} representing the order {1,16,32,48} in our example. So signal/Complex.re[0] will give the Real part of the 1st order.



Then do the same for the imaginary part by adding .im[0]:

```
'OT0/acc/Complex'.im[0]
```

Then take the XY recorder and assign first *Real1*, then *Imag1* to it.

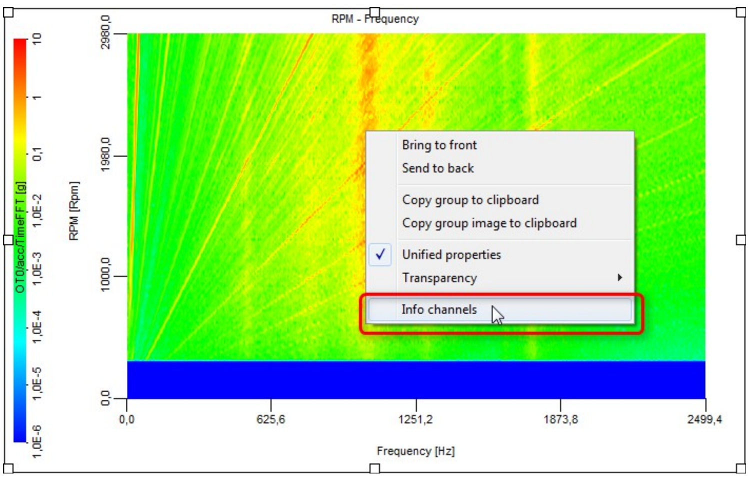


The x and y axis were manually scaled to the same min/max value to show the angle proportion correctly.

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

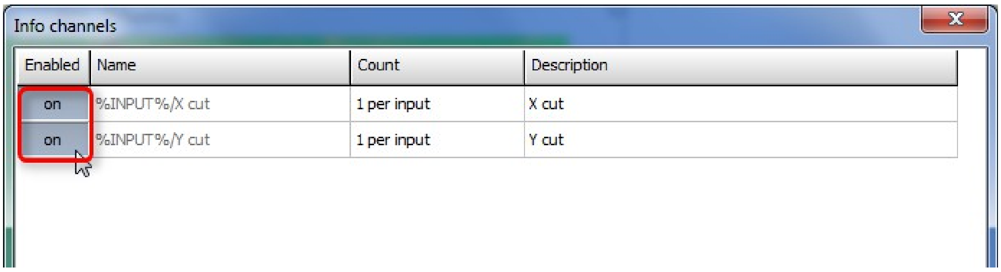
4.2.5 3D FFT cut

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

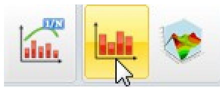


Open a datafile, go to design mode and right-click on the 3D FFT instrument, select “Info channels”.

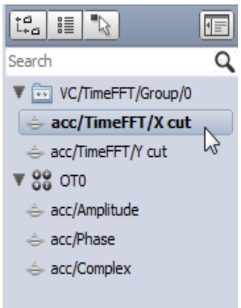
Enable the channels *X cut* and *Y cut*.



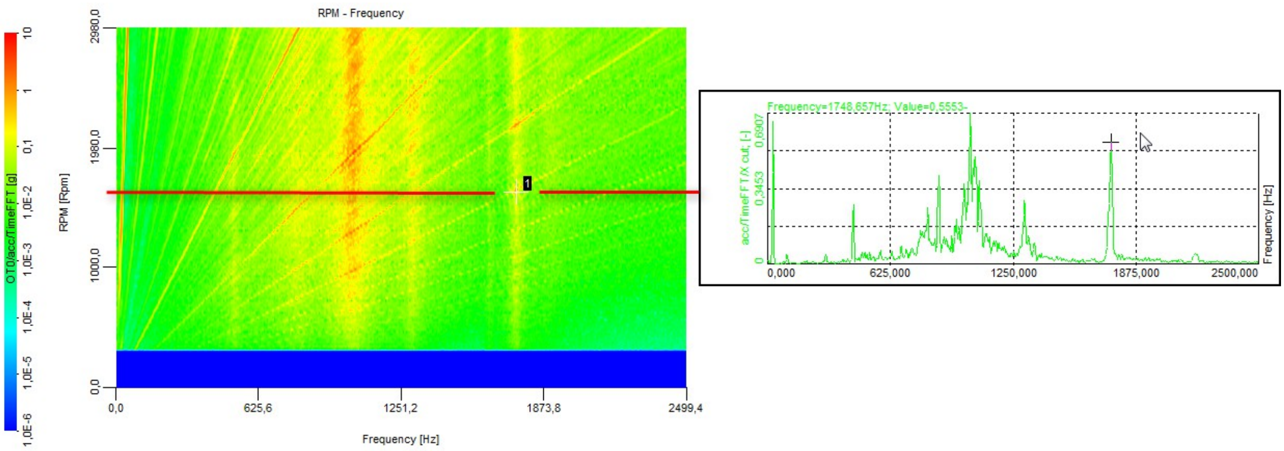
Then add a 2D graph from the instrument toolbar.



Unassign all other channels, only assign the channel *signal/TimeFFT/X cut* to it.



Exit the design mode. Then click on the 3D FFT instrument on the interesting point, where you want to cut the FFT. When you see a marker, e.g. “1”, move the mouse over the 2D graph on the right and it will be updated.

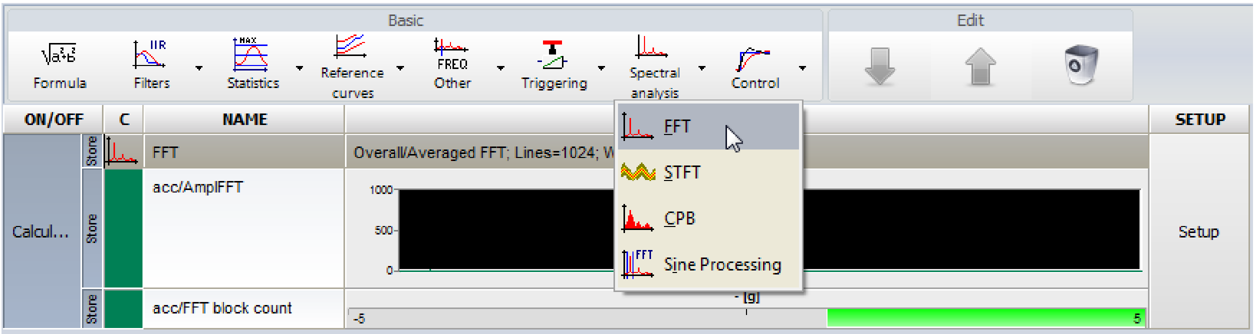


For exporting a 3D FFT cut, please look up page 32, chapter 5.2 3D FFT cut export.

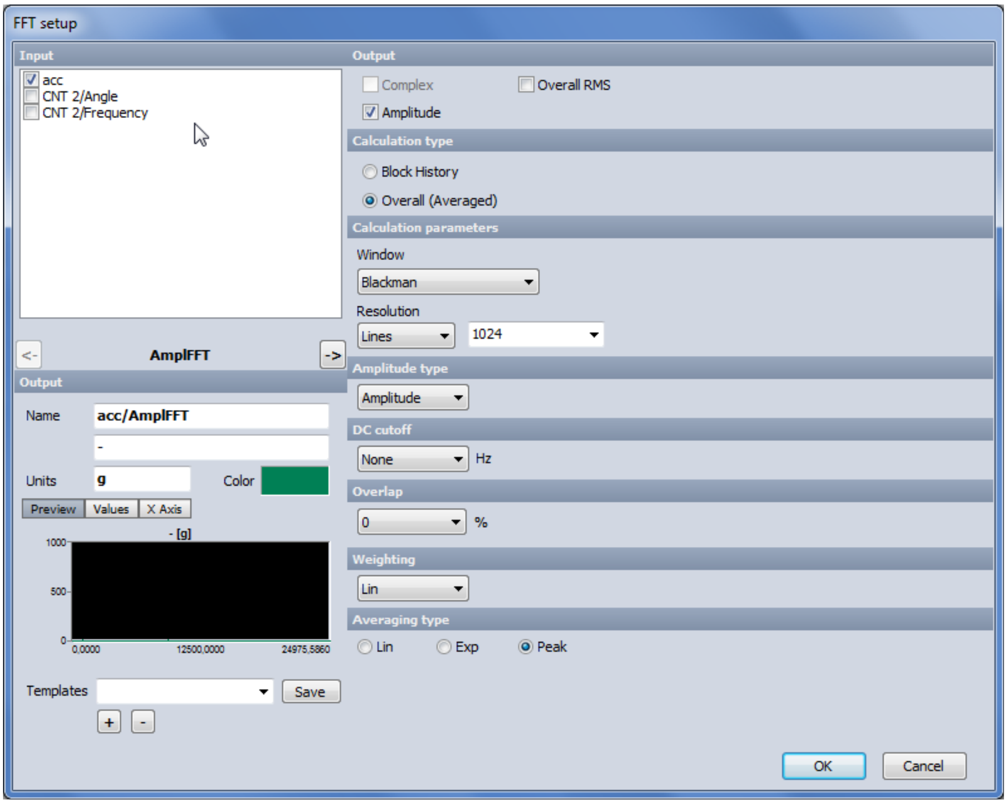
4.2.6 FFT peak calculation

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

Add a FFT function from the “Spectral analysis” section in math.



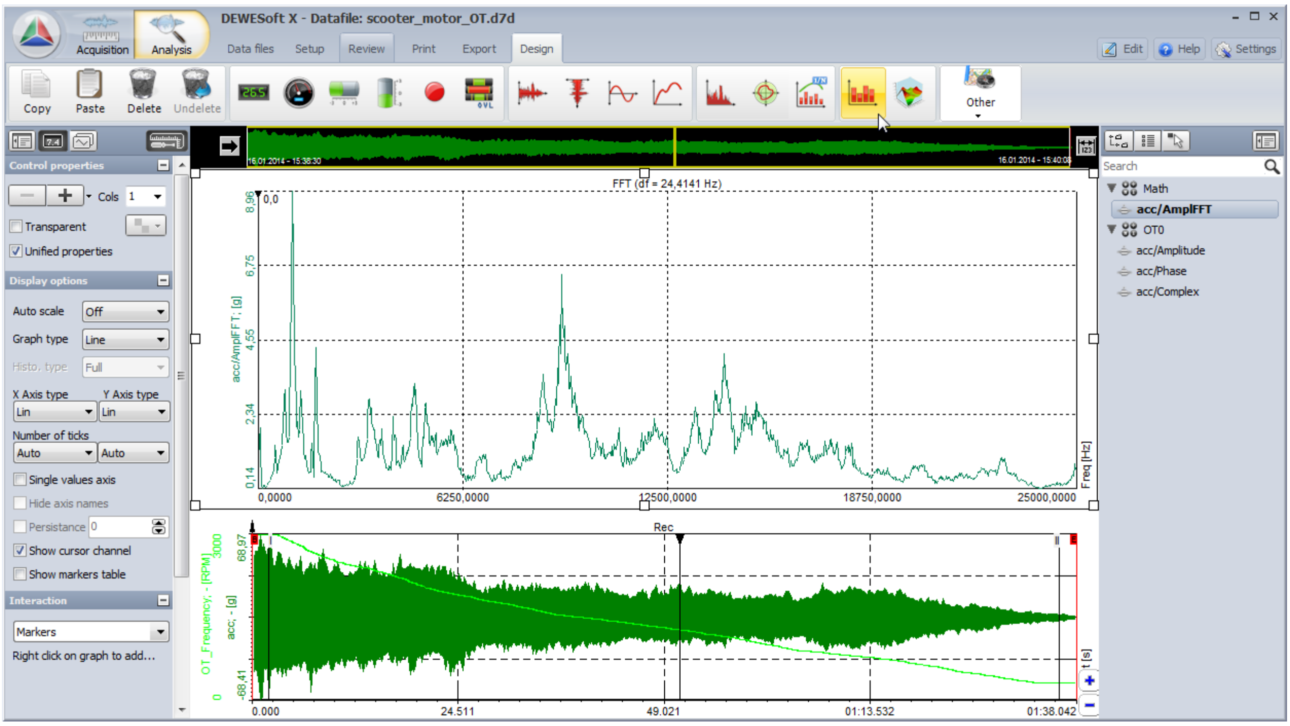
Then select the input channel, here for example an acceleration sensor. Set to amplitude, Overall, and averaging type peak.



Here is an example, done "offline" on a datafile, after the measurement (of course you also can do it during measurement).

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

Y axis type can be set to logarithmic in the 2D graph properties (left side) for convenience.

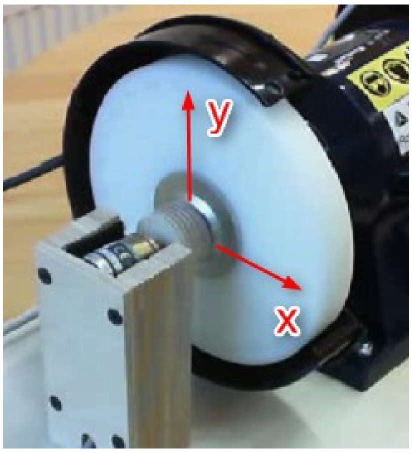


Furthermore you can also only select one section of a datafile in the recorder, to perform the PeakFFT over a specific RPM range.

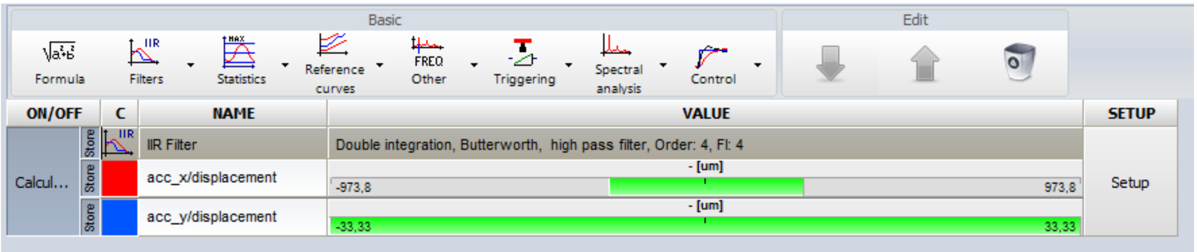
After that, calculated math data can of course also be exported.

4.2.7 Orbit graph

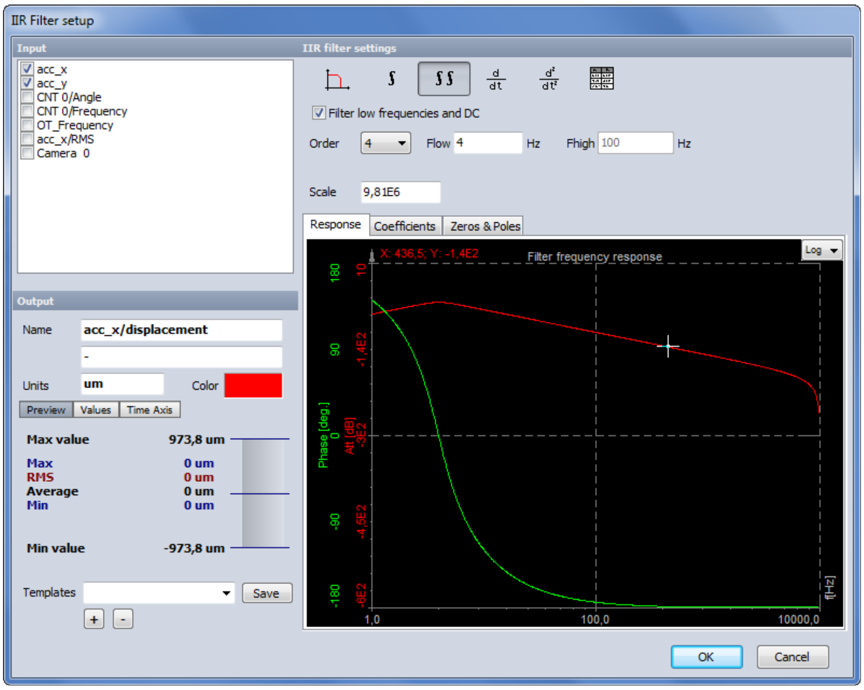
In this example we want to visualize the movement of a rotating disk. To have high angular resolution we use an encoder with 1024 pulses per revolution. A 2-axis acceleration sensor is mounted on the metal frame holding the motor. The axis orientation is shown as below.



The output of the sensor is acceleration in m/s². If we use double-integration on it, we can calculate the displacement in um. This can be done using IIR filter in DEWESoft mathematics.

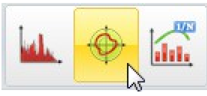


The filter order and low-pass frequency have to be chosen carefully in order not to create unwanted, unstable output signal. To determine the filter frequency, make an FFT spectrum on the acceleration sensor and look for the lowest dominant frequency. 4th order 4 Hz is a good starting point (signals 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.

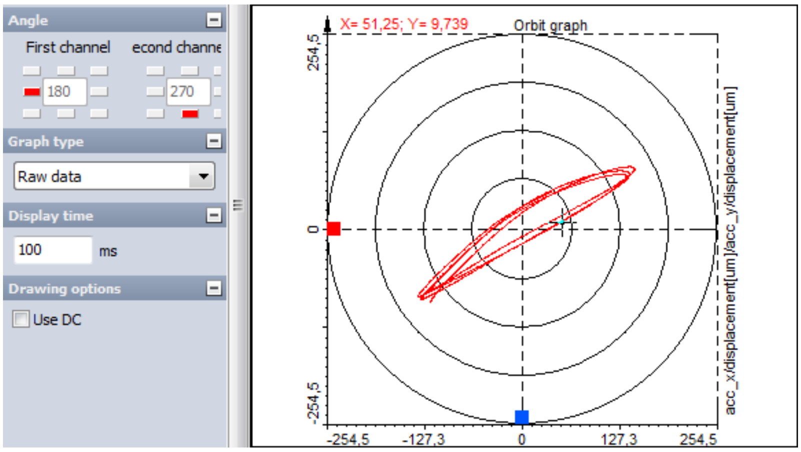


The visual instrument for that operation is the "Orbit graph".

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



The orientation of the sensors can be modified on the left side, and also the displayed time can be selected.



5 Analyse and export

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

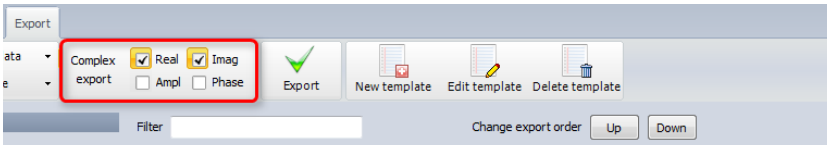
For general introduction please look up the Tutorial & Manual inside DEWESoft. In the following section only the application specific options are explained.

5.1 Export of Complex data

On page 22, chapter 4.2.3 Extract specific orders we have seen how to display single orders and their phases. The next step would be to export them.

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 on the Complex dataset.



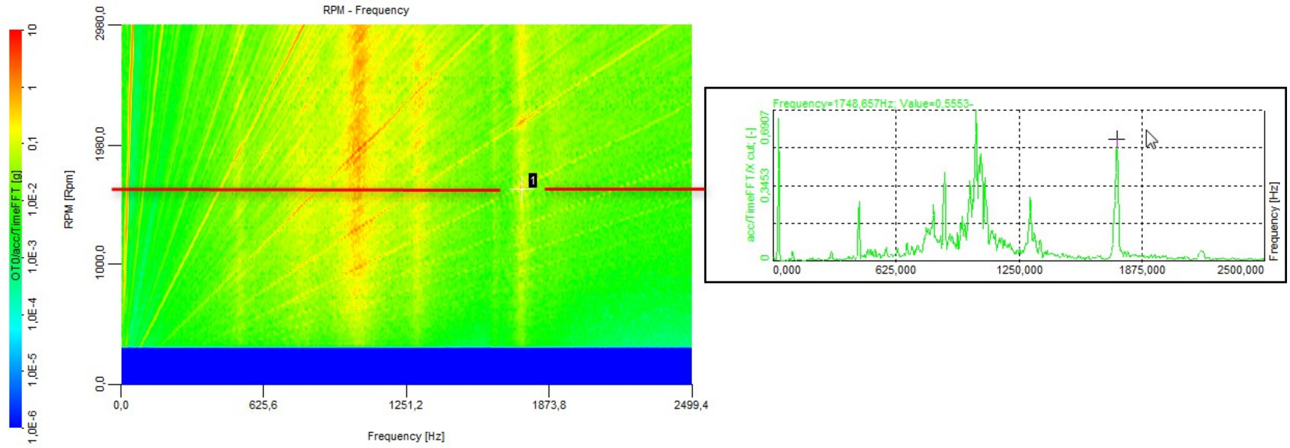
Order	Exported	Type	Acq. rate	Dimension	Name
1	No	AI 1	50000	Scalar	acc
2	No		50000	Scalar	CNT 2/Angle
3	No		50000	Scalar	CNT 2/Frequency
4	No	Math 0 (Order tracking)	2,7	Scalar	OT_Frequency
5	No	Math 0 (Order tracking)	10,7	Scalar	OT0/acc/RMS
6	No	Math 0 (Order tracking)	single	Matrix (512x150)	OT0/acc/OrderFFT
7	No	Math 0 (Order tracking)	single	Matrix (8192x1...	OT0/acc/TimeFFT
8	No	Math 0 (Order tracking)	2,7	Vector (4)	OT0/acc/Amplitude
9	No	Math 0 (Order tracking)	2,7	Vector (4)	OT0/acc/Phase
10	Yes	Math 0 (Order tracking)	2,7	Vector (4)	OT0/acc/Complex
11	No	Math 1 (Basic statistics)	10,0	Scalar	Stat0/acc/RMS
12	No	Math 4 (Formula)	2,7	Scalar	Real1
13	No	Math 5 (Formula)	2,7	Scalar	Imag1

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

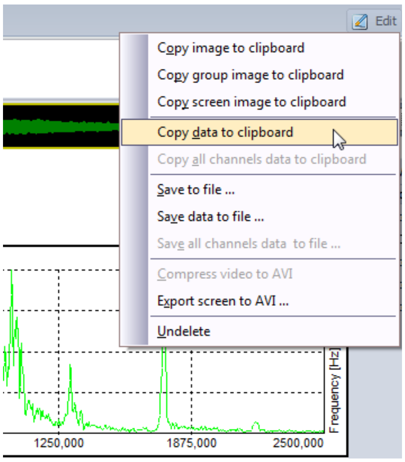
	A	B	C	D	E	F	G	H	I
1	Time	OT0/acc/Complex1_Real	OT0/acc/Complex16_Real	OT0/acc/Complex32_Real	OT0/acc/Complex48_Real	OT0/acc/Complex1_Imag	OT0/acc/Complex16_Imag	OT0/acc/Complex32_Imag	OT0/acc/Complex48_Imag
2	s	g	g	g	g	g	g	g	g
3	0,3264	-1,8924294	-1,8670999	-0,59492481	0,6226669	0,14801131	1,7072728	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

5.2 3D FFT cut export

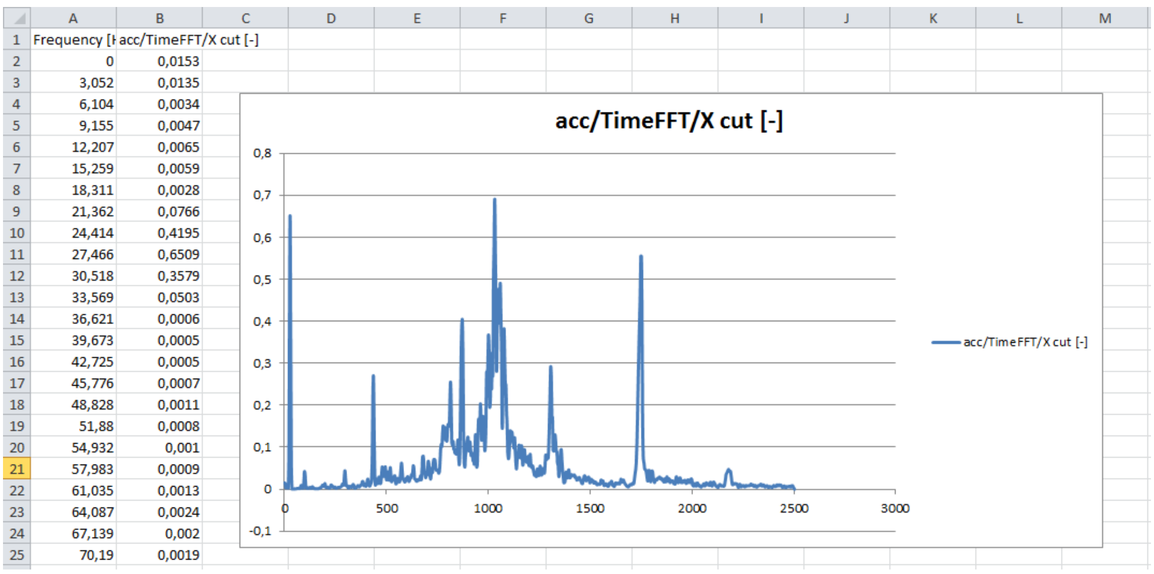
In section 4.2.5 3D FFT cut on page 24 we explained how to generate a 3D FFT cut (FFT for a specific RPM).



Select the 2D instrument, the data can be copied by using the “Copy data to clipboard” function from the “Edit” menu on the right upper section in DEWESoft.



The clipboard data is then easily pasted into e.g. Excel.



	A	B
1	Frequency [I	acc/TimeFFT/X cut [-]
2	0	0,0153
3	3,052	0,0135
4	6,104	0,0034
5	9,155	0,0047
6	12,207	0,0065
7	15,259	0,0059
8	18,311	0,0028
9	21,362	0,0766
10	24,414	0,4195
11	27,466	0,6509
12	30,518	0,3579
13	33,569	0,0503
14	36,621	0,0006
15	39,673	0,0005
16	42,725	0,0005
17	45,776	0,0007
18	48,828	0,0011
19	51,88	0,0008
20	54,932	0,001
21	57,983	0,0009
22	61,035	0,0013
23	64,087	0,0024
24	67,139	0,002
25	70,19	0,0019

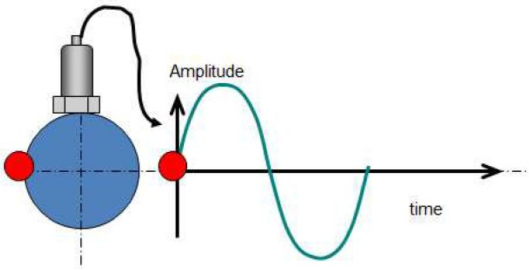
Hint: The copy data to clipboard function is also available on the standard FFT instrument.

6 Additional information

After we have shown how to extract orders and visualize them in DEWESoft, this chapter should give a rough idea what 1st, 2nd … order means and what might be possible sources.

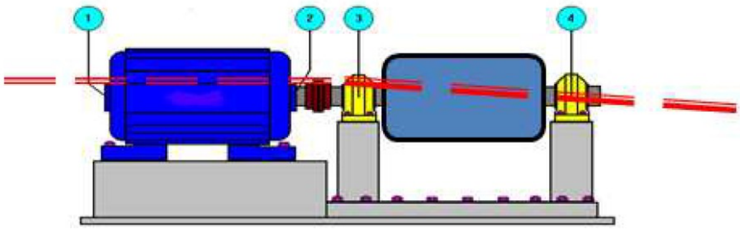
6.1 1st order = imbalance

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.



Imagine a blade or shaft or any rotating part has a higher weight at one side. This weight will rotat with exactly the rotation 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.

6.2 1st and 2nd order = 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 over the mechanical structure and creates vibration.

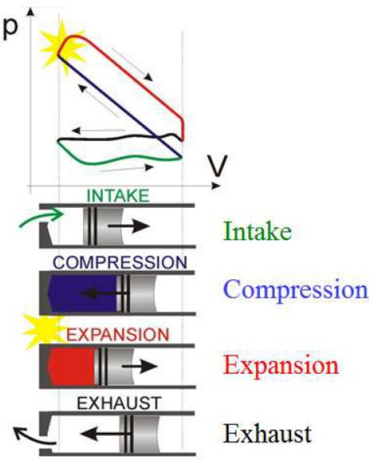
6.3 Diesel and gasoline engines

At Diesel and gasoline engines we can observe that 2nd, 3rd or 6th order are almost every time dominant, why?

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

At 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.



7 Documentation version history

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Version	Date [dd.mm.yyyy]	Notes
1.0	*14.02.14*	☑ *initial revision*

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