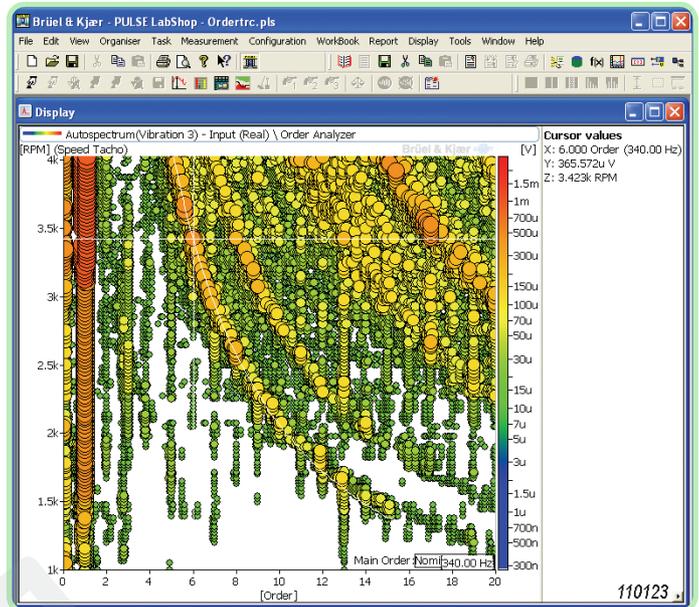


# PRODUCT DATA

## Order Analysis Type 7702 for PULSE, the Multi-analyzer System

Order Analysis Type 7702 provides PULSE™ with Tachometers, Autotrackers, Order Analyzers and related post-processing functions, as well as additional trigger types. The software includes PULSE Application Projects that cover the main uses of Type 7702. The system can be easily customised for other measurement tasks.



### Uses and Features

#### Uses

- Separation of rotational and structural noise and vibration phenomena
- Identification of noise generated by rotational vibrations
- Determination of critical speeds and resonances
- Investigation of instabilities in rotating machinery

#### Features

- Order analysis with high-speed tracking
- Run-up/down testing with or without tracking
- Tachometers based on tacho pulses and/or a voltage proportional to the RPM

- Autotrackers to extract the fundamental frequency from the measured signals, instead of using a dedicated tacho signal
- Tacho, speed and speed interval triggers
- Order analyzers with individual tracking references
- Run-up and coast-down in a single test session
- Synchronous averaging through tacho gearing
- Simultaneous noise and vibration analysis
- Slice mode for data reduction, rapid processing and fast display of slices during measurement
- Real-time calculation of average RPM
- Interpolation of slices to “round” values allowing averaging of slices
- RPM scaling to velocity

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## Introduction

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Order analysis is a technique for analysing imperfections in the moving parts of rotating and reciprocating machinery that cause unwanted noise and vibration. Engineers' or scientists' knowledge about machinery such as aircraft and automotive engines, power trains, pumps, compressors and electric motors is greatly improved by performing order analysis. This is because it allows measurements to be related to the revolutions of a rotating part.

Order Analysis Type 7702 provides three instruments, namely, an Order Analyzer, a Tachometer and an Autotracker, plus related post-processing functions and a wide range of display facilities. There are also three additional trigger types: tacho, speed and speed interval. These supplement the tools available in FFT & CPB Analysis Type 7700 to provide a complete diagnostic toolbox for both order tracking and general noise and vibration measurements. Type 7702 can also be used with FFT Analysis Type 7770.

A number of PULSE Application Projects can be found in the PULSE Knowledge Library. These cover the main uses of Order Analysis Type 7702 and allow you to perform order analyses quickly and easily. You can also easily customise projects for other measurement tasks. The predefined PULSE Projects supplied can be used for the following applications:

- **Run-up/down Acoustic Performance Test** – projects for performing, for example, cabin noise or exhaust noise tests using octave analysis and orders versus engine RPM
- **Run-up/down Vibration Diagnostics** – a number of projects for the determination of critical speeds, resonances and instabilities from measurements performed with and without tracking

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## Measurement

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Order Analysis Type 7702 is for analysing data acquired during a change in the rotational speed of a shaft. Noise and vibration can be measured simultaneously and any instrument available in Type 7700, 7770 or 7771 can be used in parallel with Order Analyzers, Tachometers and Autotrackers.

Type 7702 features frequency spectra or order spectra, frequency band profiles and order profiles as functions of RPM. The spectra can be displayed as waterfalls or colour contours. The frequency bands and order profiles can be “cut out” from the colour contour spectra and are therefore referred to as “slices”. Because they are defined on inspection of the spectra as a function of RPM, the slices are called post-slices.

If the frequency bands or orders of interest are known prior to the measurement, the analyzer can extract these slices during the measurement (pre-slices). Omitting the spectrum calculations reduces the demand for processing power and dramatically reduces the storage space required for the results.

Recording data for later analysis can overcome excessive real-time demands.

Order analysis can be made with or without tracking:

- without tracking, good for analysis of lower orders and moderate RPM slew rates
- with tracking, for the analysis of higher orders or higher RPM slew rates

To obtain the fundamental frequency for the Order Analysis a Tachometer or an Autotracker is used.

### Order Analysis with Tracking

An Order Analyzer and a Tachometer (or an Autotracker) are used to measure order spectra. The tachometer provides a tracking reference in cases where there is a dedicated tacho signal. The Autotracker provides the tracking reference in cases where there is no tacho signal directly available. In this case, the fundamental frequency can be extracted indirectly from the measured vibration or acoustic signal\*. The order analyzer, which consists of a tracking mechanism followed by an FFT analyzer, tracks the data and then performs an FFT on it to provide an order spectrum.

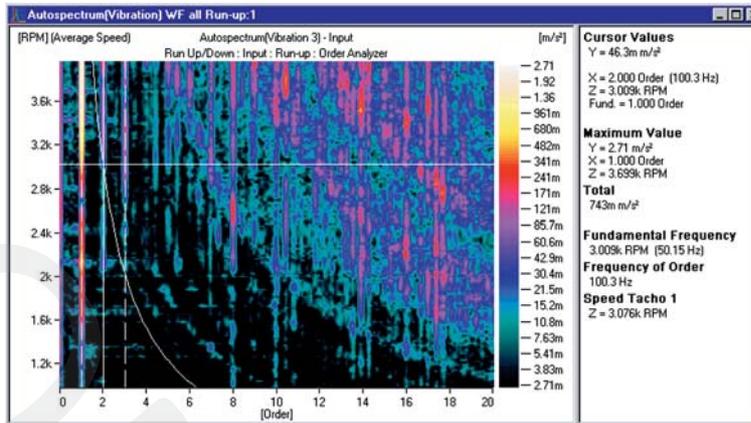
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\* The indirect (Autotracker) method is recommended in situations where direct access to rotating parts (for example, an encapsulated hot engine) is not possible or the tacho signal is of poor quality. It can be used very easily where the fundamental frequency and/or harmonic components are prominent. It should be noted, however, that if a well conditioned tacho signal can be obtained from the tachometer, this is still the preferred (and most accurate) method.

The amplitude and/or phase of the various orders as a function of (average) RPM/Hz is obtained by extracting slices parallel to the RPM/Hz axis from contour plots showing order spectra (see Fig. 1 and Fig. 2).

**Fig. 1**

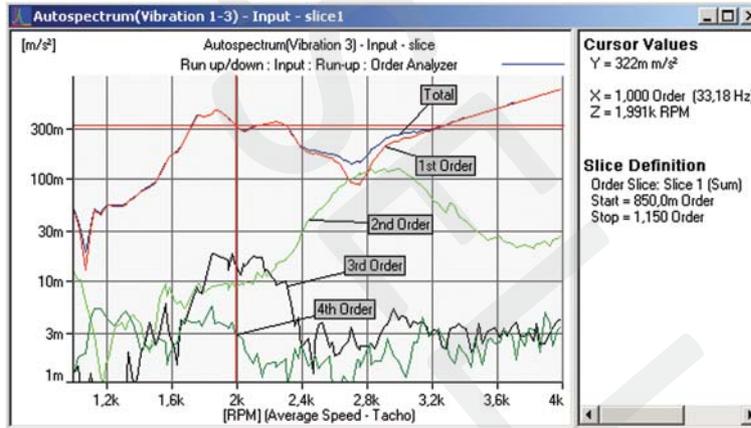
A contour plot showing order spectra as a function of RPM. The X cursor is marking the 2nd order, which has a frequency of 100.3 Hz at 3009 RPM, marked by the Z cursor. The curved line that passes through the intersection of the X and Z cursors indicates all the components in the plot at the same frequency (100.3 Hz). The first three orders are selected by the harmonic cursor



Alternatively, you can reduce the amount of data acquired and obtain faster processing by selecting calculation of order slices in the analyzer. This allows you to extract data at a number of orders and discard the data that does not interest you. In this way you can obtain the order slice data illustrated in Fig. 2 without all the data included in Fig. 1.

**Fig. 2**

A curve graph showing the 1st, 2nd, 3rd and 4th order slices extracted from the contour plot in Fig. 1 using the harmonic cursor. The total level is also shown allowing comparison of the power in each slice with the total power. The annotation feature has been used for easy identification of slices



Order analysis using tracking is beneficial if frequency smearing is significant due to, for example, fast run-up or run-down or when analysing higher order components. The order components remain in the same analysis line independent of the machine speed, and orders are easily identified for diagnostic purposes.

### Run-up/down Tests without Tracking

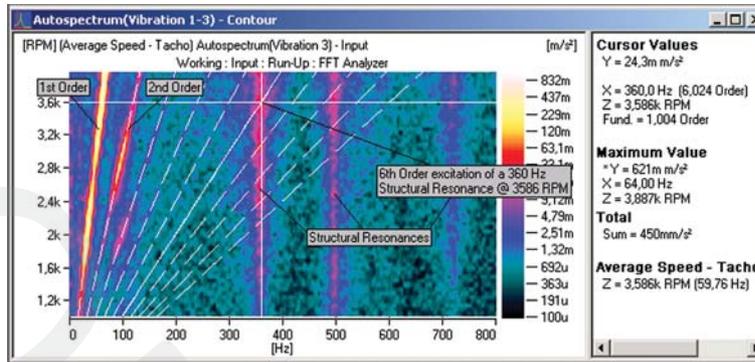
To perform a run-up/down test without tracking, use a Tachometer or Autotracker and an FFT Analyzer\*. The Tachometer, or Autotracker, supplies triggers that allow FFT measurements to be made and stored in a multi-buffer when specified conditions relative to the change in speed of a shaft occur.

Displaying these stored FFT spectra allows the identification and extraction of orders and/or frequency bands (structural resonances). The amplitude and/or phase of the various orders as a function of RPM are obtained by cutting and extracting oblique slices from contour plots showing frequency spectra versus RPM (see Fig. 3 and Fig. 4).

\* Requires Type 7700 or Type 7770.

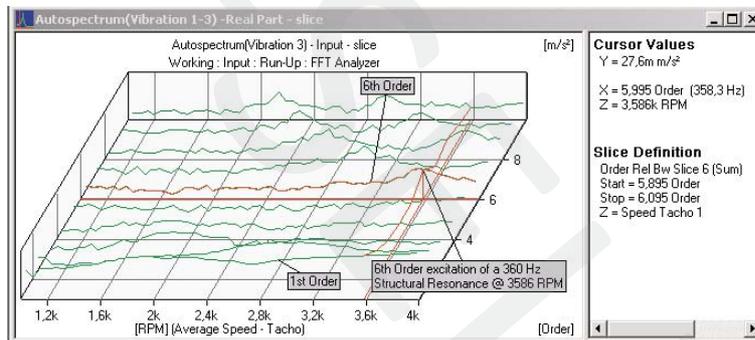
Alternatively, you can reduce the amount of data acquired and obtain faster processing by selecting calculation of slices in the analyzer. This allows you to extract data at a number of specified order and/or frequency bands and discard the data that does not interest you. In this way you can obtain the slice data illustrated in Fig. 4 without all the data included in Fig. 3.

**Fig. 3**  
A colour contour plot of a run-up test performed without tracking. The line passing through the intersection of the X and Z cursors identifies the 6th order. The harmonic cursor marks the first ten orders for the extraction of order slices by making oblique cuts in the contour plot of frequency spectra versus RPM



Run-up/down tests without tracking are useful where frequency smearing is insignificant. This can, for example, be the case when analysing lower order components. One of the main benefits of this method is the real-time enhancement. A further advantage is that it shows structural resonances at fixed frequencies parallel to the RPM axis.

**Fig. 4**  
A waterfall showing the harmonic order slices extracted from the contour plot in Fig. 3. The 1st and the 6th orders are annotated. The slice definition indicates the method and bandwidth used to extract the selected (order) slice



### Inputs and Tachometer

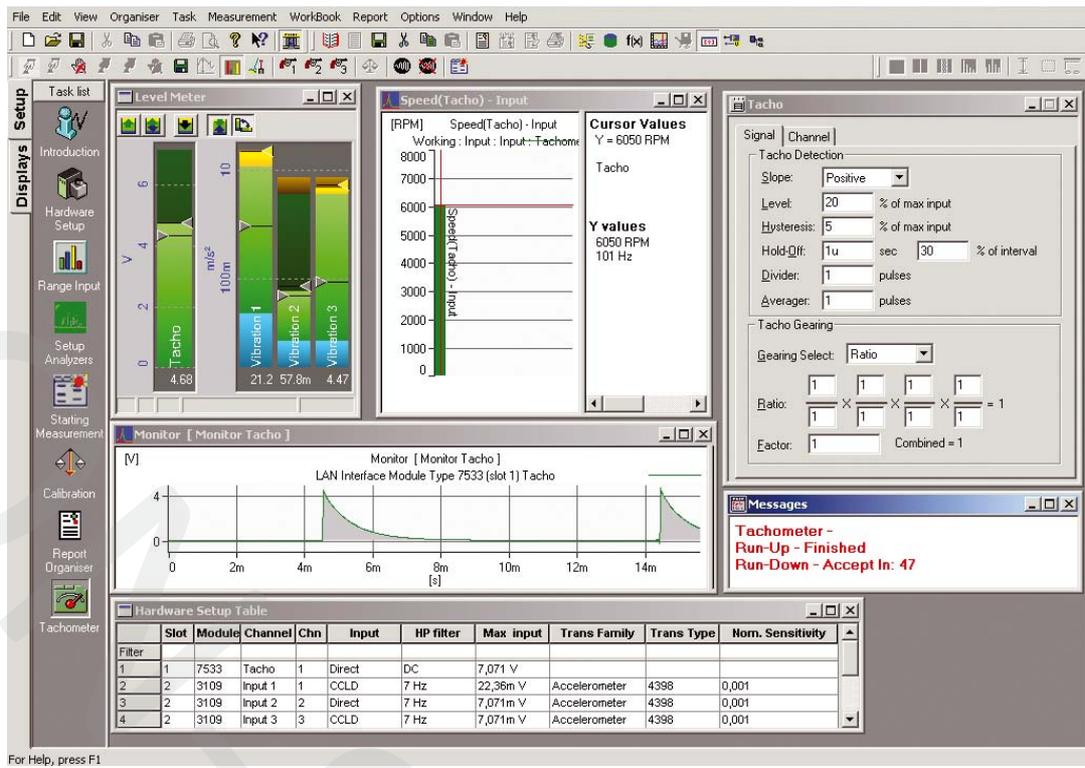
Input signals can be preprocessed by applying, for example, an acoustic weighting or integration/differentiation for conversion between acceleration, velocity and displacement. The same input signal can be connected to a number of different types of instrument, for example, order and CPB analyzers, a tachometer, etc. Auxiliary signals may also be connected to a tachometer just as they are connected to an auxiliary logger. Each tacho signal connected to a tachometer can be individually processed, conditioned and used as a tracking reference. This allows order tracking using multiple tracking references. Using a voltage signal connected to the tachometer, the sensitivity of the auxiliary signal is set to account for the sensitivity ( $V/RMS$ ) of the voltage signal and for possible gearing.

Using a pulse signal, there is a comprehensive set of parameters, including slope, level, hysteresis and hold-off, which can be set to ensure correct identification of tacho pulses in a contaminated tacho signal and a divider parameter allows the removal of unevenly spaced tacho pulses (see Fig. 5).

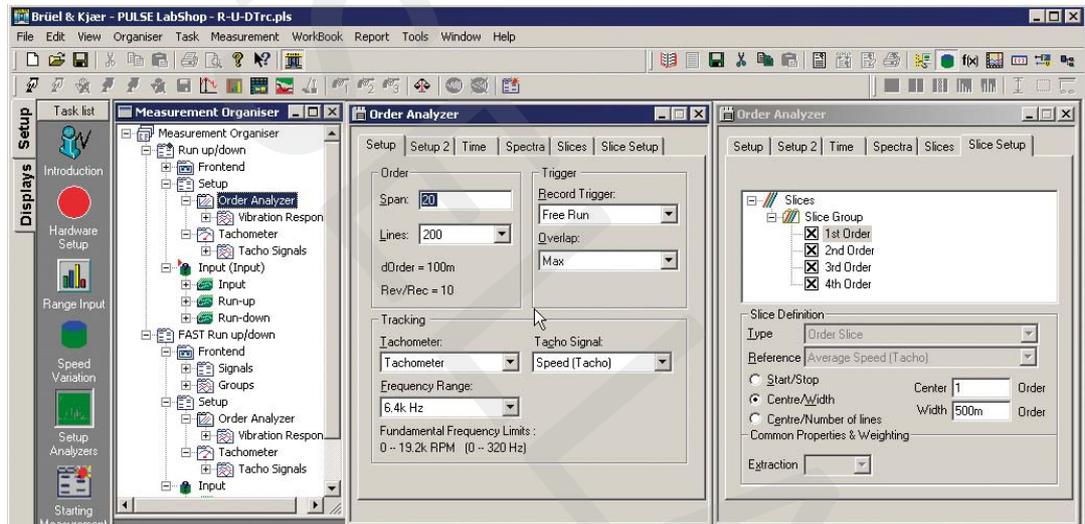
For removal of jitter from a low-quality tacho signal, you can apply an averager. This provides a running average for the distance between tacho pulses. If the shaft under analysis in a machine is not the one supplying the tacho pulses, a tacho gearing can be defined as either a single factor, a ratio containing up to 4 fractions, or the product of these two methods.

Monitoring of the tacho signals before measuring allows you to adjust the tacho parameters to suit the measurement. During measurements, the program gives assistance in the form of warning messages, for example, "Acceleration too high", indicating when the measured data are not reliable.

**Fig. 5**  
 Hardware setup, input level meter, tachometer signal monitor and the settings for the tachometer signal processing



**Fig. 6**  
 A measurement template in the Measurement Organiser and the setup for an Order analyzer. The Slice Setup tab shows how to define "pre-slices". (Note: The Setup tab page and the Slice Setup tab page cannot be displayed at the same time)



### Autotracker

To be able to use Autotracker on a measured signal you have to make sure the RPM you are looking for is present in the signal. The RPM should manifest itself in the form of a corresponding frequency (1st Harmonic/Order), together with (possibly) other orders. Prior knowledge in recognising these orders within the measured signal is an advantage, because this means you can insert the appropriate values into Autotracker straight away. (If you are not sure, use an FFT analyzer and contour plot to find the corresponding order(s)). Once you have established what the orders are, enter the appropriate values for Speed Range, Max. Acceleration and Dominant Orders into Autotracker using the Primary Settings panel on the Autotracker Property page, see Fig. 7.

Autotracker generates default values for the Secondary Settings, but in the case of a 'difficult' signal, you may adjust the values in the Secondary Settings panel.

Start the Autotracker running and it will then extract RPM directly from the signal – eliminating the need to use a tachometer/probe.

**Note:** Autotracker will only work if the RPM you are looking for is actually present in the measured signal. If it is **not** present, Autotracker will run, but will be unable to extract an RPM!

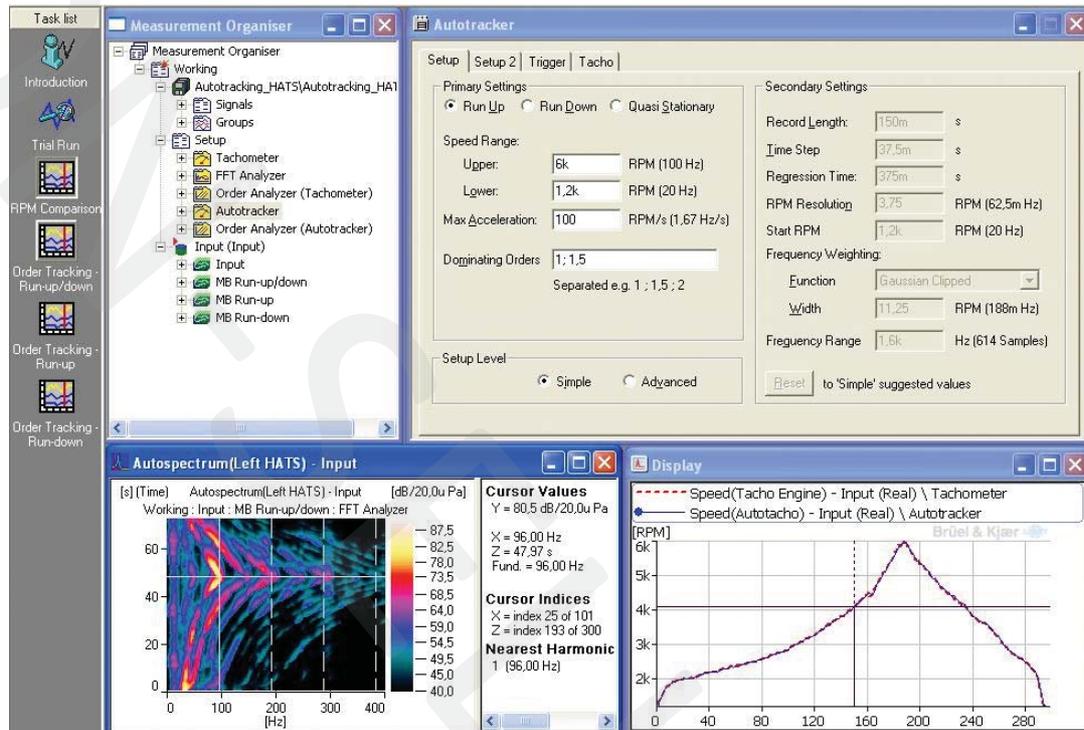
The Autotracker algorithm establishes a model of the signal and by using Bayesian statistics, it correlates the model with the signal and estimates the RPM profile.

Autotracker has a lot of advantages over the tachometer method:

- No need for direct access to the rotating parts
- No need for tacho probes and tacho channels
- Ease-of-use (no mounting of tacho probes)
- Reduced safety requirements

Fig. 7 shows a typical Autotracker display, where Autotracking was performed using a microphone located in the left ear of a Brüel & Kjær Head and Torso Simulator (see contour plot). The result was compared to the output from a Tachometer using a tacho probe mounted on the engine (see RPM plot, bottom right). In addition, the Measurement Organiser and the property page for setting up the parameters for the Autotracker are shown.

**Fig. 7**  
RPM profiles obtained from Autotracker (blue curve) and the Tachometer (red curve) – mostly concealed by the blue curve) for a 72 s car engine run-up/down measurement from 1.2 k RPM to 6 k RPM



The output from the Autotracker can be used as a tracking reference (for order analysis with tracking), as a speed trigger or as a speed interval trigger (for run-up/down tests without tracking).

### Measurement Control

The Tachometer and Autotracker can supply two types of trigger output for use in measurement control. These are:

- Speed Trigger
- Speed Interval Trigger

A **Speed Trigger** operates by using the calculated RPM of the shaft. A trigger event occurs when the calculated RPM passes through a specified RPM, going up, down or in both directions.

A **Speed Interval Trigger** measures the change in RPM of a shaft and generates a trigger event when the speed changes by a predefined value in the specified direction. The direction can be set as up, down or both.

In addition, the Tachometer (only) can supply a **Tacho Trigger** that can also be used for measurement control. A tacho trigger event occurs each time a tacho pulse that conforms to the specified conditions is detected at the Tachometer output for the chosen trigger signal.

These three trigger types can, for example, each be used for triggering measurements or starting, updating or stopping storage to multi-buffers. The start, update and stop conditions for the multi-buffers can be set up individually, as can the number of time signals, spectra and slices to store, meaning that a run-up and coast down measurement can be performed in a single test session.

## Post-processing

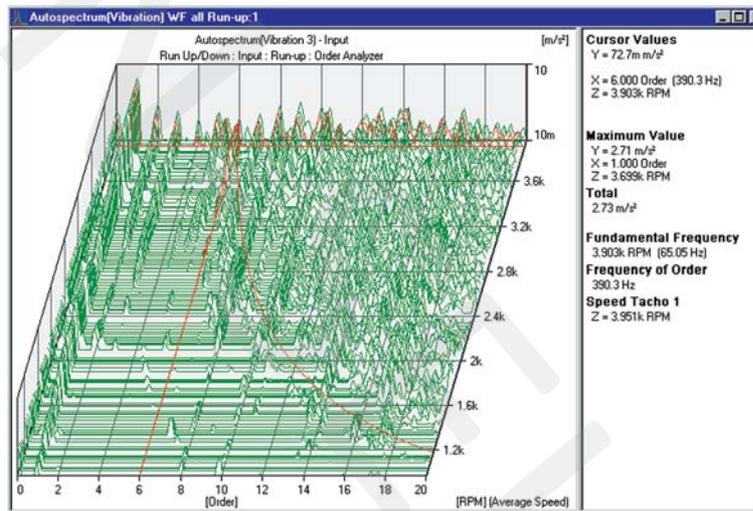
A wide range of functions are available for post-processing tracked and non-tracked data. All functions that are available for the FFT analyzer, supplied as part of FFT & CPB Analysis Type 7700 and FFT Analysis Type 7770, are also available for the order analyzer. A function for calculating rotational speed of a shaft can be applied to tachometer and Autotracker outputs.

In addition, time data recorded simultaneously with a measurement, or PULSE ASCII files exported from PULSE LabShop's Function Organiser can be imported for post-processing in PULSE Reflex™, which adds dedicated post-processing applications to the PULSE software environment and provides data import, data management, data display and integrated reporting tools for communicating processed data. For more information see Software for PULSE Reflex ([BP2258](#)).

## Display

Data can be viewed in a variety of 2 D graphs and a sequence of measured time signals or spectra can be shown in waterfall or contour plots, including Campbell diagrams.

**Fig. 8**  
A waterfall showing the results of a run-up test using tracking.



In Fig. 8, it can be seen that order and non-order components are present. The cursor readings indicate that the maximum measured value is 2.71 m/s<sup>2</sup> for the 1st order at 3699 RPM. The speed tag reading gives the speed at the moment the spectrum was stored. The fundamental frequency and the average speed values give the average speed (and frequency) during measurement of the selected spectrum

If speed values are stored in the multi-buffer, the RPM/Hz values or averaged RPM/Hz values can be used as the Z-axis annotation for displays showing noise and vibration data. RPM/Hz values are taken at the time the data are stored in the multi-buffer. Averaged values are averaged over the duration of measurement of each spectrum, giving better RPM and order alignment for run-up/down measurements.

The RPM/Hz values can also be shown as RPM/Hz versus time profiles or RPM/Hz values for different tacho or Autotracker signals can be compared using a multi-value display.

If the measurement setup also includes an Overall Level Analyzer for which slice data have been saved in a multi-buffer, these values can also be used as the Z-axis annotation.

### Cursors

A number of different types of cursor can be used to extract information from displays, and points of interest, such as resonances, can be annotated.

In addition to the cursor types in Type 7700, 7770 and 7771, a set of order cursors is available for use on non-tracked data and includes harmonic and sideband cursor types. For tracked data, it is possible to identify fixed frequency components by using the fixed frequency indicator.

The fundamental frequency for a tracked record and the actual frequency of a selected order, as well as any of the values available for Z-axis annotation, can be shown as cursor readings.

## Slices

In a colour contour or waterfall plot, individual or harmonic orders can be extracted and viewed in a 2 D graph. These order slices show the amplitude and/or phase of the orders as a function of, for example, RPM or time.

Slices can be extracted from tracked and non-tracked data using the cursors. For non-tracked data, if the Z-axis is rotational speed and annotated in RPM or Hz, an order slice is made by cutting across the spectra at an oblique angle with a user-definable width of cut. Thus, an order analysis is obtained using post-processing, i.e., without using an order analyzer.

Slices made as analyzer calculations are specified before measurement starts and extracted during measurement. They can be used as functions in the Function Organiser (slices extracted from a contour or waterfall plot are sub-functions) and collected in groups, simplifying data import and export and comparison of results.

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## Applications

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*Fig. 9 Typical Order Analysis applications are found within a wide range of industries*



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## Specifications – Order Analysis Type 7702

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Type 7702 is software for use with PULSE Type 3560

### Requirements

- The PC requirements for PULSE must be fulfilled (see [BU0229](#))
- FFT & CPB Analysis Type 7700 or FFT Analysis Type 7770 must be installed

### Application Projects

Type 7702 includes a number of application projects for:

- Run-up/down Acoustic Performance Test
- Run-up/down Vibration Diagnostics

The projects can be found in the PULSE Knowledge Library

### Measurement

Type 7702 includes:

- Order Analyzer
- Tachometer
- Autotracker

Tachometer, Autotracker and Order Analyzer specifications are given below

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## Specifications – Tachometer

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A number of variants of the tachometer output can be used simultaneously

The outputs of a tachometer are used:

- As tracking references
- As tacho triggers
- As speed triggers
- As speed interval triggers
- For displaying rotational speed
- For updating the multi-buffers

### Performance

The precision of determination of the time period between tacho events is governed by the rise/fall time of the tacho signal. For pulses (short rise/fall time), the precision is better than 5 ppm. For a sine wave tacho signal, the precision ranges from 50 ppm for low frequencies to 5 ppm for high frequencies

Using an auxiliary signal, the tachometer generates one 'tacho pulse' per revolution of the referenced shaft. Since the sampling frequency of the aux. signal is 10 Hz, speeds > 600 RPM will be measured as the average of speed (RPM)/600 revolutions (RPM)

### Measurement

Any input signal can be used as a tachometer input

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## Specifications – Autotracker

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A number of variants of Autotracker output can be used simultaneously

The outputs of Autotracker are used:

- As tracking references
- As speed triggers
- As speed interval triggers
- For displaying rotational speed
- For updating the multi-buffers

### Measurement

Any input signal can be used as an Autotracker input

### Measurement Control

The following additional trigger types are available with Type 7702:

- Tacho Trigger (Tachometer only)
- Speed Trigger
- Speed Interval Trigger

### Display

Specifications are the same as for FFT & CPB Analysis Type 7700 (see System Data BU 0229) with the following additions:

#### CURSORS

- Order indicator for non-tracked data
- Fixed frequency indicator for tracked data

#### CURSOR READINGS

- Fundamental frequency for a record
- Actual frequency of a selected order
- Speed
- Average speed from one or more tachometer channels (limited by the channel count of Type 7702)

#### SLICES

Order slices from non-tracked data

#### PARAMETERS

The following parameters can be set for each tachometer signal:

- **Reference Level:** user-defined level that can be used instead of Max. Input Level for setting Level and Hysteresis
- **Level:** can be set with 1% resolution relative to Max. Input Level or Reference Level
- **Hysteresis:** can be set with 1% resolution relative to Max. Input Level or Reference Level
- **Slope:** positive or negative
- **Hold-off:** set as the higher of the relative distance between two successive tacho pulses and the absolute value  
Relative: can be set from 1 to 90%  
Absolute: 0 to 10 s
- **Divider:** can be set from 1 to 8192 in integer steps
- **Averager:** running average of distance between a number of pulses.  
Can be set from 1 to 999 in integer steps
- **Gearing:** tacho gearing can be defined as a single factor, a ratio containing 4 fractions or the product of these

#### AUX. SIGNAL

The sensitivity (V/RMS) and offset (RPM) of the signal is set in the sensitivity of the individual auxiliary signals. The setting of the sensitivity can be used to account for a possible gearing

### Post-processing Functions

- Rotational speed

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#### PARAMETERS

The following can be set for the Autotracker analyzer:

Primary Settings:

- **Speed Range:** of the RPM or corresponding fundamental frequency
- **Max. Acceleration:** The max RPM/s during the measurement session
- **Dominating Orders:** The orders, visible in the signal, from which the algorithm should estimate the RPM

Secondary Settings:

The Autotracker suggests a set of default values, which you can adjust in the case of 'difficult' signals.

### Post-processing Functions

- Rotational speed

## Specifications – Order Analyzer

A number of variants of the order analyzer can be used simultaneously. The order analyzer resamples time signals, then performs an FFT transform on the result. One tachometer output is used as a tracking reference and it determines the digital low-pass filtering, decimation, interpolation and resampling in the order analyzer

### Measurement

Any input signal can be measured using an order analyzer

#### TIME DOMAIN OPERATIONS

- Single or double integration
- Single or double differentiation

### FREQUENCY WEIGHTING

- A, B, C, D
- $j\omega^2$ ,  $j\omega$ , 1,  $1/j\omega$ ,  $1/j\omega^2$

### ORDER SPECTRUM ANALYSIS

Order Span: 1–10000 orders

Spectral Lines: 50 – 6400

### Post-processing Functions

- Rotational speed

The other specifications for the order analyzer are the same as for the FFT analyzer, see the System Data for PULSE Software (BU 0229)

## Performance – Tachometer and Order Analyzer

The processing power required of the PC is measured in terms of “beats”. The more analyzers and the more demanding the individual analyses, the greater the number of beats required. See the System Data for PULSE software (BU 0229) for details of PC performance specifications

The following examples show how the order analyzer performs and how many beats are required for various settings. The examples are made from a basic setup for acquisition of 3 signals at 25.6 kHz span, with 1 signal for tacho reference and 2 signals for order analysis

- Acquisition and tachometer cost 8 beats (6 for Acquisition, 2 for the tachometer)
- Max. overlap itself does not require as many beats as 0% overlap, as max. overlap has a range down to –1000%. But when max. overlap is chosen, the system will use every available resource to get an overlap as high as possible

#### Beat costs for 75% overlap\* at various analysis spans:

Span [kHz]	Overlap [%]	Beats Required 7702	Beats Required in Total
25.6	75	63	71
12.8		38	46
6.4		25	33
3.2		19	27
1.6		16	24

#### Beat costs for 67% overlap at various analysis spans:

Span [kHz]	Overlap [%]	Beats Required 7702	Beats Required in Total
25.6	67	59	67
12.8		36	44
6.4		24	32
3.2		18	26
1.6		15	23

\* Most demanding overlap specification in terms of beats required

#### Beat costs for 0% overlap at various analysis spans:

Span [kHz]	Overlap [%]	Beats Required 7702	Beats Required in Total
25.6	0	48	56
12.8		30	38
6.4		21	29
3.2		17	25
1.6		15	23

#### Possible max. overlap on a system with 75 beats available at various analysis spans:

Span [kHz]	Overlap [%]	Beats Required 7702	Beats Available in Total
12.8	82	28	75
6.4	94	20	
3.2	97	16	
1.6	98	14	

#### ON CHANGING THE NUMBER OF SIGNALS

- Doubling the number of signals for the Order Analyzer doubles the number of beats it requires

#### BEATS REQUIRED BY THE TACHOMETER

- The Tachometer is analysing the signal at the acquired span
- When using half the acquisition span, the Tachometer uses half the number of beats
- Doubling the number of signals for the Tachometer doubles the number of beats required by the Tachometer

## Performance – Autotracker

### AUTOTRACKER ACCURACY

The accuracy of Autotracker depends primarily on the choice of parameters and the overall signal to noise ratio of the dominant harmonic orders in the measured signal.

The tables below summarise the accuracy obtained for a simulated run-up from 1000 RPM to 6000 RPM over 27.8 seconds for different parameter combinations.

The test signal consisted of a clipped sine wave, linearly sweeping from 6 Hz to 100 Hz at a rate of 3 Hz/s. The fundamental frequency was measured using both the Tachometer and Autotracker and recorded in a multi-buffer as average speed tags using an FFT analyzer, running maximum overlap with records of  $T = 0.5$  s. The Autotracker error was then defined as the difference between the two average speed tags. The multi-buffer was updated every 100 ms.

#### Accuracy for varying number of harmonics:

No. of Harmonics	Fund. Freq. Resolution [Hz]	Record Length [s]	Signal Freq. Range [Hz]	Mean Error [RPM]	Std. Deviation [RPM]	Max. Abs. Error [RPM]
1	1	0.125	200	1.94	5.23	28.00
2	1	0.125	200	1.64	4.55	19.47
3	1	0.125	200	1.95	4.19	17.30

The table shows that the accuracy generally increases with the number of harmonics

#### Accuracy for varying fundamental frequency resolution:

No. of Harmonics	Fund. Freq. Resolution [Hz]	Record Length [s]	Signal Freq. Range [Hz]	Mean Error [RPM]	Std. Deviation [RPM]	Max. Abs. Error [RPM]
1	0.125	0.125	200	1.50	3.63	24.34
1	0.250	0.125	200	1.68	3.75	15.65
1	0.500	0.125	200	1.51	4.27	23.49
1	1.000	0.125	200	1.94	5.23	28.00

The table shows that the accuracy generally increases with increasing resolution

#### Accuracy for varying record length:

No. of Harmonics	Fund. Freq. Resolution [Hz]	Record Length [s]	Signal Freq. Range [Hz]	Mean Error [RPM]	Std. Deviation [RPM]	Max. Abs. Error [RPM]
1	0.250	0.500	200	2.32	1.52	7.60
1	0.250	0.250	200	1.87	2.04	8.81
1	0.250	0.125	200	1.68	3.75	15.65

The table shows that the accuracy generally increases with increasing number of samples (record length)

#### Accuracy for varying signal frequency range:

No. of Harmonics	Fund. Freq. Resolution [Hz]	Record Length [s]	Signal Freq. Range [Hz]	Mean Error [RPM]	Std. Deviation [RPM]	Max. Abs. Error [RPM]
1	0.250	0.250	400	0.98	1.51	7.34
1	0.250	0.250	200	1.87	2.04	8.81

The table shows improved accuracy for higher signal frequency range

## Beats Required by Autotracker

Number of Harmonics	Lowest Harmonic [Order of fundamental]	Highest Harmonic [Order of fundamental]	Range of Fundamental Frequency			Beats Required		
			Lower [Hz]	Upper [Hz]	Resolution [Hz]	0% overlap	67% overlap	75% overlap
1	1.0	1.0	10	100	0.5	2	4	6
1	1.0	1.0	10	100	0.25	3	8	11
1	1.0	1.0	10	100	0.125	6	17	22
1	1.0	1.0	10	200	0.5	11	35	46
1	1.0	1.0	10	400	0.5	92	279	368
1	1.0	2.0	10	100	0.5	5	16	22
1	1.0	4.0	10	100	0.5	21	65	85
2	1.0	2.0	10	100	0.5	9	28	37
2	1.0	2.0	10	100	0.25	18	55	73
2	1.0	2.0	10	100	0.125	37	111	146
2	1.0	2.0	10	200	0.5	75	229	302
2	1.0	4.0	10	100	0.5	36	109	143
4	1.0	4.0	10	100	0.5	66	198	262

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## Ordering Information

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### Type 7702-Xy\* Order Analysis

The licenses allow measurements on the specified number of channels with order analyzers and the specified number of tachometer channels for Average Speed calculations. The license does not restrict the number of tachometer channels for speed monitoring purposes

\* X = license model either N for node-locked or F for floating  
y = optional channel count, from 1 (single) to 7. No number denotes unlimited channels (channel-independent)

### SERVICES

M1-7702-Xy Software Maintenance and Support Agreement  
M3-7702-Xy Update of M1-7702-Xy

See the Software Maintenance and Upgrade Product Data (BP 1800) for further details of M1 and M3 Agreements

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