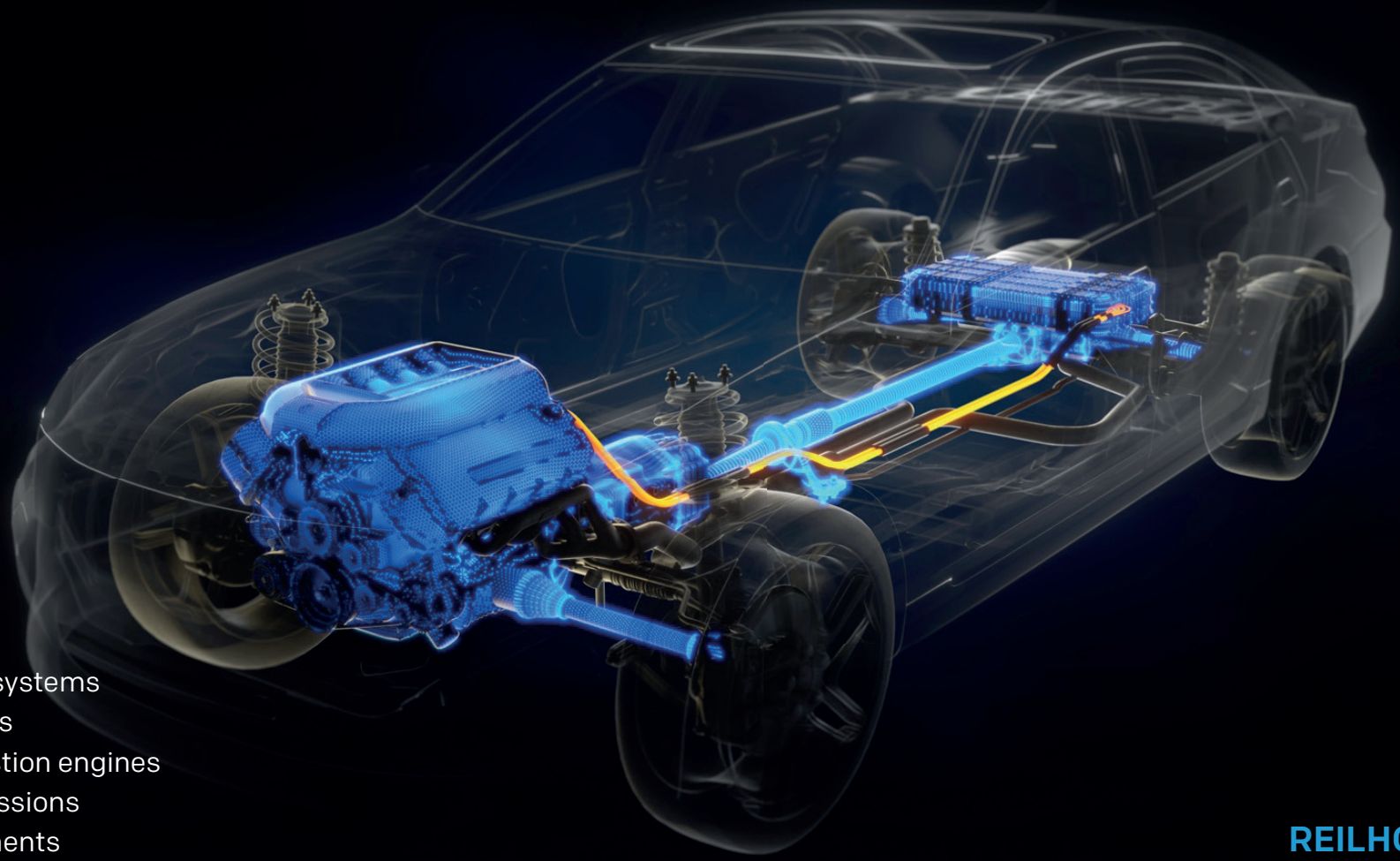
ACOUSTIC EARLY DAMAGE DETECTION AND QUALITY ASSURANCE ON THE POWERTRAIN



- E-drive systems
- E-motors
- Combustion engines
- Transmissions
- Components

REILHOFER KG

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FAULTLESS.

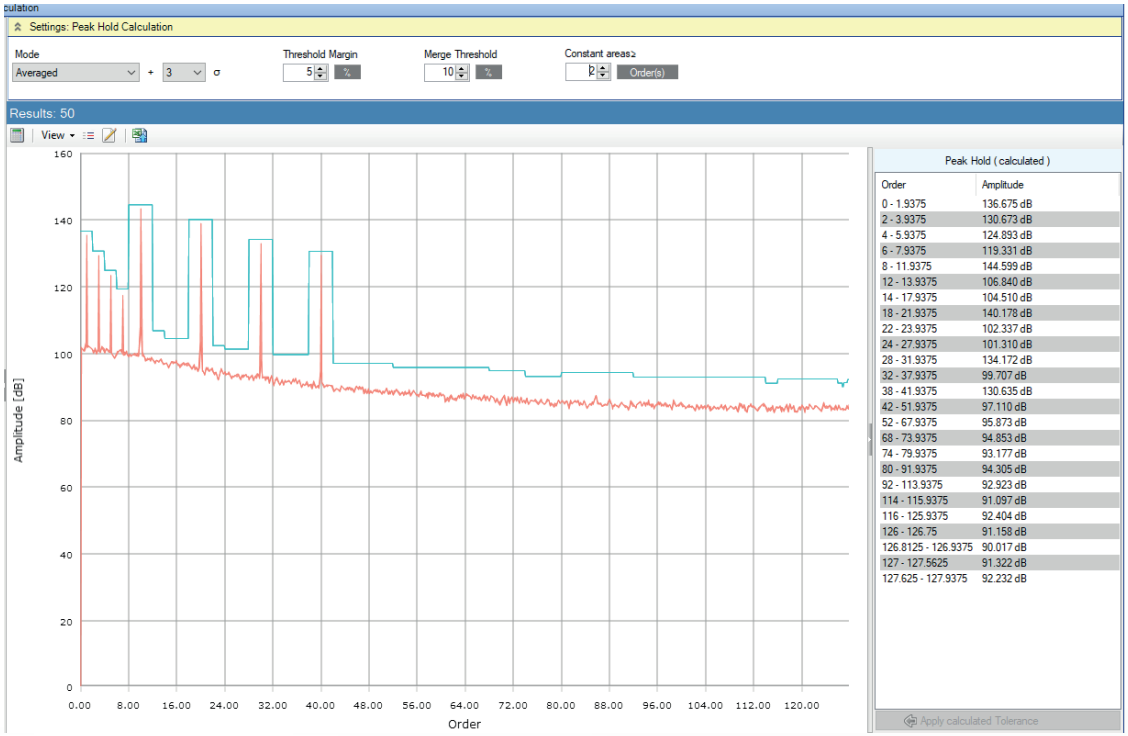
eol ANALYSER v3

The eolANALYSER was originally - more than 20 years ago - developed especially for quality control of the powertrain. It was mainly used for the detection of production faults for transmissions and combustion engines. But just like the test items the demands and requirements of the customers have changed and developed over the years. It goes without saying that a fault-free, functional product is a prerequisite for the customer. The quality of the product is also defined by other properties such as noise comfort / acoustics. Furthermore, thanks to our deltaANALYSER, which is used in the development field, we learned a lot about the requirements and demands of the new drive technologies at an early stage. We have already successfully integrated the resulting increased demands on final quality control and its methods into our acoustic final quality control diagnosis system, the eolANALYSER. Thus, we have been successfully testing alternative drive concepts such as hybrids, electric axes or even the individual components such as the electric motor or the reduction gear box for our customers for quite some time. Without the internal combustion engine - which, in contrast to the above-mentioned drives, generates much more noise - components that were previously acoustically inconspicuous now become relevant for testing. Therefore, we have optimized the eolANALYSER for the use on components like smaller actuators and drive motors.

For the two main tasks of an acoustic diagnostic system there are two independent concepts of threshold value definition to be pursued.

1. Noise Comfort – the acoustic behaviour inside the vehicle – manual threshold definition

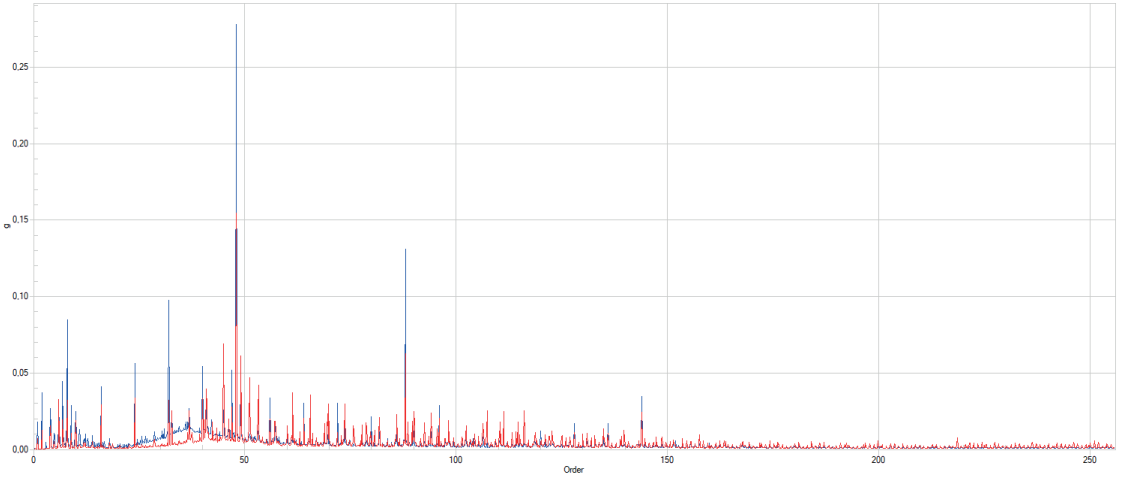
What kind of background noise does the test item cause and at what point is it perceived by the customer as unpleasant or unacceptable, even though there is no mechanical fault? This threshold depends on many factors and can vary from vehicle to vehicle or already from one derivative to another. Therefore, these thresholds can only be determined by timely extensive measurements and empirical methods. The threshold values determined in this way are then valid right from the start of series production. Therefore, a manual definition of threshold values should be possible in a modern eol diagnostic system. Nevertheless, the system should ideally support its user in defining the threshold values. For example, by quickly and easily determining threshold value recommendations based on existing measurements and using known and common static methods such as standard deviation with or without offset. If necessary, the suggested threshold values can be exported to Excel. This file can be loaded as a threshold value definition and thanks to the available network-based configuration it can be activated immediately on the eolANALYSER. Also, an adaptation of individual values in the file or the final threshold value definition is possible at any time.



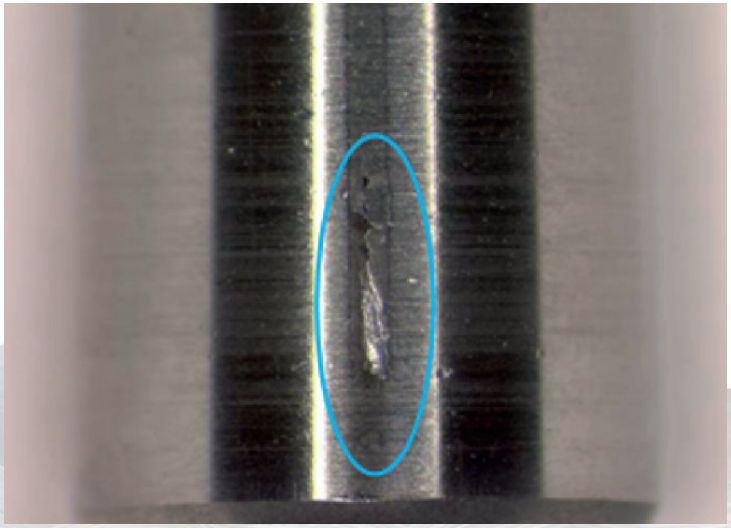
Measurement data-based threshold definition for peak hold spectrum with different sigmas

2. Production Failures

Drive systems and even smaller components consist of a large number of parts. The possible sources and types of errors in the production of all components as well as the acceptable tolerance ranges for each component are so large and different that not all conceivable error patterns can be taught or estimated. Therefore, in addition to manual threshold values, a system and a methodology for defining threshold values is required. These thresholds should be based on the current behaviour of production and adjust itself automatically to the continuously changing but acceptable fluctuations in production. Only in this way is it possible to detect the entire range of possible error patterns with the greatest sensitivity at all times.



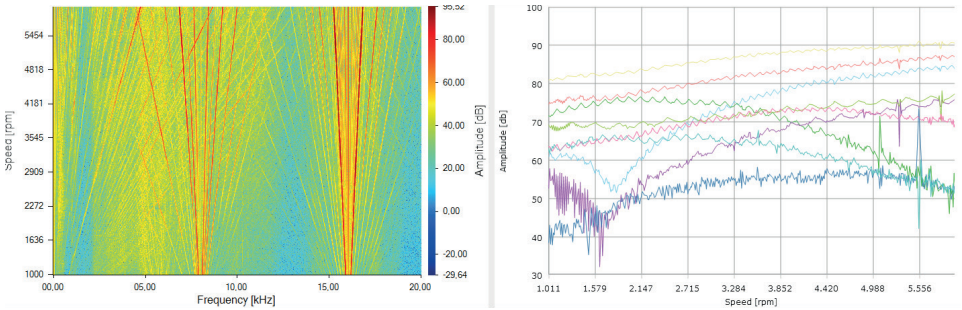
Spectrum of a bearing damage with defective rolling element



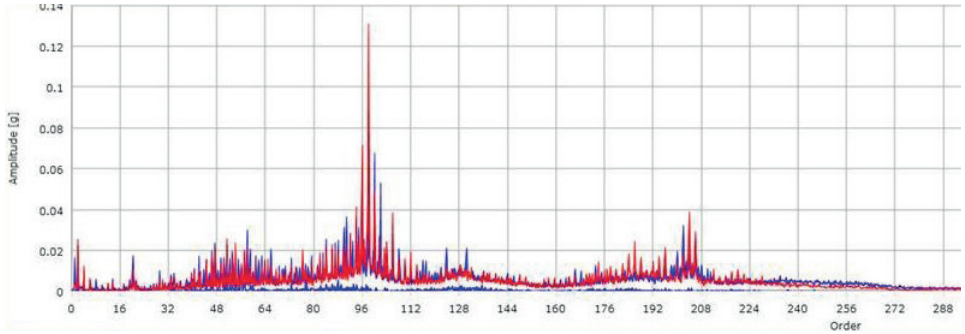
Damaged bearing – defect rolling element

Methods for detecting acoustic abnormalities and production errors

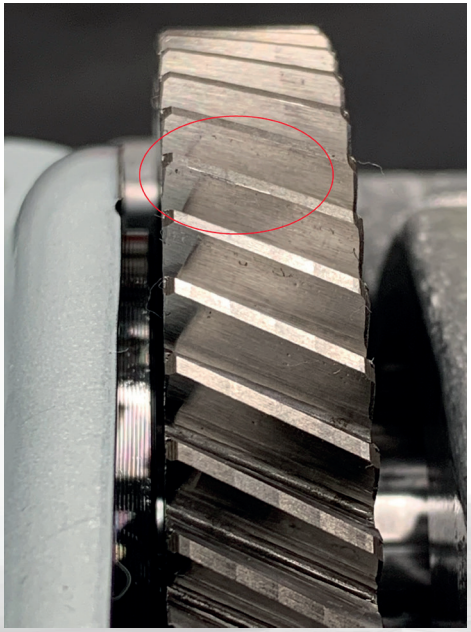
For every product and every production there is a multitude of possibilities to influence errors and error patterns. Also, the ways in which these defects show and express themselves are very different. In addition, the different test items require different procedures and analysis methods. Therefore, the eolANALYSER has currently more than 25 different evaluation methods to achieve the best possible result. Like for example the especially for electric motors integrated method of „frequency cuts" for the analysis of inverter sidebands.



Example of an eolANALYSER evaluation of an e-drive: spectrogram and frequency cut



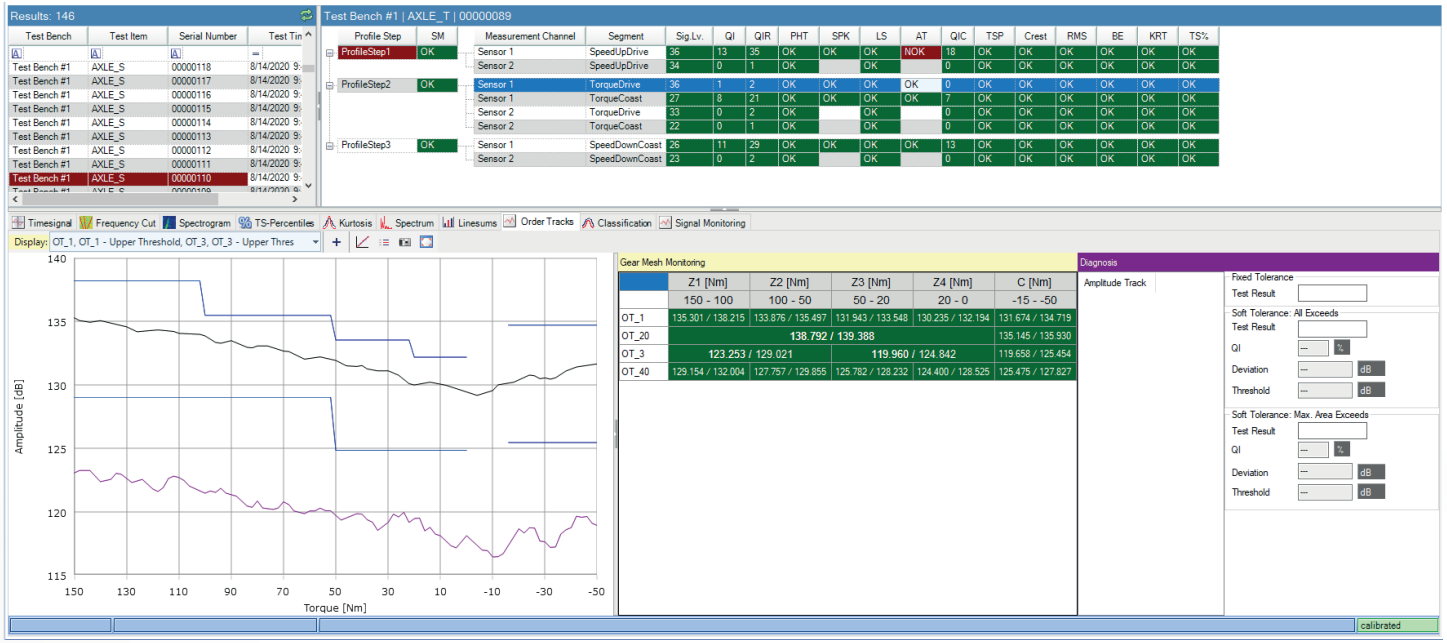
Spectrum of the gearing damage



Error pattern of a gearing

Data analysis and reporting

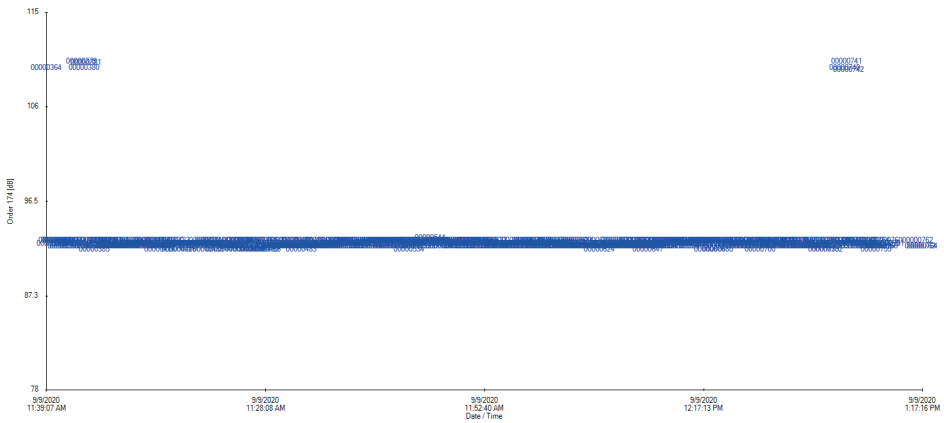
The integrated evaluation software enables the measurement results of each test item to be analysed down to the smallest detail. When entering the serial number in the Live Filter, all tests performed on the test item appear, independent of the test bench. This is helpful, for example, if you want to compare the results and spectrum of the original test with a re-test or regularly test a master test item as a reference.



Example of a detailed analysis in the Evaluation.NET software: Order / Amplitude tracking

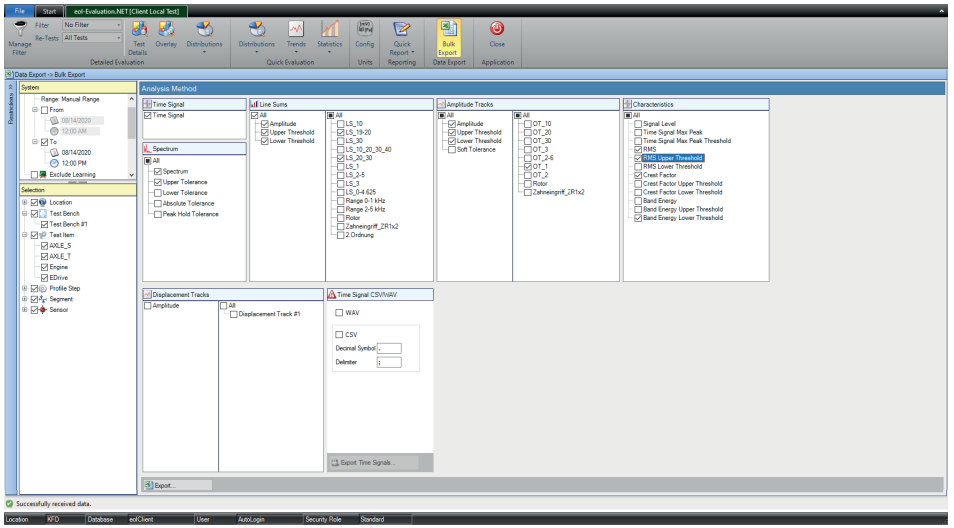
Configurable and storable filters optimize the workflow and help to reduce the amount of data when required. This makes it possible to obtain an overview of the current production within a short time and, if necessary, to analyse specific focal points.

A multitude of statistics functions and trend representations such as the order cloud further facilitate the daily work of quality assurance and control. With just a few clicks, the stability of acoustically relevant orders, such as tooth mesh, can be visualized and checked.



Order cloud of the tooth mesh order's level in the Evaluation.NET software

For comprehensive reporting, various functions and formats, such as ASAM ODS ATFX, wav, xml, csv etc., are available for individual or mass export.



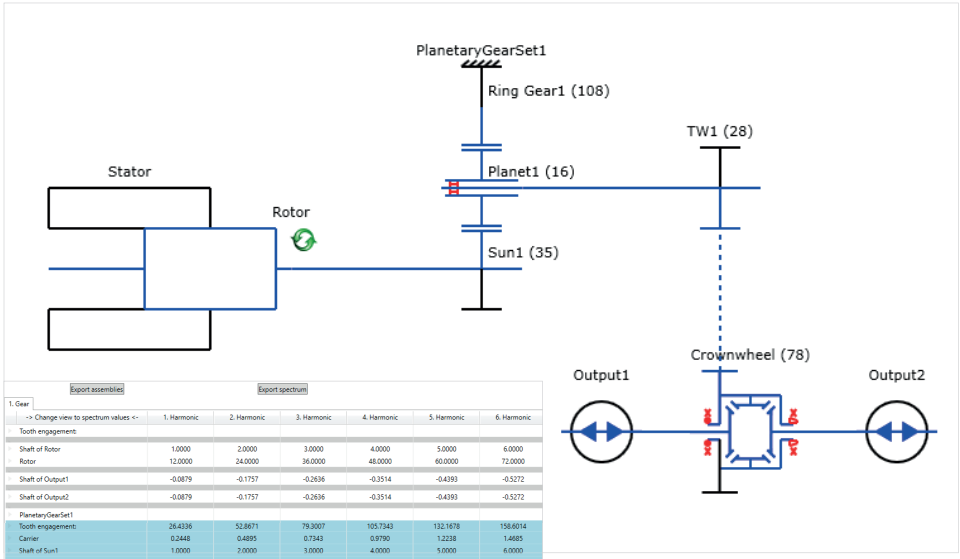
Mass Export from the Evaluation.NET software

HIGHLIGHTS OF THE Evaluation.NET

- Single or mass export in various formats, such as ASAM, wav, xml, csv etc.
- configurable filters for effective data selection
- Overlay and comparison options
- Optimal reporting thanks to integrated quick overviews of trend developments and extensive statistics and distribution functions

Analysis support through integration of the Reilhofer Order Calculator (ROC)

Each test item with moving components generates more or less loud noises. Rotating components, such as gears of a transmission or the magnet pairs of an electric motor, cause a continuous, constantly repeating noise. The frequencies/orders of these noises can be calculated to identify this component and its possible errors in the spectrum. Since each component, depending on its construction, transfer path or sensor position, not only expresses itself in a frequency/order. Thus, also effects such as harmonics and sidebands have to be considered. The list of relevant orders for damage analysis quickly becomes very large and extensive. Other components such as rolling bearings already have 4 frequencies/orders that can manifest themselves in case of damage - cage, inner or outer ring and the rolling elements - again with harmonics and sidebands. In its calculation and visualization, the ROC takes into account all possible options and combinations up to the 50th harmonic and the associated sidebands.
Thanks to the numerous available standard modules, a test item model can be calculated in a few minutes. Due to the memory functions, derivatives with slightly different gear wheel pairs or modified bearing geometry etc. can be adapted quickly and easily based on the main design. Thus, all analysis-relevant orders are available recalculated within a very short time. The determined orders can be exported and used as manual analysis support. Furthermore, it is possible to import the models into the eolANALYSER to use them for an automated pattern recognition.



Export assemblies Export spectrum

1. Gear

-> Change view to spectrum values <-	1. Harmonic	2. Harmonic	3. Harmonic	4. Harmonic	5. Harmonic	6. Harmonic
Tooth engagement:						
Shaft of Rotor	1.0000	2.0000	3.0000	4.0000	5.0000	6.0000
Rotor	12.0000	24.0000	36.0000	48.0000	60.0000	72.0000
Shaft of Output1	-0.0879	-0.1757	-0.2636	-0.3514	-0.4393	-0.5272
Shaft of Output2	-0.0879	-0.1757	-0.2636	-0.3514	-0.4393	-0.5272
PlanetaryGearSet1						
Tooth engagement:	26.4336	52.8671	79.3007	105.7343	132.1678	158.6014
Carrier	0.2448	0.4895	0.7343	0.9790	1.2238	1.4685
Shaft of Sun1	1.0000	2.0000	3.0000	4.0000	5.0000	6.0000
Shaft of Planet1	-1.6521	-3.3042	-4.9563	-6.6084	-8.2605	-9.9126
Shaft of Ring Gear1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
TW1 X Crownwheel	6.8531	13.7063	20.5594	27.4126	34.2657	41.1189
Shaft of TW1	0.2448	0.4895	0.7343	0.9790	1.2238	1.4685
Shaft of Crownwheel	-0.0879	-0.1757	-0.2636	-0.3514	-0.4393	-0.5272
Output left	-0.0879	-0.1757	-0.2636	-0.3514	-0.4393	-0.5272
Output right	-0.0879	-0.1757	-0.2636	-0.3514	-0.4393	-0.5272
Bearings:						
Planet Carrier - left on PlanetaryGearSet1						
cage	0.6884	1.3767	2.0651	2.7535	3.4419	4.1302
inner ring	10.6010	21.2019	31.8029	42.4038	53.0048	63.6058
outer ring	7.5721	15.1442	22.7163	30.2885	37.8606	45.4327
rolling element	4.8186	9.6372	14.4559	19.2745	24.0931	28.9117
1. Hollow shaft Case - left on Crownwheel						
cage	0.0366	0.0732	0.1098	0.1464	0.1830	0.2197

Reilhofer Order Calculator excample e-drive

HIGHLIGHTS OF THE Reilhofer Order Calculator (ROC)

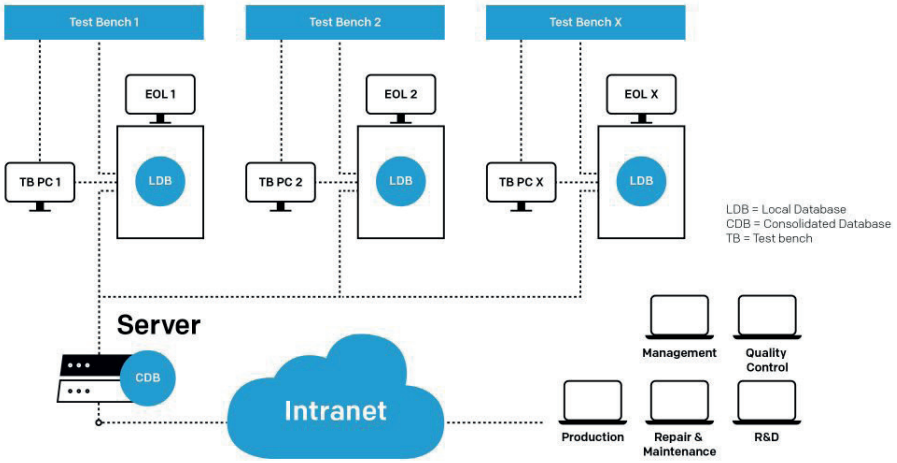
- Suitable for the design and calculation of various types of test items, e.g. transmissions/E-drive/combustion engines/E-motors/components
- Individual components or constructions can be combined into an assembly, for example a complete drive train consisting of combustion engine, transmission and differential.
- Export functions
- Integrable in eolANALYSER as well as in deltaANALYSER

Web-based system configuration and data evaluation

The eolANALYSER can be operated and configured separately on each test stand. To achieve the best user comfort, measuring PC performance and data security, we recommend to integrate the eolANALYSER into the company network. With our web applications all measuring systems can be configured from any PC in the network. Even the detailed analysis of the measured data, measurement comparisons or static evaluations of single or multiple test benches are possible at any time via the network.

Thanks to the network integration the eolANALYSER can replicate the measurement data and results after each test to a defined server (hardware / virtual). So, the local data base (LDB) on the industrial PC at the test bench is kept as small as possible, because only the settings and limit values of the possible test items have to be kept available.
This significantly increases the system performance. Data replication also has the advantage in unfavourable cases, such as the crash of an industrial PC, that the data can be quickly and easily extracted from the server's database (CDB) to the measuring system's industrial PC, so that the system is immediately ready for use again after the hardware has been repaired. The system availability is significantly higher due to the low downtime, as the recommissioning is not delayed by complex configurations and threshold value settings. This is possible because the server database (CDB) is up to date with the second last measurement due to direct data replication. The risk of data loss is reduced to a minimum.
In the case of network-based central data storage and filing, data backups and back-up routines are much easier and faster for IT departments, which further increases overall data security.

eolANALYSER in the production



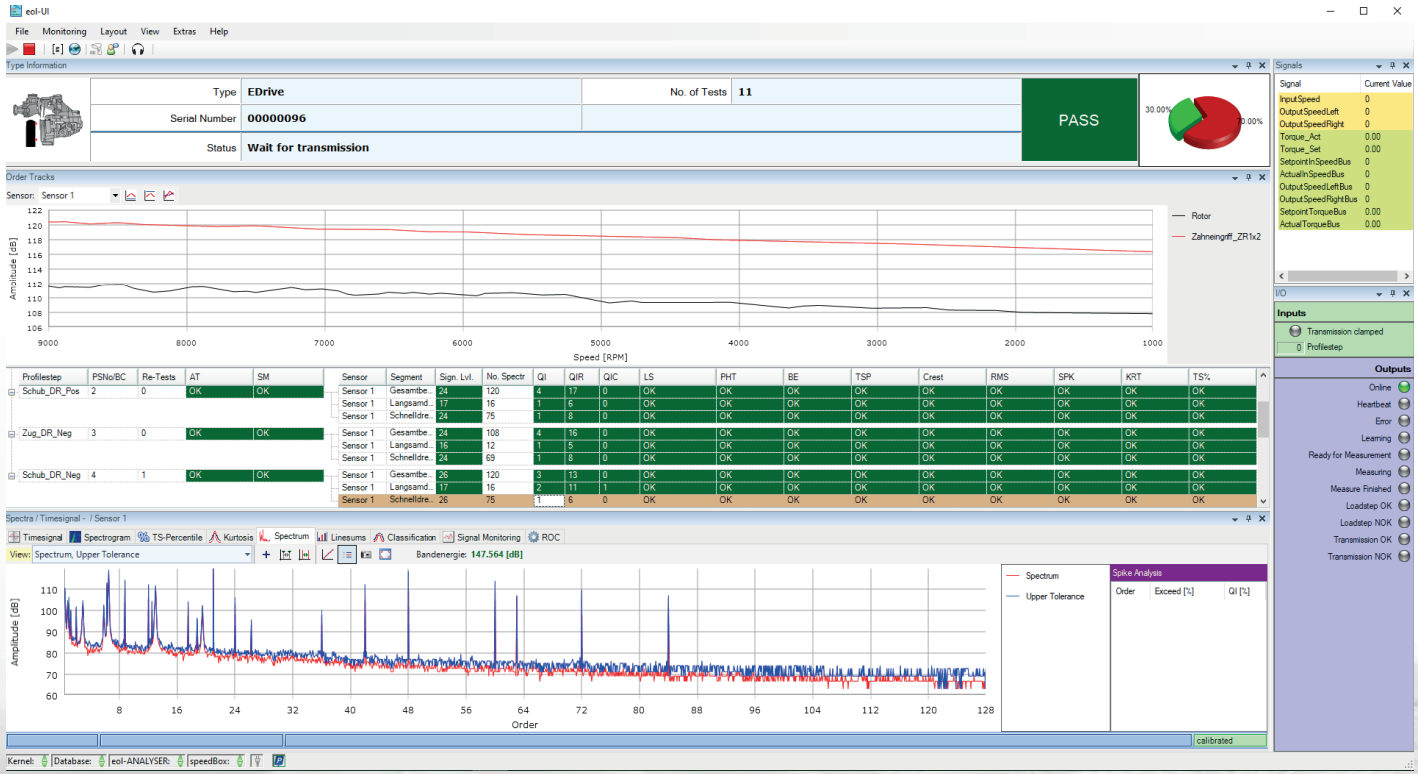
Data management

The requirements for data retention are customer-specific. In order to retain as little data as possible but as much as necessary for each requirement, we offer a data management program. Here it is possible to have all older data records automatically deleted after freely definable periods of time, for example 3 years. This has the advantage that the size of the server can be limited. Manual checks and corresponding manual data reduction processes are thus a thing of the past.

UserInterface at the test bench

Our user interface can be specifically adapted to the needs of our customers. Thanks to a large number of selectable modules, it is possible to display a very clear presentation with only the essential information OK/NOK. Of course, an extensive detailed presentation of the results for all test steps and methods is also possible. If required, evaluation details such as spectra or order tracks can also be visualized directly.

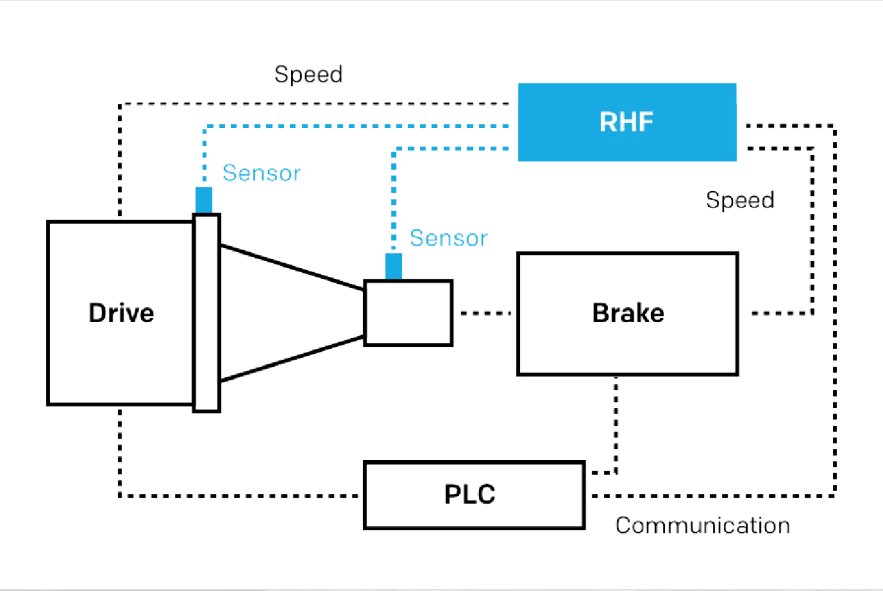
Even with a more extensive display with many details, as in the graphic below, the essentials are always in view and easy for the operator to read thanks to a simple and effective colour scheme [green OK- red NOK].



User Interface with comprehensive presentation

Test bench integration of the eolANALYSER

The integration of the eolANALYSER into a new or existing test bench is usually very easy. For most of the communication or the required handshake a variety of bus systems are available, for example Profi/Mod/Ethercat/CAN, covering the most common interfaces of modern automation technology. If necessary, the use of analogue inputs and outputs is also possible. During the test cycle there is a constant data exchange between eolANALYSER and master computer, so that the master computer can also visualize the single or overall result if necessary.



Test bench integration of the eolANALYSER

Sensors

The selection of the sensors depends strongly on the application and the requirements. The eolANALYSER offers great flexibility due to its inputs compatible with a large number of sensors. Most often fixed or pressed-on accelerometers, rotary accelerometers, laser vibrometers or microphones are used. If required, we will be pleased to support and advise you in selecting the optimal sensor concept for the respective application.

3-axle ICP sensor

ICP sensor

Pressing device with ICP sensor

Microphone

Laser vibrometer

Torsional vibration sensor

Technical data eolANALYSER

GENERAL	Supply Voltage	110 V / 230 V 50 – 60 Hz
	Power Rating	120 W
	Dimensions	19“ slide-in module 3 RU D 430 / W 448/ H 133 [mm]
	Dimensions incl. Cabling	D 540 / W 448 / H 133 [mm]
	Weight	approx. 8 kg
	Inspection	CE compliant
	IP Class	IP 30 by IEC 60529
	Operating Temperature	-10°C ... +55°C
	Supply Voltage of the Sensor	5 V DC
INPUT	Acceleration Signal	Input Voltage: ±10 V
Analog	Vibration 1 – 4	Sampling Rate max.: 1 MSPS
	Channel 1 and 2	Digitalization: 16 Bit
		Input Filter: adjustable low-pass filter, adjustable high-pass filter
	2 Channels	Resolution: depending on selected gain
	optional up to 8 channels	Parallel measurement: All 8 channels can measure parallelly
INPUT	Speed TTL-Signal (cf. speedBox)	Speed signal is transmitted as TTL-Signal by the speedBox
Digital	Digital Input	Input voltage Range: ±32 V
	Unit 1 – 16	Max. Sampling Rate: 25 k Samples
OUTPUT	Analog Output	Output Voltage:: ±10 V
Analog	Unit 1 – 8	I_{max}: 17 mA
		I_{max} total: 100 mA
		U_{max}: 10 V
OUTPUT	Digital Output	2 x 8 galvanic isolated Outputs
Digital	DOUT Unit 1 – 16	V_{extern}: 5,5 V ... 28 V
		I_{max}: 350 mA
INTERFACES	Ethernet	100 Mbit/s
	Serial	RS 232
	CAN Bus (optional)	integrated to the Fieldbus Board
	Profibus DP	Anybus Compact Com DPV1 Slave (AB6200)
	Modbus TCP	Modbus TCP 2 Port Version (AB6223)

eolANALYSER v3 installed in mobile 19“ rack as well as rear and front view

CLEVER **HEARING**

delta
ANALYSER v3

The fine-tuning of the design and the final release is only made after extensive endurance tests. Although the simulation programs are continuously developed and improved, there are always unpleasant surprises for the design engineers and developers. It does not matter whether the tests are for individual components, electric motors, mechatronic systems, combustion engines or even complete drive trains. The process Testing -> Adapting -> Testing is repeated until the durability of all single or all system components can be assured.
In order to keep this release process as effective and short as possible, it is elementary to detect damages in time to be able to determine the causes. This is only possible at an early stage of the damage, since the previous damage causes consequential damage during continuous operation. Therefore, cause and effect can no longer be clearly distinguished.
The deltaANALYSER has been specially developed for this type of tests and this task. It monitors the test item 24 hours a day, 7 days a week. In case of damage it generates a trigger to shut down the test bench and thus helps to avoid serious consequential damage to the test item and to optimize the design with regard to the weakest component.

MONITORING THE POWERTRAIN

The deltaANALYSER is suitable for any kind of powertrain as well as component tests.

- e-drive
- gearboxes of all kinds
- e-engines
- combustion engines
- axles
- hydraulic pumps + motors
- components
- complete power train / combinations
- Bearing test benches

STRENGTHS OF THE deltaANALYSER

- reliable 24/7 monitoring
- Presentation of the fault and damage progressions
- easy failure analysis thanks to ROC integration
- quick break shutdown
- easy integration into the pre-existing test bench
- Component-independent configuration for system testing, e.g. of complete powertrains

Methods for evaluation

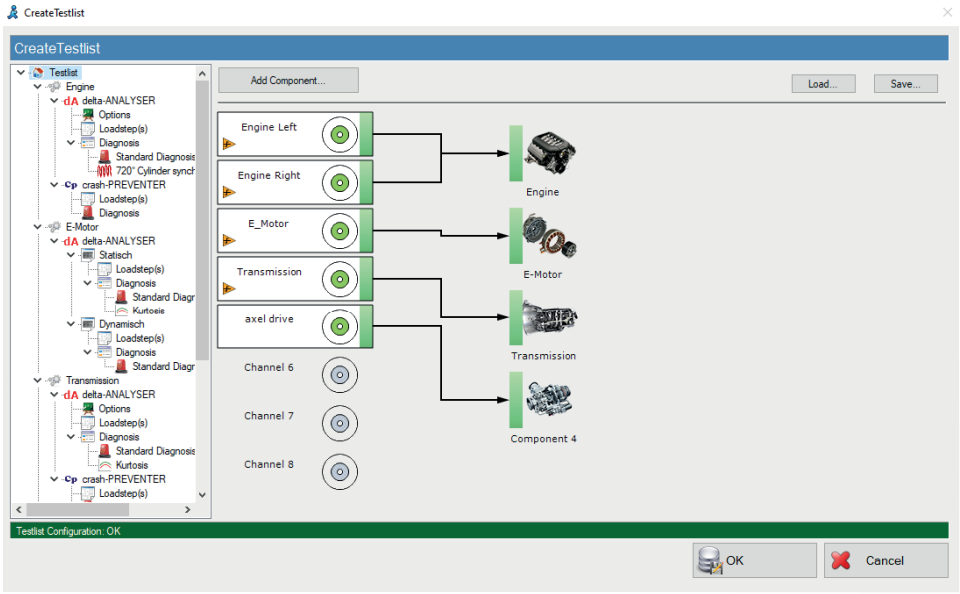
For a reliable early stage damage detection, different methods of signal evaluation and analysis are required depending on the test object and the developing damage.

Mostly spectral analyses are used, which are helpful, for example, in detecting bearing damage. For the detection of damage, which manifests itself through regular impact pulses, procedures based on time signal evaluations are required. For damage patterns that occur spontaneously, a summation level-based shutdown is necessary. This is made possible with the crashPREVENTER. For combustion engines we have integrated a procedure with reference to 720° crankshaft to enable cylinder or angle-selective monitoring.

The deltaANALYSER supports its users by determining the necessary tolerances independently at the beginning of the test cycle. With the large number of integrated methods and thus also the required threshold value settings, no time is lost through extensive configurations and settings. Of course, users can also specify manual threshold values.

Component or system specific test list configuration

When monitoring independently operating system groups or monitoring a complete drive train, it is useful to configure the individual systems/components/test items differently. Thanks to the intuitive software and the clear display, even such a complex configuration can be implemented quickly and easily in the deltaANALYSER. The software also includes a validation of the settings in order to exclude possible sources of error during configuration.



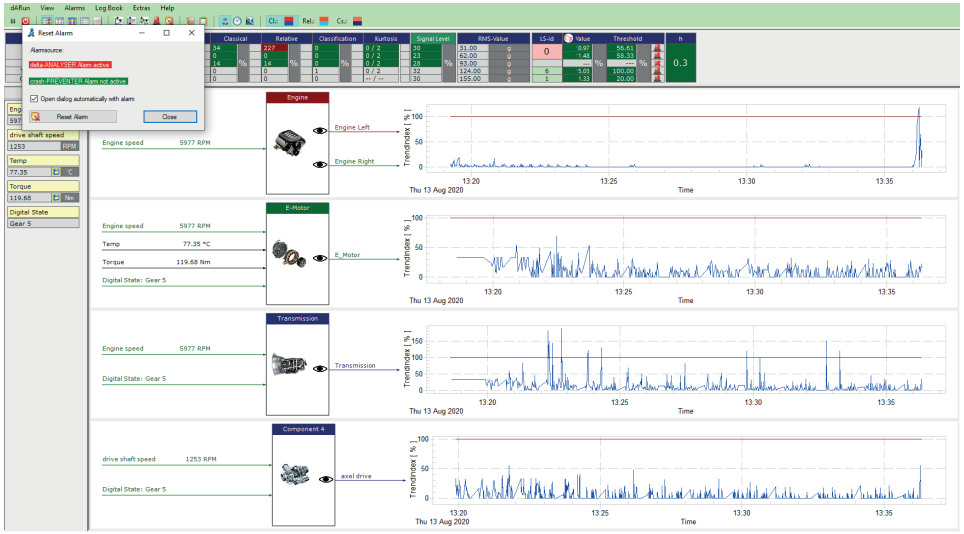
deltaANALYSER settings mask

Measurement during an endurance test run

In endurance test runs it is important to recognize the beginning of a damage.
This requires constant and continuous monitoring. A random inspection every x hour involves high risks. What about damages that occurs between control intervals?
When exactly and under which circumstances did the damage occur?
Did the damage develop quickly or slowly?

For this reason, the deltaANALYSER continuously records and analyses the measurement data - from beginning to end 24/7, thus ensuring reliable early stage damage detection and providing developers and designers with the opportunity to analyse and evaluate the course of the damage.

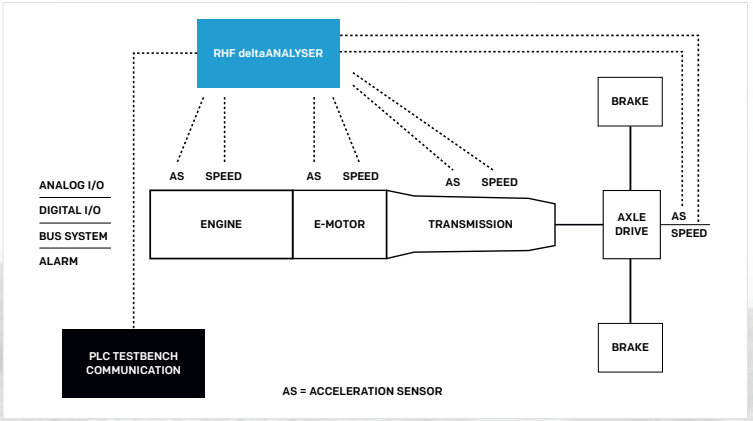
We have developed the global trend index so that the user - even without NVH knowledge - can quickly and easily find out about the „state of health" of his test object at any time during the endurance run. With regular values >= 60%, a proactive detailed analysis with the integrated deltaEvaluation.NET software becomes useful. At values = 100% the system triggers the alarm.



Monitoring mask

Integration into the test bench

A wide range of options is available for test bench integration. The deltaANALYSER offers the possibility to integrate various BUS modules. In addition, inputs and outputs are available in analogue and digital form. This covers the „standard" interfaces. Thus, a subsequent integration is also very easy in most cases.

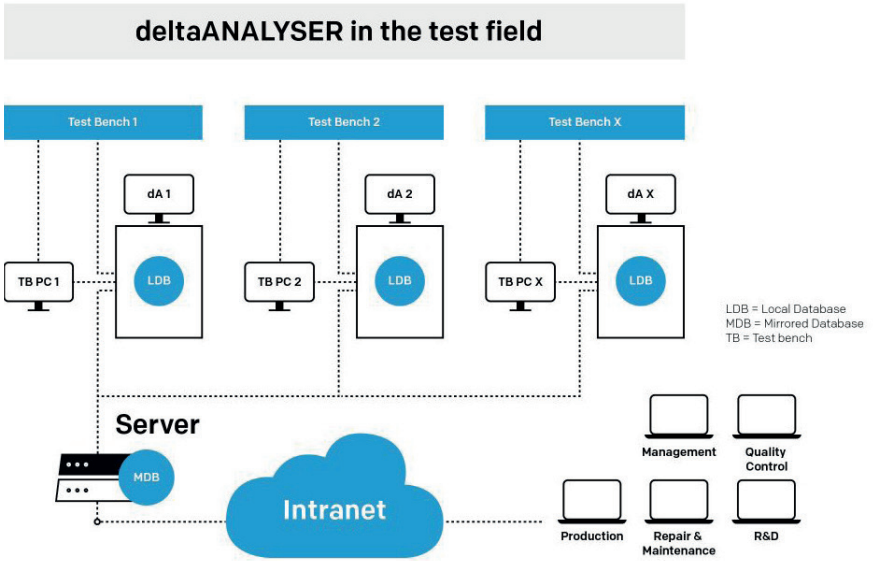


deltaANALYSER test bench integration

The deltaANALYSER in the company network

Often the test benches are spread over the factory premises or the office of the responsible person is located at a greater distance from the test benches. For quick and easy remote access, network access can be set up via remote desktop. In this case, access must be set up separately for each system and the data is simply backed up locally in the visualization PC's integrated RAID system.

However, we recommend a fully-fledged network integration in which the newly generated measurement data are automatically transmitted to a defined server (cloud or hardware server) by replication at definable time intervals. In this way, the measurement data of all systems are stored in a central storage location. Through the replication on the server and the integrated RAID system in the visualization PC, the data is now doubly backed up. The central storage space also makes it easier for the internal IT department to activate back-up functions.



Integration of the deltaANALYSER into a company network

Knock sensor

ICP sensor

Sensors

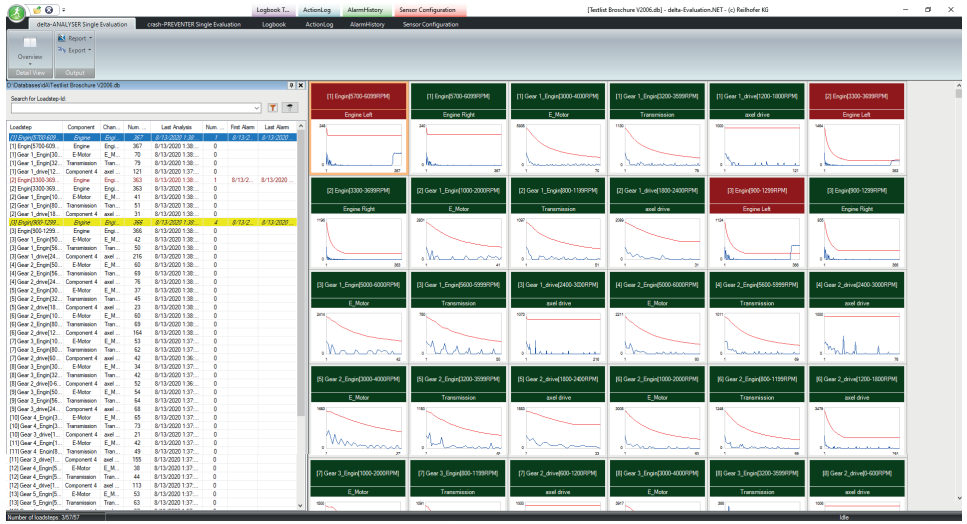
Bosch knock sensors with charge amplifiers developed by us are most frequently used for early damage detection in endurance runs and function tests due to their good cost/benefit ratio. This combination is very robust and offers high resistance to fuels, oils and other liquids.

However, if loudness/level-based shutdowns or comparative measurements are the focus of your application, we recommend the use of ICP acceleration sensors. These offer better performance for parameters such as calibration/linearity/temperature sensitivity. For both sensor types, a fixed screw connection to the test item is preferred, if feasible. An adhesive or magnetic attachment carries the risk of drop off due to vibration, contamination or too high temperature.

EVALUATION

Damage analysis and cause identification in 3 steps:

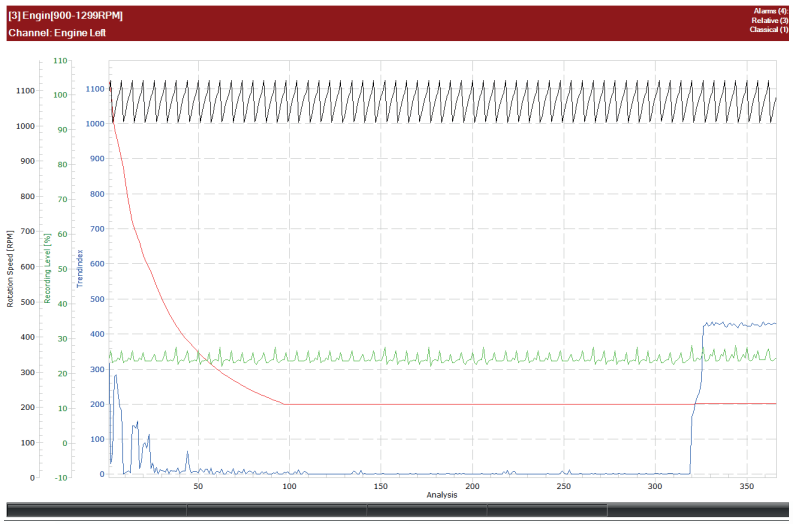
1. Open database / Overview of all load steps



Overview of all load steps of a test run

In the overview, relevant and interesting load levels can be quickly identified using the trend index visualization and the red colour marking of the header (load levels with alarm). Thanks to the extensive filter function, the amount of data can be reduced quickly and in a targeted manner.

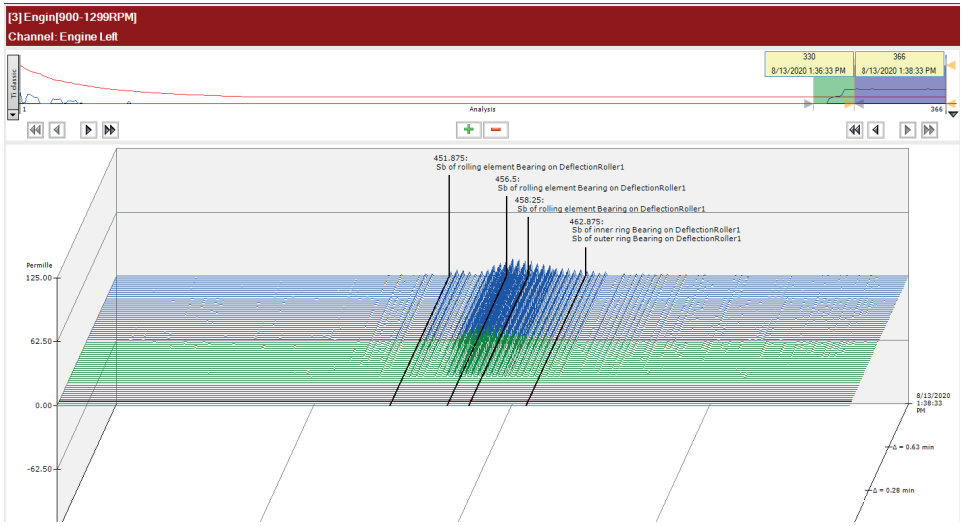
2. Select conspicuous load level and check state variables



Trend index for conspicuous load steps

The checking of the state variables shows that the change of the acoustic signature was not caused by a change of a state variable. Therefore, the cause of the change must be sought in the system, which can only be damage-related during operation.

3. Open the waterfall diagram and use the ROC integration to identify the causing component



Waterfall diagram with integrated ReilhoferOrderCalculator (ROC) data visualization

Of course, the evaluation software provides the deltaEvaluation.NET with a multitude of other functions and possibilities. For example, 2D spectra can be compared with each other or the dependence of defined orders on certain state parameters can be analysed. Our report generator helps you to present the relevant data and information clearly and quickly for every testing task and task definition.

The disassembly confirms the analysis - there is a bearing damage:

HIGHLIGHTS

- Display of the acoustic change during the test run and the stored state variables in a graphic is possible
- Damage progression over the entire test run can be visualized and evaluated
- Integration of the ReilhoferOrderCalculator (ROC) simplifies and speeds up the damage analysis and basically the identification of the components responsible for the noise

Technical Specifications deltaANALYSER

GENERAL	Supply Voltage	110 V / 230 V 50 – 60 Hz
	Power Rating	120 W
	Dimensions	19“ slide-in module 3 RU D 430 / W 448/ H 133 [mm]
	Dimensions incl. Cabling	D 540 / W 448 / H 133 [mm]
	Weight	approx. 8 kg
	Inspection	CE compliant
	IP Class	IP 30 by IEC 60529
	Operating Temperature	-10°C ... +55°C
	Supply Voltage of the Sensor	5 V DC
INPUT	Acceleration Signal	Input Voltage: ±10 V
Analog	Vibration 1 – 4	Sampling Rate max.: 1 MSPS
	Channel 1 and 2	Digitalization: 16 Bit
		Input Filter: adjustable low-pass filter, adjustable high-pass filter
	2 Channels	Resolution: depending on selected gain
	optional up to 8 channels	Parallel measurement: All 8 channels can measure parallelly
INPUT	Speed TTL-Signal (cf. speedBox)	Speed signal is transmitted as TTL-Signal by the speedBox
Digital	Digital Input	Input voltage Range: ±32 V
	Unit 1 – 16	Max. Sampling Rate: 25 k Samples
OUTPUT	Analog Output	Output Voltage:: ±10 V
Analog	Unit 1 – 8	I_{max}: 17 mA
		I_{max} total: 100 mA
		U_{max}: 10 V
OUTPUT	Digital Output	2 x 8 galvanic isolated Outputs
Digital	DOUT Unit 1 – 16	V_{extern}: 5,5 V ... 28 V
		I_{max}: 350 mA
INTERFACES	Ethernet	100 Mbit/s
	Serial	RS 232
	CAN Bus (optional)	integrated to the Fieldbus Board
	Profibus DP	Anybus Compact Com DPV1 Slave (AB6200)
	Modbus TCP	Modbus TCP 2 Port Version (AB6223)

deltaANALYSER v3 installed in mobile 19“ rack as well as rear and front view


ORDERLY
BUSINESS.
REILHOFER
ORDER CALCULATOR

REILHOFER ORDER CALCULATOR (ROC)

Which test items or which components generate noise in the first place? Which acoustic signatures and effects do we expect? Is the present phenomenon a defective component and if so, which one? Is there a resonance? How do behave in even more complex applications such as an engine-transmission combination or even when building a complete powertrain including differentials for a four-wheel drive application? Do we expect the same acoustic signature for derivatives?

Our in-house developed Reilhofer Order Calculator (ROC), supports users in these complex issues. Its perfect integration into our other programs and applications allows data to be analysed and interpreted without requiring an NVH expert.

In the deltaANALYSER, the component responsible for the change in the acoustic signature can be easily identified in the evaluation, thanks to the ROC-models. This significantly accelerates the process of analyzing the cause of the damage. In the eolANALYSER the ROC-models can be used for automated pattern recognition, which indicates to the causes of damage in real time at the test bench. Thereby the analysis and work effort are reduced considerably. Of course, the ROC-data are also available for further detailed analysis in the eolANALYSER.

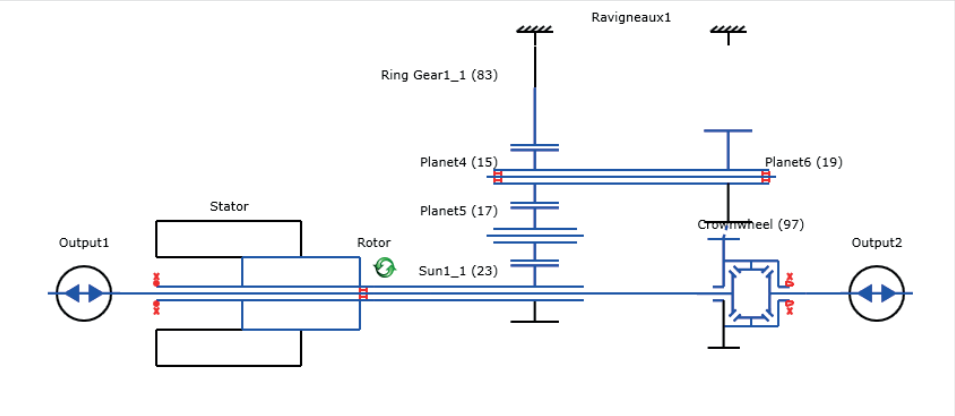
Thanks to the export functions of our evaluation programs, the detailed data of the ROC including the desired spectra can be exported to the Global Failure Database if required. Thus, detailed data can be shared with other responsible parties in a network-based manner, which significantly reduces reporting workload. Thanks to a large number of preconfigured and standardized modules, as well as intuitive handling, complex powertrains can be modelled quickly and easily. The relevant component orders and acoustic effects are then automatically calculated.

To ensure that only correct models are used for later analyses, the model is checked for plausibility before the calculation - for example, force flow errors, blockages or incorrect synchronizations are identified and visualized by the system, making corrections easy.

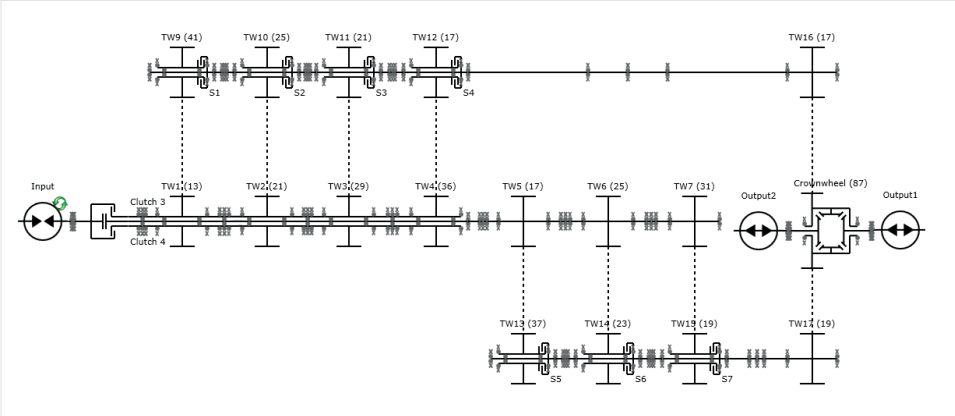
BENEFITS

- Calculation of orders from rotating parts
- Grouped in assemblies
- Calculation of the fundamental order and up to the 50th harmonic order
- Different types of bearings
- Auxiliary units
- Calculation of the entire powertrain
- Rapid component identification
- Fast calculation of engine types and their derivatives
- Fast calculation of transmission types and their derivatives
- Integration of calculated data in evaluations of deltaANALYSER and eolANALYSER
- User-friendliness through straightforwardly structured buttons

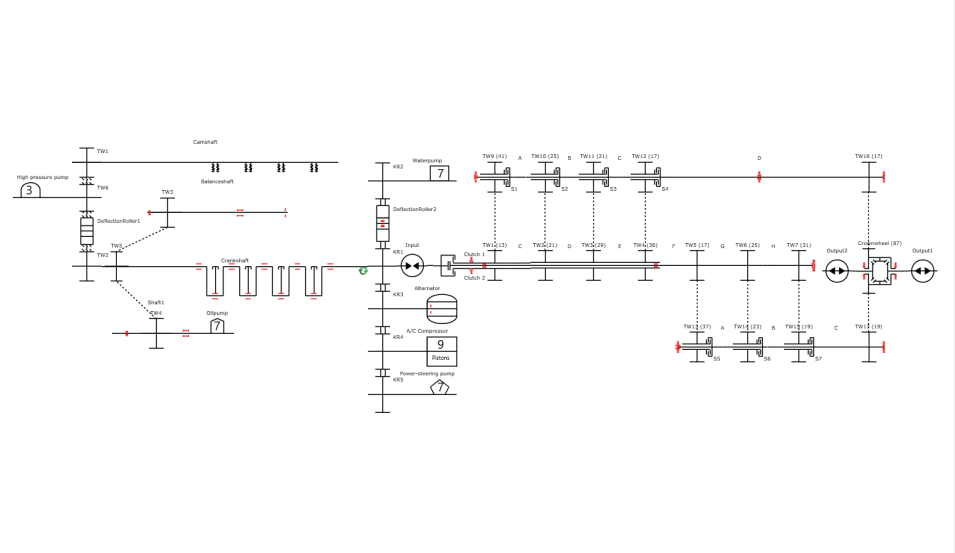
Examples



Example design of an e-drive



Example design of a double clutch transmission



Powertrain (combustion engine with double-clutch transmission)

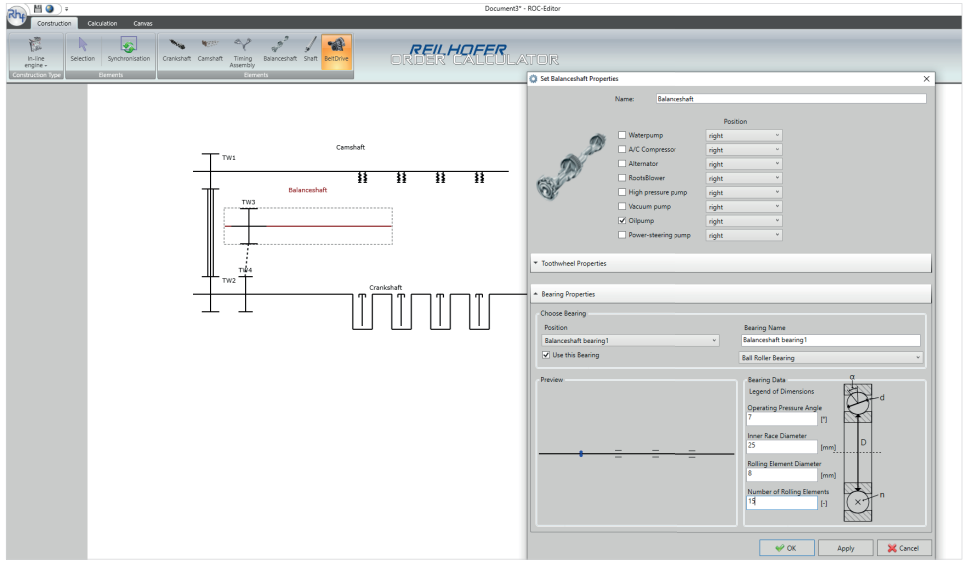
Export assemblies | Export spectrum

1. Gear | 2. Gear | 3. Gear | 4. Gear | 5. Gear | 6. Gear | 7. Gear

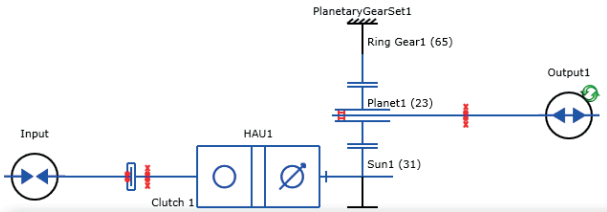
-> Change view to spectrum values <-	1. Harmonic	2. Harmonic	3. Harmonic	4. Harmonic	5. Harmonic	6. Harmonic	7. Harmonic	8. Harmonic
cage	0.3500	0.7000	1.0500	1.4000	1.7500	2.1000	2.4500	2.8000
inner ring	5.3900	10.7800	16.1700	21.5600	26.9500	32.3400	37.7300	43.1200
outer ring	3.8500	7.7000	11.5500	15.4000	19.2500	23.1000	26.9500	30.8000
rolling element	2.4500	4.9000	7.3500	9.8000	12.2500	14.7000	17.1500	19.6000
Hauptwelle Gehäuse - links on TW13								
cage	0.3758	0.7516	1.1274	1.5032	1.8789	2.2547	2.6305	3.0063
inner ring	4.1337	8.2674	12.4011	16.5347	20.6684	24.8021	28.9358	33.0695
outer ring	4.1337	8.2674	12.4011	16.5347	20.6684	24.8021	28.9358	33.0695
rolling element	2.2547	4.5095	6.7642	9.0189	11.2737	13.5284	15.7832	18.0379
Hauptwelle Gehäuse - rechts on TW16								
cage	0.3500	0.7000	1.0500	1.4000	1.7500	2.1000	2.4500	2.8000
inner ring	5.3900	10.7800	16.1700	21.5600	26.9500	32.3400	37.7300	43.1200
outer ring	3.8500	7.7000	11.5500	15.4000	19.2500	23.1000	26.9500	30.8000
rolling element	2.4500	4.9000	7.3500	9.8000	12.2500	14.7000	17.1500	19.6000
Hauptwelle Gehäuse - rechts on TW17								
cage	0.3132	0.6263	0.9395	1.2526	1.5658	1.8789	2.1921	2.5053
inner ring	4.8226	9.6453	14.4679	19.2905	24.1132	28.9358	33.7584	38.5811
outer ring	3.4447	6.8895	10.3342	13.7789	17.2237	20.6684	24.1132	27.5579
rolling element	2.1921	4.3842	6.5763	8.7684	10.9605	13.1526	15.3447	17.5368
1. Hollow shaft Case - left on Crownwh								
cage	0.0684	0.1368	0.2052	0.2736	0.3420	0.4103	0.4787	0.5471
inner ring	1.0532	2.1064	3.1597	4.2129	5.2661	6.3193	7.3725	8.4257
outer ring	0.7523	1.5046	2.2569	3.0092	3.7615	4.5138	5.2661	6.0184
rolling element	0.4787	0.9575	1.4362	1.9149	2.3937	2.8724	3.3511	3.8299
1. Hollow shaft Case - right on Crownwl								
cage	0.0684	0.1368	0.2052	0.2736	0.3420	0.4103	0.4787	0.5471

Exemplary calculation of a double-clutch transmission

Examples



Design window for a combustion engine



Export assemblies | Export spectrum

1. Gear

-> Change view to tooth engagement <-	
3.3333	Sb rolling element Main shaft Case on / Sb outer ring Main shaft Case on / 8. Harm cage Main shaft Case on
3.5326	3. Harm cage Planet Carrier - left on PlanetaryGearSet1
3.7500	Sb outer ring Main shaft Case on / Sb rolling element Main shaft Case on / 9. Harm cage Main shaft Case on
3.8710	3. Harm cage Main shaft Case - right on
4.1667	Sb outer ring Main shaft Case on / Sb rolling element Main shaft Case on / 10. Harm cage Main shaft Case on
4.5833	1. Harm outer ring Main shaft Case on / Sb rolling element Main shaft Case on / 11. Harm cage Main shaft Case on
4.7101	Sb rolling element Planet Carrier - left on PlanetaryGearSet1/ 4. Harm cage Planet Carrier - left on PlanetaryGearSet1
5.0000	Sb outer ring Main shaft Case on / Sb rolling element Main shaft Case on / 12. Harm cage Main shaft Case on
5.1613	Sb rolling element Main shaft Case - right on / 4. Harm cage Main shaft Case - right on
5.1667	Sb inner ring Main shaft Case on
5.4167	Sb outer ring Main shaft Case on / Sb rolling element Main shaft Case on / 13. Harm cage Main shaft Case on
5.5833	Sb inner ring Main shaft Case on
5.6522	2. Harmonic of Shaft of Planet1
5.8333	Sb outer ring Main shaft Case on / 2. Harm rolling element Main shaft Case on / 14. Harm cage Main shaft Case on
5.8877	Sb rolling element Planet Carrier - left on PlanetaryGearSet1/ 5. Harm cage Planet Carrier - left on PlanetaryGearSet1
6.0000	Sb inner ring Main shaft Case on
6.1935	Sb inner ring Main shaft 1. Hollow shaft on / Sb outer ring Main shaft 1. Hollow shaft on / Sb rolling element Main shaft 1. Hollow sh
6.2500	Sb rolling element Main shaft Case on / 15. Harm cage Main shaft Case on

Components incl. calculation

POSSIBLE TRANSMISSION DESIGNS

- Manual transmission
- Automatic transmission
- Double-clutch transmission
- Beltless continuously variable transmission (CVT)
- Axle drive
- Transfer case
- e-drive

POSSIBLE ENGINE DESIGNS

- 1-16 cylinder engine
- In-line engine
- V-type engine
- W engine
- Boxer engine

SELECTABLE.
SPEED.

speed Box

speedBOX – SPEED SIGNAL CONDITIONING

Since our measuring systems are suitable for a very wide range of test items, the requirements for the acquisition and processing of the speed signals also vary, sometimes considerably. For example, processing a signal from the crankshaft encoder in an internal combustion engine requires different functions than signal processing from a resolver in an electric engine or even a high-speed application such as a turbocharger. The measuring principle used for speed measurement, the cable length and the environment can also have a considerable influence on the quality of the speed signal

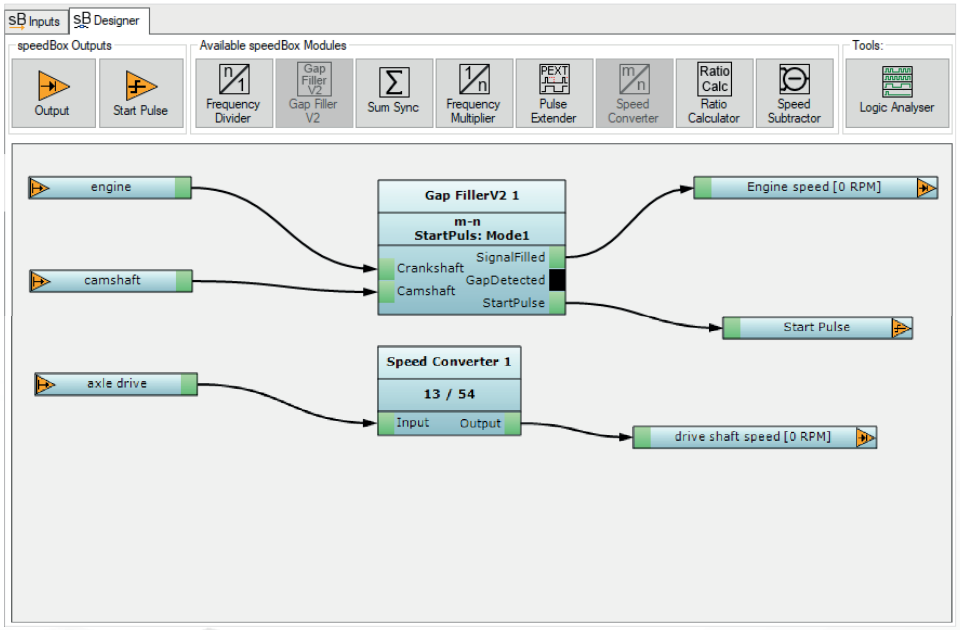
Our speedBox combines a variety of hardware functions and software modules in a small handy box, so that you are ideally prepared for the different tasks of speed measurement at test benches or even in the vehicle.

THE MODULES FOR THE SPEED SIGNAL CONDITIONING ARE

- Frequency Divider
- Frequency Multiplier
- Pulse Extender
- Gap Filler (60-2) v2 including start pulse generation for TDC cylinder 1
- Sum Sync
- Speed Converter
- Ratio Calculator
- Speed Subtractor

Due to its small dimensions, the speedBox can be integrated quickly and can be used flexibly and variably for different testing tasks thanks to its memory function.

Our well thought-out and simple operating concept allows a quick and easy configuration.

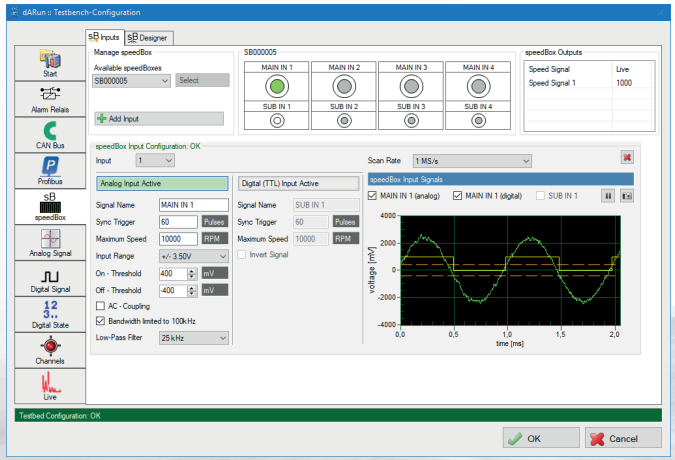


Setup window for the speedBox

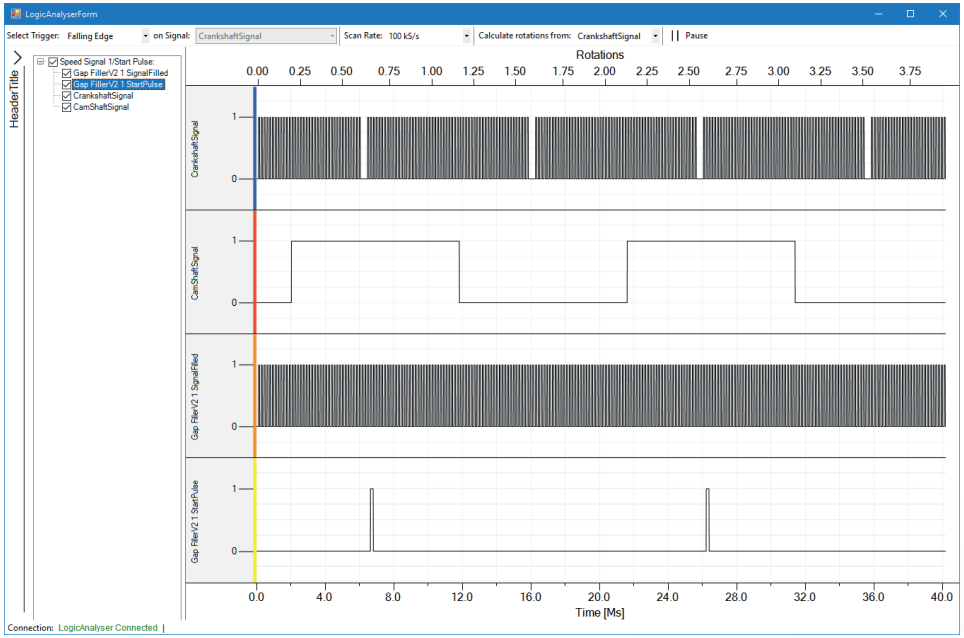
The various filter functions, addable AC coupling, as well as the settings of the voltage range leave nothing to be desired. Thanks to the integrated oscilloscope function, you can directly visualize and check the graphs of the input and output signals.

The functionality of the software modules, such as the correct generation of the trigger required for the 720° analysis for TDC cylinder 1 of combustion engines, can also be checked directly and in real time in our Logic Analyser.

arriving speed signal (green)



processed speed signal (green)

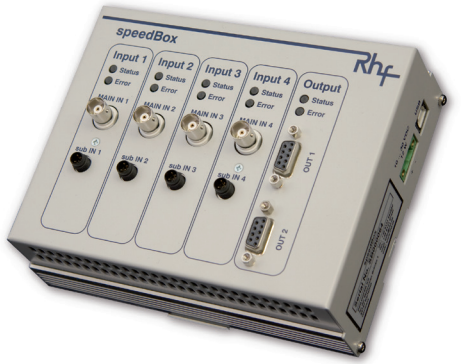


Logic Analyser with input signals and output signals

Technical data speedBOX

GENERAL	Power Supply	10 V ... 30 V DC, external power supply unit (min. 12 W)
	Device Fuse	M2,5 A (20x5)
	Housing	Metal Case (suitable for DIN (Top Hat) Rail mounting) (TS35 in USA))
	Dimensions	D 74 / W 170 / H 135 [mm] (incl. protruding parts)
	Dimensions incl. cabling	D 160 / W 220 / H 145 [mm]
	Dimensions of the power supply unit	D 110 / W 25 / H 110 [mm] (suitable for DIN (Top Hat) Rail mounting) (TS35 in USA)
	Weight	Ca. 950 g
	Operating Temperature	0°C ... +55°C
INPUT **Analog**	4 x Speed Signal	Input Voltage Range: ±100 mV ... ±15 V, higher voltages up to 100 V are possible but will be cut off at 15 V for the internal processing. Overvoltage Protection: up to approx. 200 V Galvanic Isolation: Yes (shares ground with the corresponding TTL-input) Signal Type: ground-referenced (unsymmetrical) or differential (symmetrical) Sampling Rate: 40 MHz Digitalization: 10 Bit Input Filter: connectable 100 kHz low-pass AC Coupling: connectable Lower Cut-off Frequency: 0 Hz (AC coupling inactive) 10 Hz (AC coupling inactive) Upper Cut-off Frequency: 1 MHz
Digital	4 x TTL-Speed Signal	Input Voltage Range: 0 V / 5 V (TTL) Frequency Range: 0 Hz ... 1 MHz Galvanic Isolation: Yes (shares ground with the corresponding analog input)
OUTPUT **Digital**	2 x 5 TTL-Speed Signal	Output Voltage: 0 V / 5 V Galvanic Isolation: Yes (shares ground with the corresponding analog input). All outputs are galvanically isolated from the inputs and the power. Max. Output Frequency: 2,5 MHz @ 500 Ω Last Short Circuit Duration:continuous External Voltage Protection: 0 V to 5 V continuous
INTERFACE	USB 2.0	For the configuration of the speedBox

DIN rail module speedBox



THE QUINTESSENCE.

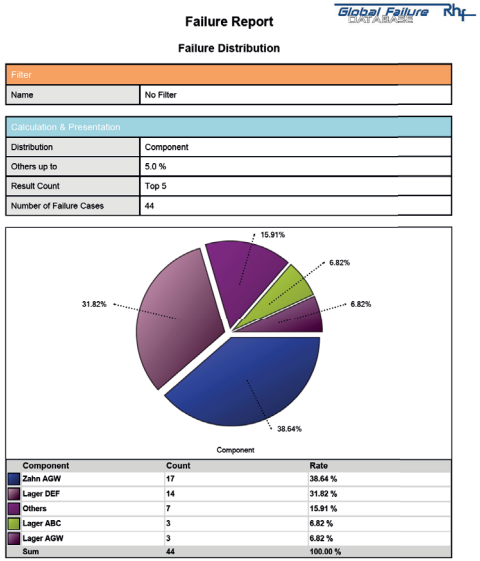
Global Failure
DATABASE

GLOBAL FAILURE DATABASE (GFD)

When detecting acoustic anomalies and faulty parts in the running production as well as for the early stage damage detection during endurance runs, one can profit greatly from previous experience and detected patterns from other projects. A large number of NVH systems are already in use at most development and production sites. Thus, valuable knowledge, measurement results and experience are generated on a daily basis.

With the Global Failure Database, we have created a tool that enables you to summarise this valuable knowledge and make it available to all responsible employees on a network basis. With the help of the Global Failure Database, you can actively and effectively bring together all the specialist departments involved in the development and life cycle of the product, regardless of their individual location.

Of course, the GFD also offers extensive possibilities for static evaluations and detailed reporting.



Failure Report

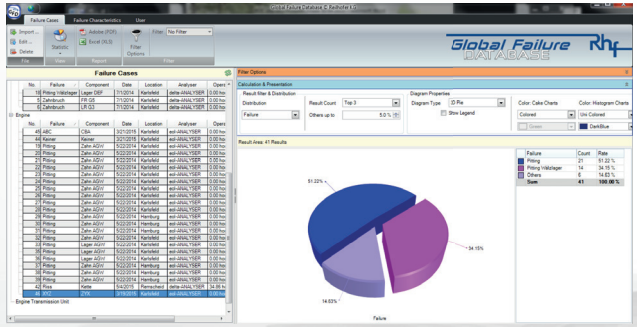
Failure Distribution

Filter	
Name	No Filter

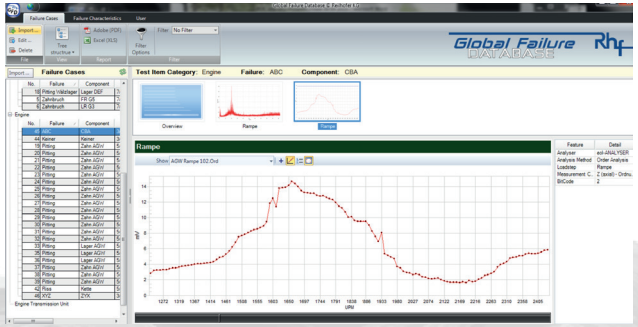
Calculation & Presentation	
Distribution	Component
Others up to	5.0 %
Result Count	Top 5
Number of Failure Cases	44

Component	Count	Rate
Zahn AGW	17	38.64 %
Lager DEF	14	31.82 %
Others	7	15.91 %
Lager ABC	3	6.82 %
Lager AGW	3	6.82 %
Sum	44	100.00 %

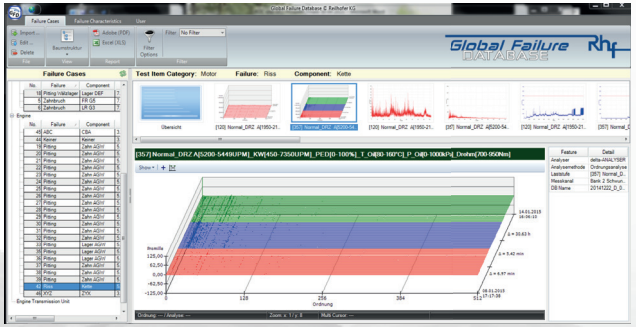
Create a report in PDF format with only one mouse click



Example statistic – Top 3 damages



Example - eolANALYSER data



Example - deltaANALYSER data

ADVANTAGES OF AN EXCHANGE

Production <-> Production
In the event of an unknown damage in production, a comparison with the global failure database for identically designed products can be carried out across different sites. The pattern matching that is possible in this way makes analysis processes easier and faster.

Development -> Production
Since NVH systems are used in both development and production. The knowledge gained in development on the cause of a damage can facilitate and accelerate analyses in production in the sense of „lessons learned". If necessary, the development departments have a quick access to critical test results in the production. This can help to speed up any release procedures that may be required.

Production -> Development
The production delivers a large amount of results every day. Due to the large number of tests and the complexity of production, various defect patterns and corresponding component assignments are available. These in return can be used by the development department for pattern recognition.

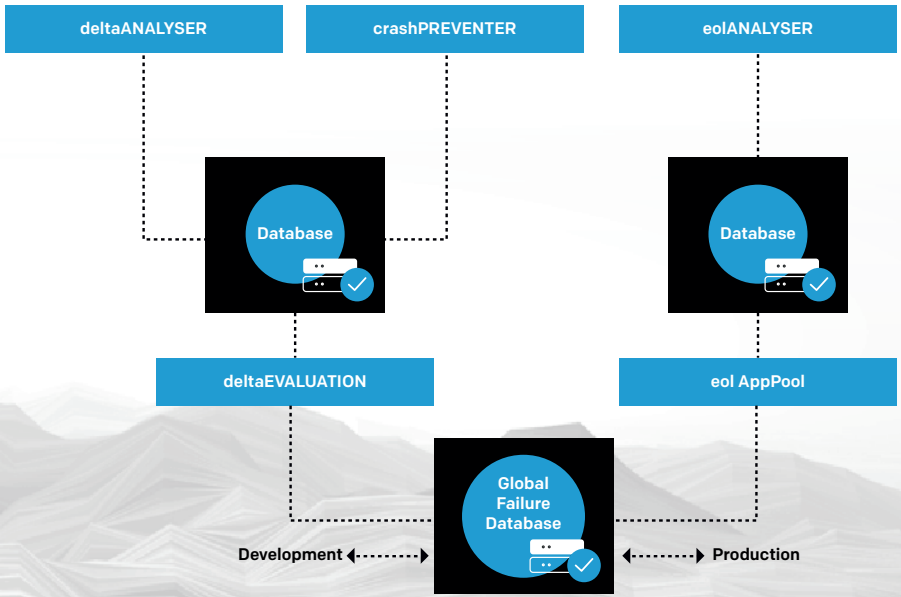
Development <-> Development
Knowledge gained during the development at all locations is globally available for future developments and evaluations.

1. Endurance Test / Production
— Measurement database

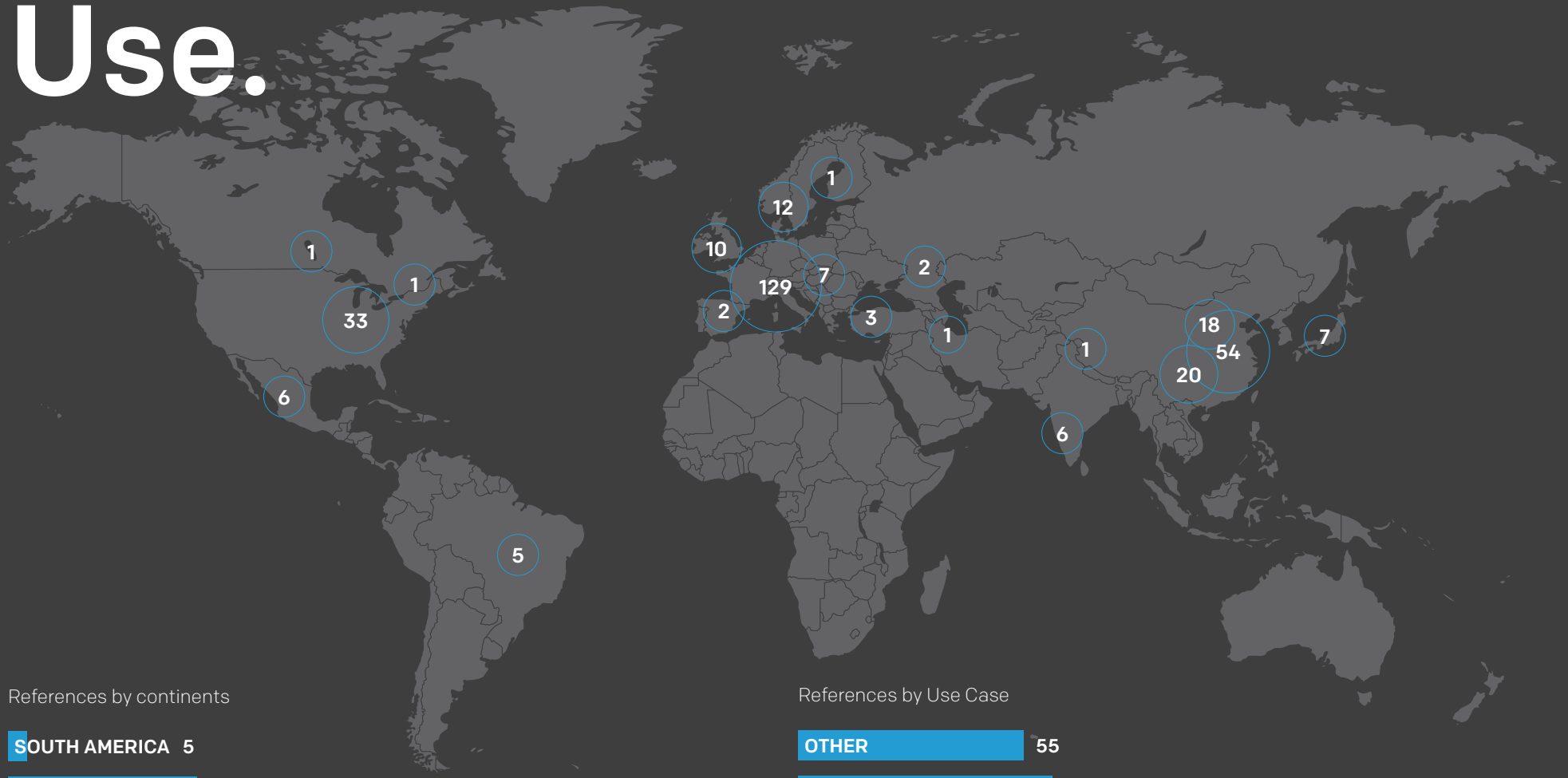
2. Evaluation
— Identification of faulty components
— Type and position of a failure
— Beginning of the damage

3. Global Failure Database
— Failure report
— Failure statistics
— Failure correlation
— Global archiving

General structure

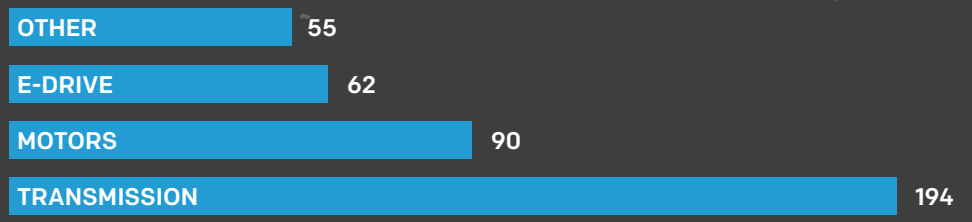


Our Systems in Use.



References by continents

References by Use Case



EUROPE


AGCO POWER
AAM
AMG
apicom
APL
Applus IDIADA
aprilia
APS
ARTEMIS INTELLIGENT POWER
ASTON MARTIN
ATESTEO
AVL
AW Europe
BENTLEY
BMTS TECHNOLOGY
BMW
BorgWarner Turbo & Emissions Systems
BOSCH BoschEngineering
Rexroth Bosch Group
BOSMAL
Castrol
BRP
BUGATTI
cetim
CHANGAN 长安汽车股份有限公司
CLAAS
Continental
DAF A PACCAR COMPANY
DAIMLER
DAM
Danfoss
DEUTZ
DeVeTec
DIRK SCHUMANN
DUCATI
elringklinger
EVONIK Leading Beyond Chemistry
FEV
FKFS
Ford
FPT POWERTRAIN TECHNOLOGIES
LUBRICANTS. TECHNOLOGY. PEOPLE. FUCHS
GENERAL DYNAMICS European Land Systems
GETRAG
GETRAG FORD Transmissions
GIMA
GKN
GRAZIANO TRASMISSIONI
PSA GROUPE
handtmann Ideen mit Zukunft.
HITACHI Inspire the Next
HOERBIGER because performance counts
Ihofer powertrain
THPE COXA
IAVF
IFT Ingenieurgesellschaft für Triebwerkstechnik mbH
The Testing Institute ISP
IVM Automotive Member of SEMCON
IVP
JOHN DEERE
JOYSON SAFETY SYSTEMS
KAMAZ

EUROPE


KOKITECHNIK
Transmission Systems GmbH
KRISTL, SEIBT & CO
KST.
LAMBORGHINI
LBF
LIEBHERR
LINAK
WE IMPROVE YOUR LIFE
THE LINDE GROUP
Linde
LOCCIONI
MAGNA STEYR
MAHLE
MAN
MAN Energy Solutions
MDC Power
Mercedes-Benz
MINI
MTK
mtu
Power. Passion. Partnership.
PANHARD
PANKL RACING SYSTEMS GROUP
PIAGGIO
PORSCHE
PTS
PUNCH
PUNCH | Powerglide
Red Bull Racing
FORMULA ONE TEAM
RENAULT
Passion for life
R.S.
ROLLS ROYCE
SCANIA
SCHAEFFLER
SIMPRO
ŠKODA
THIELEN
Feinmechanik
Hightech for metal & plastic
TOFAŞ
GR TOYOTA GAZOO Racing
TREMEC
Valeo SIEMENS
eAutomotive
VOLVO
VICURA
CAPTURE THE MOTION
vitesco
TECHNOLOGIES
VOLKSWAGEN
GROUP SERVICES
万里扬
WAN LI YANG
wilo
ZF

ASIA


Aimil Ltd.
Instrumentation & Technologies
GRC ATESTEO
ATJ AUTO TECHNIC JAPAN
AVL
AVTEC
北京汽车
BAIC MOTOR
FOTON
BorgWarner
Turbo & Emissions Systems
Rexroth
Bosch Group
BYD
CATARC
China Automotive Technology & Research Center
CHANG FENG MOTOR
长安汽车
CHANGAN
常州汉迪机器人科技有限公司
ChangZhou Handy Robotics Technology Inc.
CHERY
中国重汽
SINOTRUK
CNGC
Chongqing TIEMA
Industries Corporation
DAIMLER
Danfoss
东风德纳车桥有限公司
DFG GETRAG
DONGFENG GETRAG TRANSISSION CO., LTD.
DYMOS
FAW
VOLKSWAGEN-FAW
FCA
FIAT CHRYSLER AUTOMOBILES
FIAT
广汽集团
GAC GROUP
GEELY AUTO
GETRAG
GKN
GM DAEWOO
Great Wall
Haima
HONDA
湖北三江航天万山特种车辆有限公司
湖南天雁机械有限责任公司
HUNAN TYEN MACHINERY CO.,LTD
HYUNDAI
HYUNDAI POWERTECH
WIA
JAC
JMC
JIANGLING MOTORS CORPORATION,LTD
江麓容大
JingLi
Kangyue Technology Co. Ltd.
Navien
KYMCO
蓝带传动
LG
LONCIN
MAGNA STEYR
Mahindra
MITSUBISHI MOTORS
National Motor vehicle Quality
Supervision and Inspection Center
宁波威孚天力增压技术有限公司
WEIFU
NIO
NISSAN
NMI
PATAC
PROTON
PSA AVTEC
GROUPE

ASIA

S&T Dynamics

SAGW

上海汽车变速器有限公司
Shanghai Automobile Gear Works

SAIC
上汽集团
SAIC MOTOR

上汽大众
SAIC VOLKSWAGEN

SCHAEFFLER

SDS
上 海 纳 铁 福


上汽通用五菱
SGMW

Shaanxi Aerospeace Power Hi-tech Co.,Ltd
陕西航天动力高科技股份有限公司


盛瑞传递股份有限公司
Shengrui Transmission Co., Ltd

中国重汽
SINOTRUK

长安汽车
CHANGAN

常州汉迪机器人科技有限公司
ChangZhou Handy Robotics Technology Inc.

CHERY

中国重汽
SINOTRUK

上海菱重
SHANGHAI MHI

ZAGC

TATA

TOYOTA

TSINGSHAN

TEL
TURBO ENERGY

TVS

Valeo SIEMENS
eAutomotive

VOLVO

VÖFON
Passion and Efficiency


VOLKSWAGEN-FAW

上海华依科技集团

万里扬
WAN LI YANG

潍柴动力
WEICHAI POWER

WLY万里扬

YUCHAI

ZF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