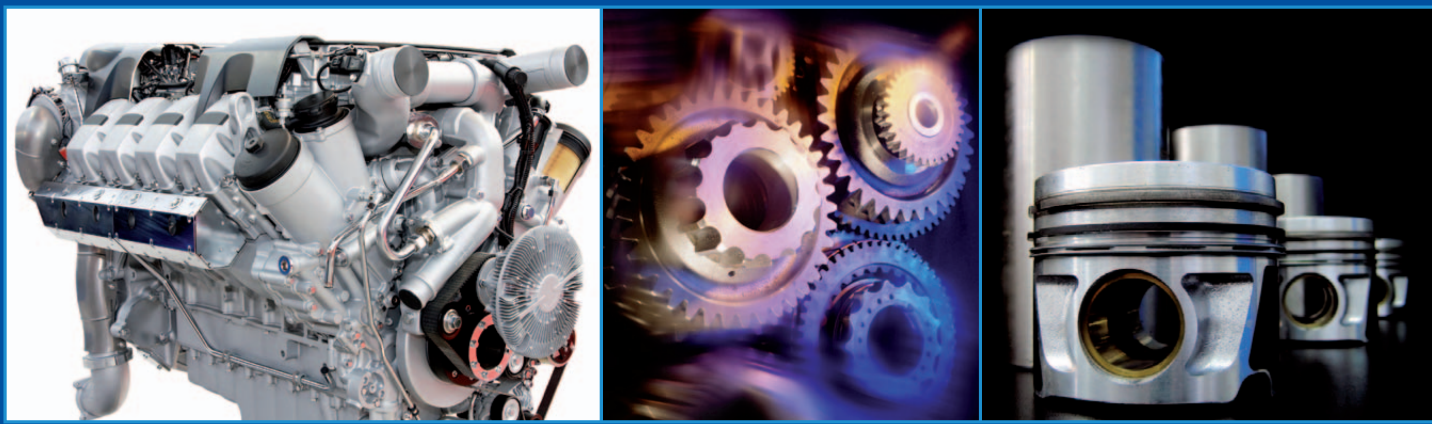
delta
ANALYSER v2

Entwicklung - *Development*



Schadensfrüherkennung für Motoren und Getriebe

Early stage damage detection for engines and transmissions

REILHOFER KG
analyse the powertrain - increase the quality
Rhf

Content of the brochure

Introduction

Today, efficiency of engines and transmissions is of key concern. Rising requirements of end users and stricter regulations add even more weight to this topic. To achieve the highest possible efficiency, performance limits of designs and materials have to be identified and used to optimal extent. However, design and manufacturing costs must not be disregarded. Unfortunately, development isn't always a streamlined process. Optimised components have to be tested for function and long-life cycle. During that test cycle often a completely different component fails, leading to destruction of the device under test. As a consequence, this test cycle is nearly useless and the design team loses precious time and money.

Sum of structure-borne vibration signal analysis is only suitable for noise-intensive incidents

In principle, modern test stands, equipped with various integrated sensors for monitoring, allow for a process shutdown. This shutdown, however, often is triggered too late and doesn't offer any chance to analyse damage occurrence and progression. In most cases there is no continuous, spectrum analysis based monitoring of structure-borne vibration signals. Often, only monitoring of the sum of structure-borne vibration signals is available. This type, however, is only capable of identifying very noise-intensive incidents.

Use of delta-ANALYSER for endurance and functional tests

delta-ANALYSER has been specially designed to prevent the occurrence of such failures. Spectrum analysis of structure-borne vibration signals provides the required basic data, indicating in detail the health condition of the test object and its mechanical components. delta-ANALYSER is capable of displaying the health condition in real time during the test cycle. In case of damage it can automatically terminate the test cycle. The resulting range of potential use of the delta-ANALYSER is manifold: from endurance test and functional tests up to in-vehicle use for rapid evaluation of "clattering" drive components. It is not only possible to monitor single components. Even monitoring of an entire all-wheel power train is no problem. Depending on the configuration level, the signals of up to eight structure-bourne vibration sensors can be evaluated concurrently in real time. All commercially available ICP sensors can be connected to the delta-ANALYSER. In addition, a module which is specially designed for mixed friction detection can be integrated. This module detects the initial occurrence of mixed friction of e.g. slide bearings.

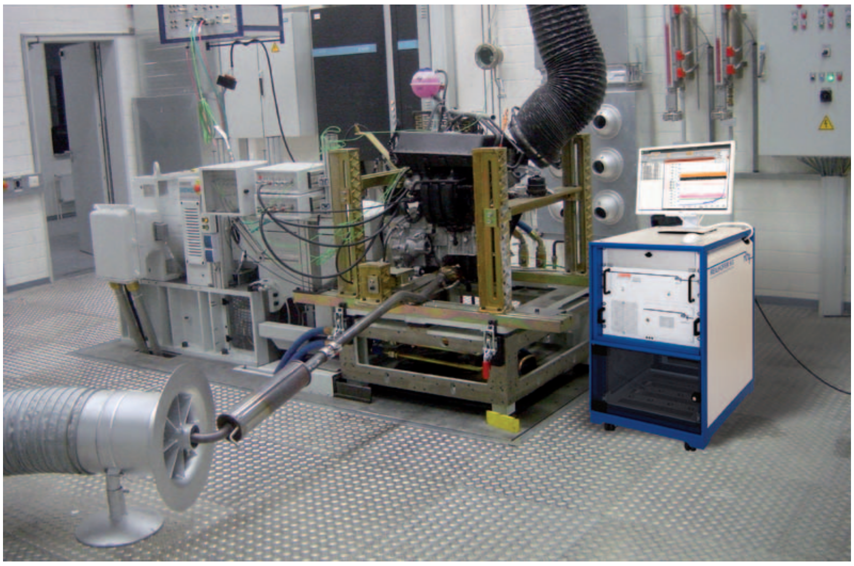


Figure 1: Engine test stand

Different procedures for different failures

Monitoring the sum structure-borne vibration signal within defined limits will not be sufficient in most cases. In 80 percent of all incidents damages manifest themselves as very slight variations which can't be detected in the signals of structure-borne vibrations. Unfortunately, even test objects in perfect condition produce noise. This white noise barely differs from the noise of a defect. If, however, the time-domain signal is used as input for order analysis or frequency-domain analysis, individual components appear in their typical spectral components. So monitoring these spectral components results in a significantly increased sensitivity concerning early damage recognition.

As possible diverse damages show different patterns, it is required to apply different test methods to get optimum results for the early damage detection. The following table shows the assignment of test methods to typical damage patterns.

Unfortunately, even test objects in perfect condition produce noise. This white noise barely differs from the noise of a defect.

Test method	To find what?
Order analysis – absolute	Rotationally symmetric faults
Order analysis – relative	Rotation dependent scraping and squeaking
Frequency analysis – absolute, relative	Static tests without rotational speed
Time signal classification	Run-out detection
Spectral line monitoring – distinct lines	Separate monitoring of individual components
Spectral line monitoring – special range	Monitoring of special resonances
Resonance analysis	Loudness-independent faults
720° Cylinder synchronous measurement	Disturbances of energy distribution over crank angle
CrashPreventer	Fast break shutdown
Noise shaping analysis	Mixed friction detection
Monitoring Windows	Angle-dependent event monitoring
Curtosis analysis	impact detection

Tab. 1: Test methods for effective early damage detection – included in delta-ANALYSER

For different applications transmission, engine or complete powertrain delta-ANALYSER with the corresponding configuration is available.

The system is designed that a retrofitting / upgrading for other measurement tasks is suitable.

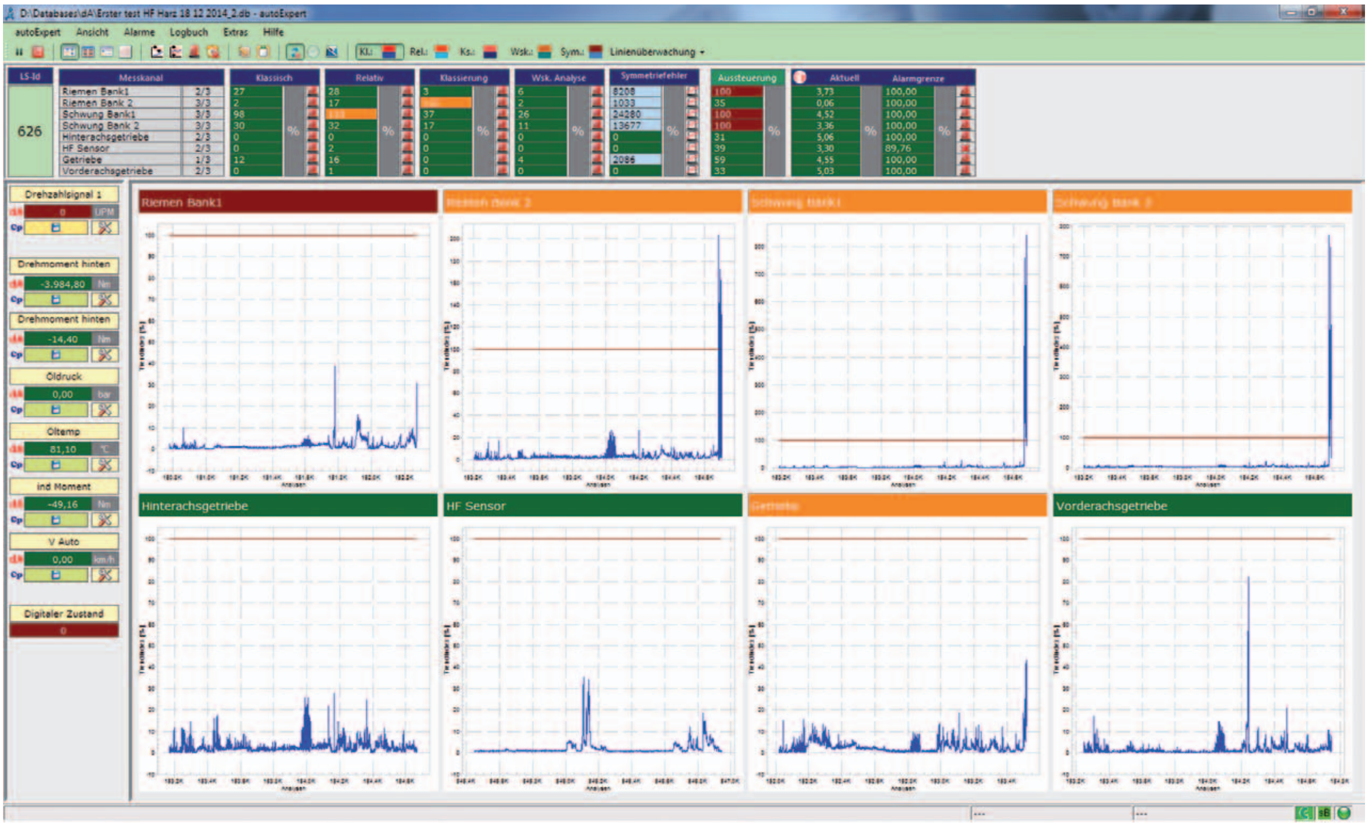
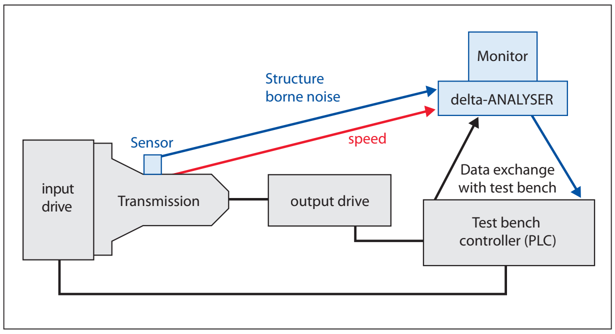
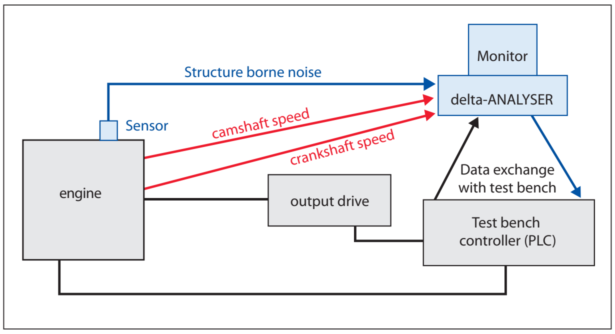
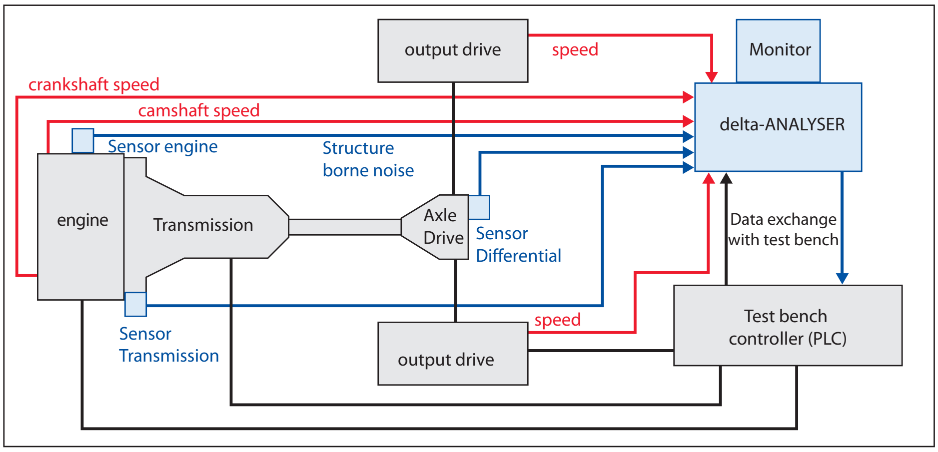


Figure 2: Monitoring mask of delta-ANALYSER

Test bench connection: Transmission / Engine / Powertrain







Cause of damage – spectrum based analysis

When the delta-ANALYSER has automatically terminated a test cycle due to changes of the test object's health condition, a spectrum based analysis of the cause of damage shall follow. Some users have highly skilled expert staff to do the analysis. But what about users, which lack those experts? Our solution for them is the Reilhofer Order Calculator (ROC). Its unique concept offers the possibility to quickly and simply map the test object or an entire powertrain. Using various included component modules like, e.g. gear wheels, bearings, balancer shaft modules, oil pumps or spring resonant frequencies, users can map complex engines and transmissions in great detail. The following, automated calculation of relevant component orders (for order analysis) and the integration in our analysis software Evaluation.NET enables technical staff with only minor vibration expertise to analyse and present damage history. Depending on specific needs, engine or transmission can be illustrated separately or in combination.

> ***Some users have highly skilled expert staff to do the analysis. We rely on our Reilhofer Order Calculator (ROC)***

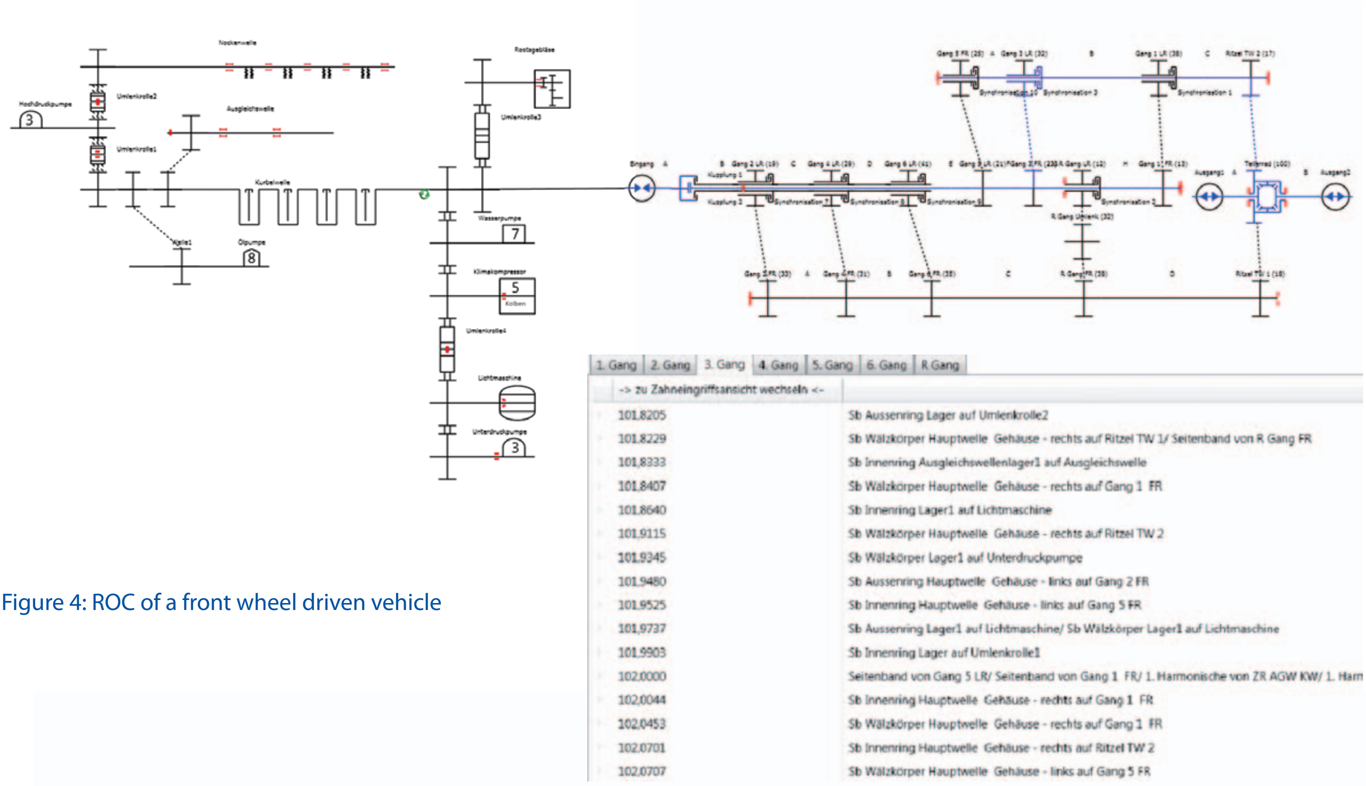
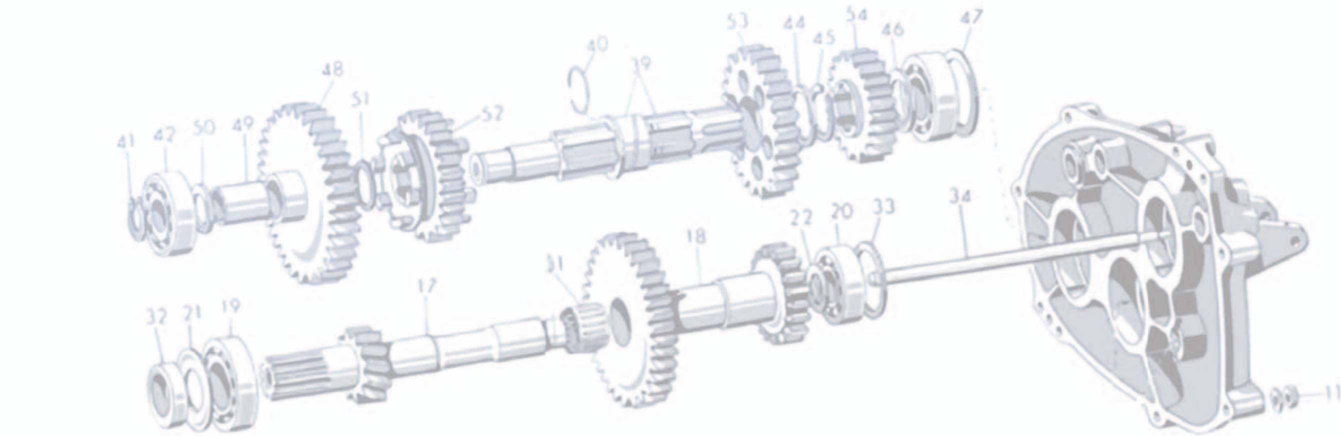


Figure 4: ROC of a front wheel driven vehicle



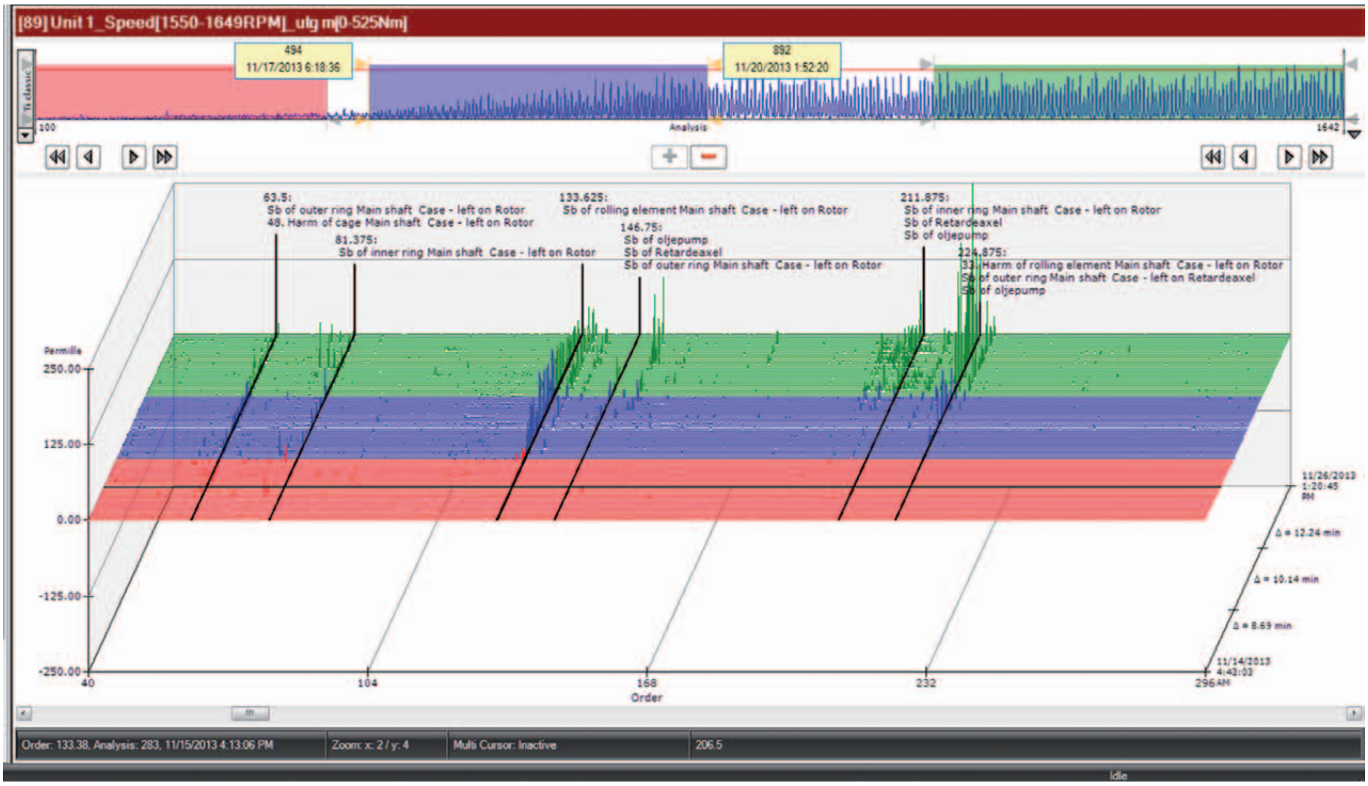


Figure 5: Waterfall diagram of Evaluation.NET with integrated ROC

Figure 6: Trend evaluation of a load step card

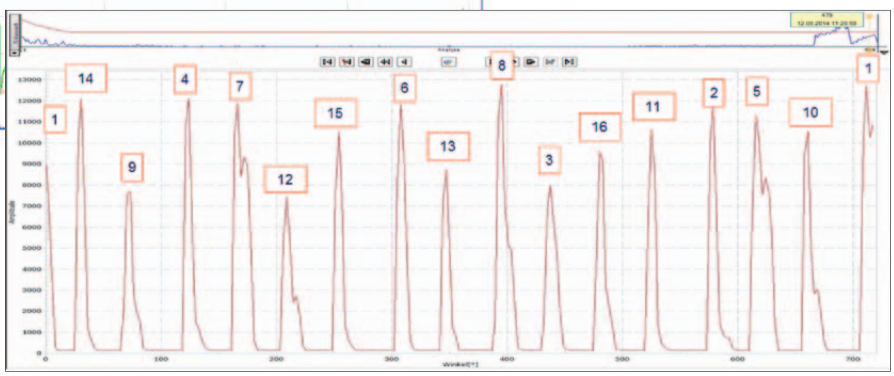


Figure 7: 720 degree display of the ignition of individual cylinders

Global Failure Database (GFD)

Some failure modes, like, e.g. mixed friction effects or casing cracks show up independent of rotation, so resulting vibration patterns can't be calculated in advance. However, a vibration pattern for this special failure mode can be derived by comparing equal failure patterns from identically constructed test objects. To get the greatest possible user benefit from this know-how, Reilhofer developed the Global Failure Database, to collect and provide those patterns. So even non-expert employees are capable to analyse related failures in a targeted manner.

> ***Mixed friction effects and casing cracks create vibration patterns, which can't be calculated - but an identical failure will produce the same pattern***

To let users benefit from this experience-based knowledge not only at one location or department, Reilhofer offers the possibility to globally use this standardised archive. This helps users a lot, as most of our customers and interested parties run a large number of NVH systems (Noise, Vibration, Harshness) in development and production departments. Every operating site generates valuable knowledge, measurement results and experience on a daily basis. Using the Global Failure Database, customers can pool the findings and make them available to all responsible employees – irrespective of their individual location. The Global Failure Database helps users to actively cross-connect all special departments involved in product development and life cycle care.

Figure 8:
Display of individual cases in the Global Failure Database

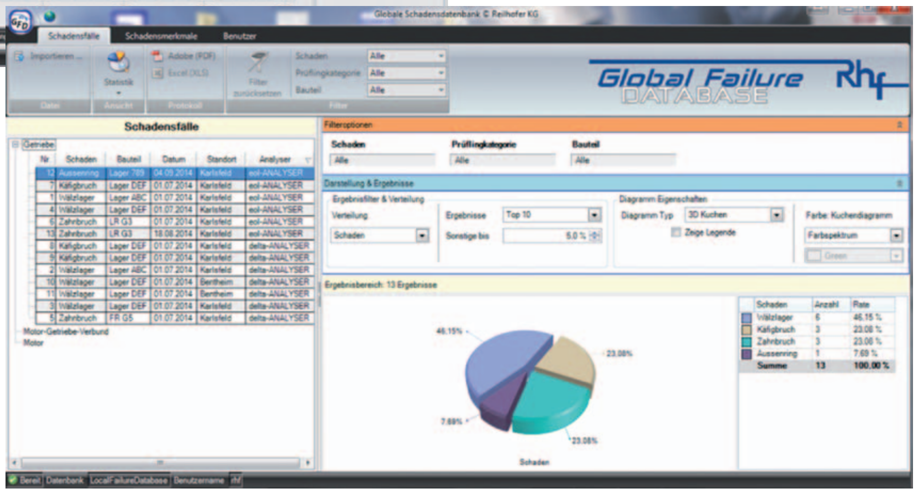


Figure 9: Global Failure Database presents statistics results

CrashPreventer included – the rapid break shutdown

Some types of failure, like, e.g. con-rod cracks or timing chain breaks occur spontaneously and evolve very fast. There is no continuous and slow growth process when those damages emerge, they come up in a sudden. So they can't be detected early through spectral variation of structure-borne vibration signals. To keep resulting damage to an absolute minimum, delta-ANALYSER features a break shutdown based on sum of structure-borne vibration signals.

Con-rod cracks or timing chain breaks can only be detected by sum of structure-borne vibration signal analysis.

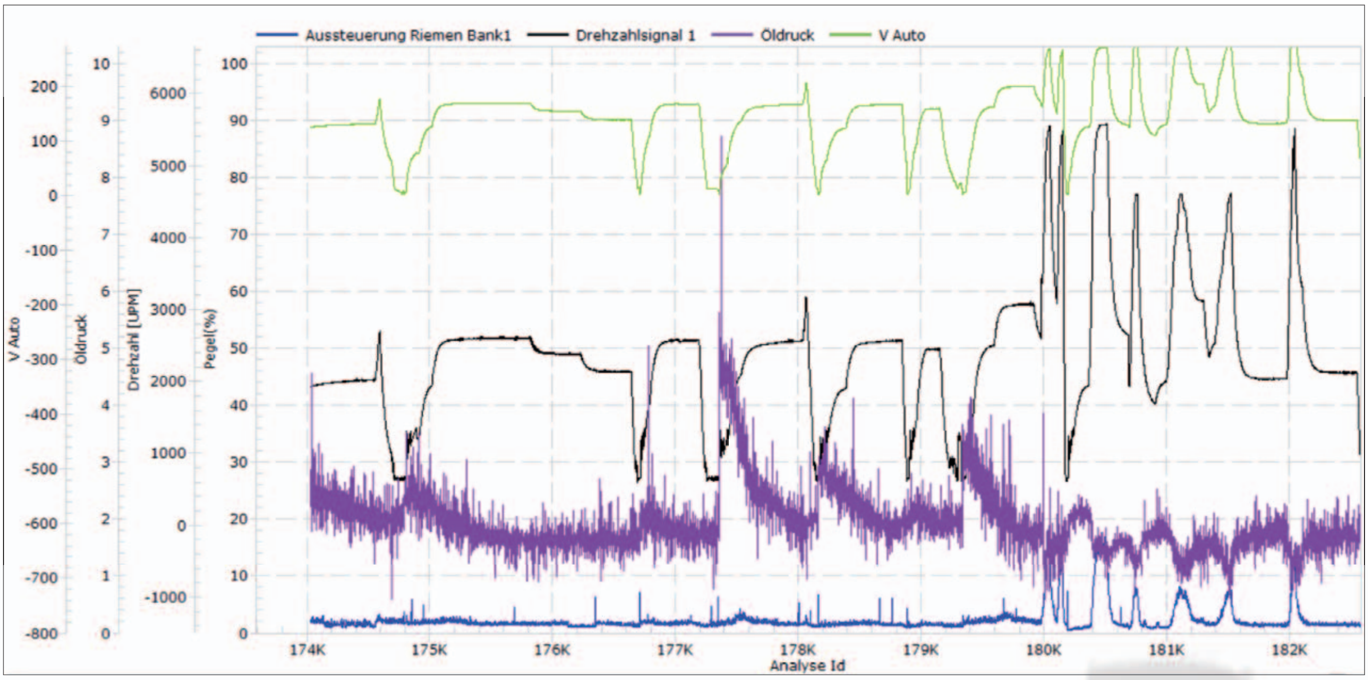


Figure 10: CrashPreventer evaluation using different parameters

Examples

Engine

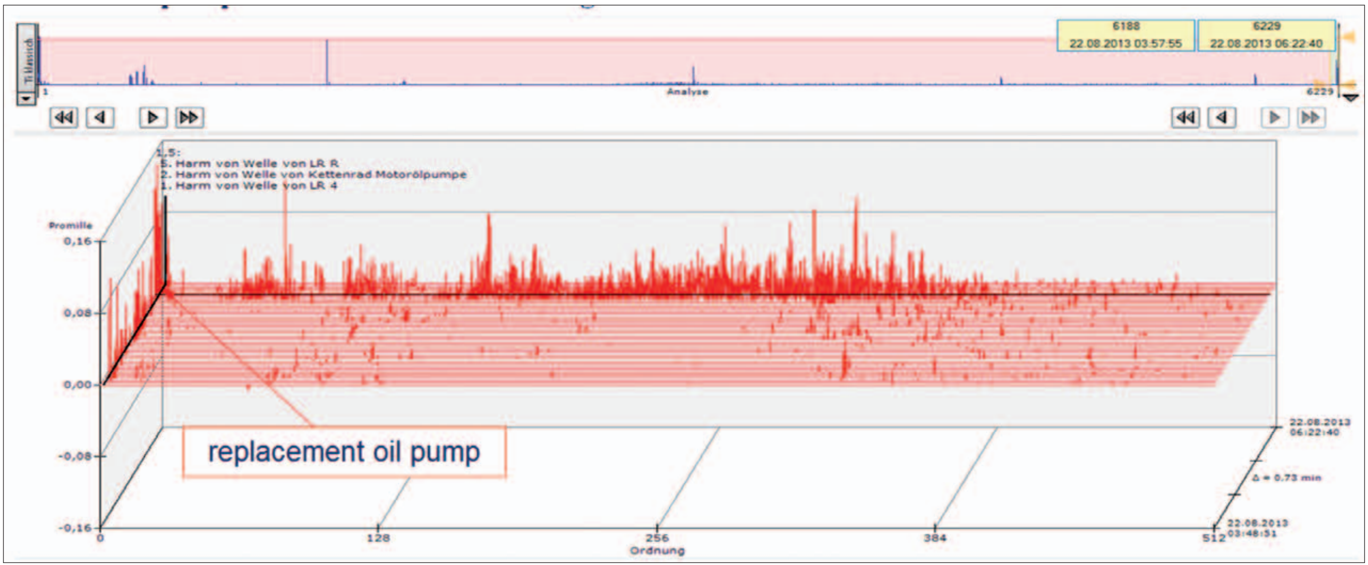


Figure 11: Oil pump damage progression

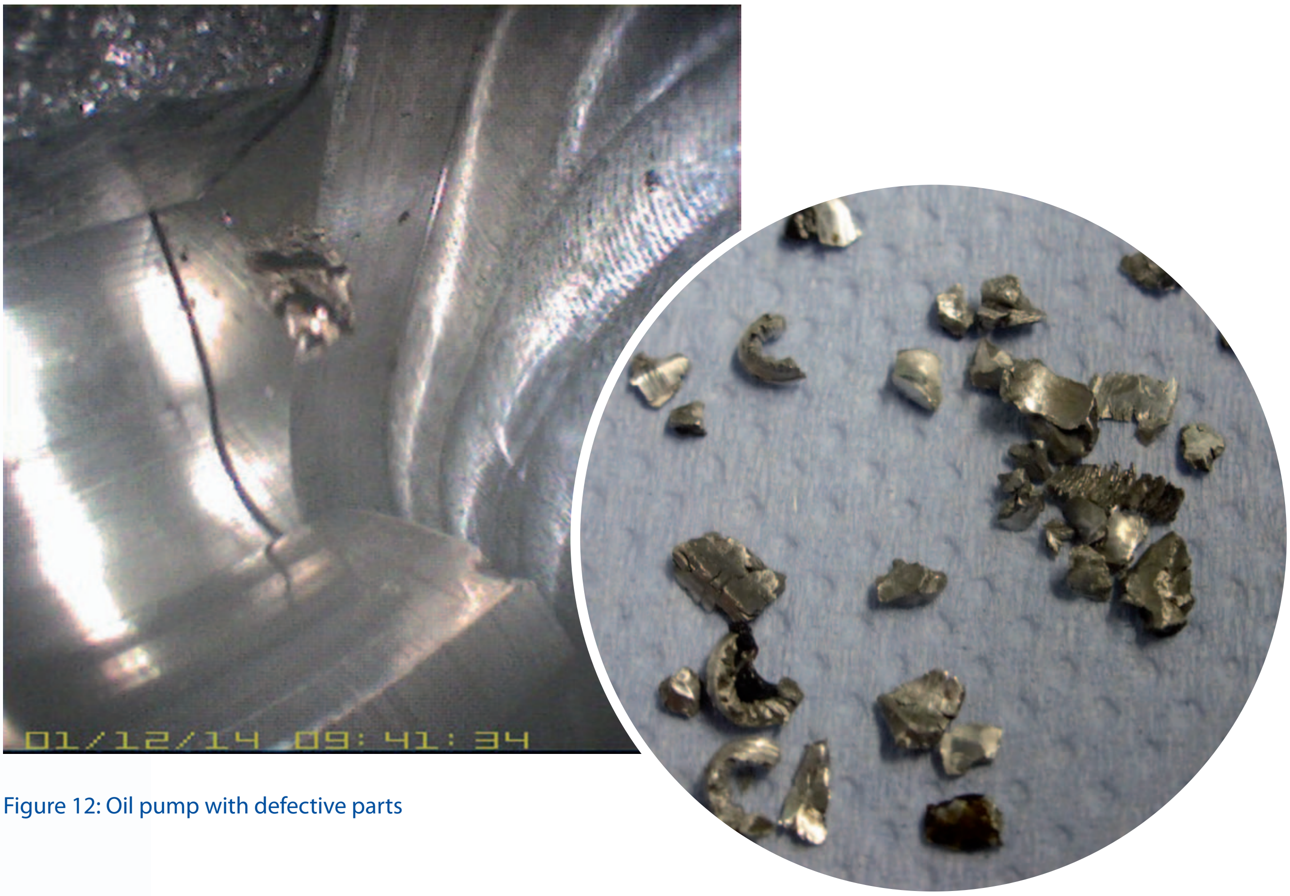


Figure 12: Oil pump with defective parts

Examples

Transmission

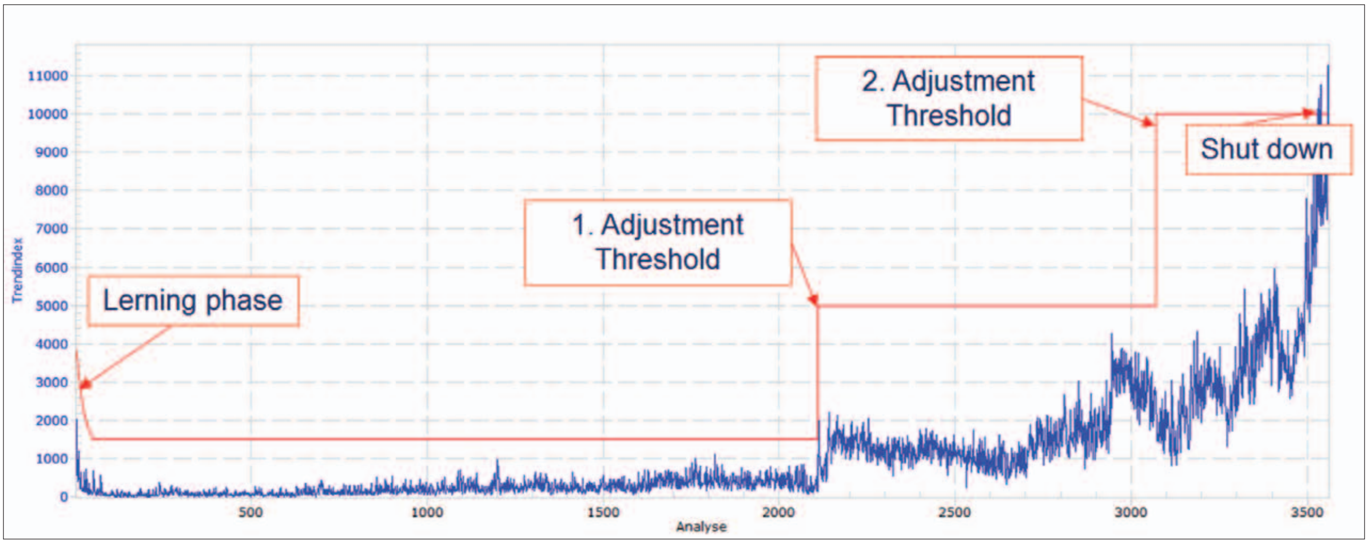


Figure 13: Trend index of a transmission tooth base crack

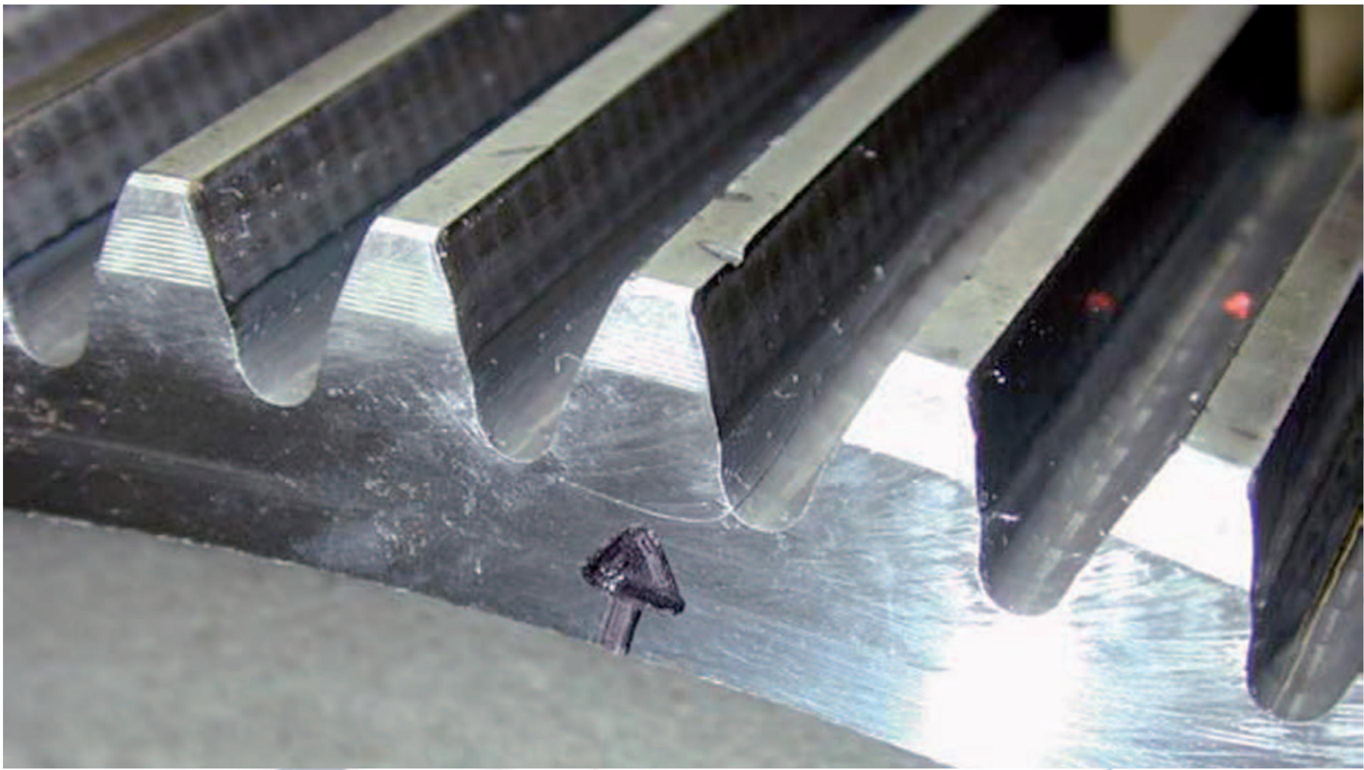


Figure 14: Tooth wheel with tooth base crack

Technical specifications:

delta-ANALYSER rack:				
General		Mains voltage	110 V / 230 V	50 – 60 Hz
		Nominal power	120 W	
		Size	19“ rack 3 U	D 430 / W 482.6 / H133
		Weight	Approx. 8 kg	
		Compliance	CE compliant	
		Protection class	IP 30, protection class I	
		Operating temperature	-10°C … + 55°C	
		Sensor supply voltage	5 V dc	
Input	analogue	Acceleration signal Vibration 1 – 4 Channel 1 and 2 2 channels optionally up to 8 channels	Input voltage: Sampling rate, max.: A-to-D conversion: Input filter: Resolution: Sampling rate, max.: Concurrent measurement:	±11.25 V 1 MSPS 16 bit Adjustable low-pass filter Adjustable high-pass filter 1 mV 50 k samples All 8 channels
	digital	Rotational speed signal (TTL) (see speedBOX)	The rotational speed signal is adapted via speedBox and fed to the system as TTL signal.	
		Digital inputs Unit 1 – 16	Input voltage range: Sampling rate, max.:	±32 V 25 k Samples
Output	analogue	Analogue outputs Unit 1 – 8	Output voltage range: I_{max}: I_{max} total: U_{max}:	±10.92 V 17 mA 100 mA 10 V
	digital	Digital outputs DOUT Unit 1 – 16	2 x 8 outputs, galvanically insulated V_{extern}: I_{max}:	 5.5 V … 28 V 350 mA
	Ethernet	100 / 1000 Mbit / s		
	Serial	RS 232		
Interfaces		CAN bus (option)	2.0B, extended frames, basic frames	
		Profibus DP (option)	Anybus Compact Com DPV1 Slave	

Technical specifications:

SpeedBox:				
General		Supply	10 V … 30 V dc, external power supply (12 W min.)	
		Device fuse	2.5 A, medium time lag, (20 x 5)	
		Casing	Metal case (suitable for DIN rail mounting)	
		Size	D 74 / W 170 / H 135 (incl. protruding parts)	
		Size incl. cabling	D 160 / W 220 / H145	
		Size of ext. power supply	D 110 / W 25 / H110 (suitable for DIN rail mounting)	
		Weight	Approx. 950 gr	
		Operating temperature	-10°C … +55°C	
Input	analogue	4 x rotational speed	Input voltage range:	±100 mV … ±15 V Voltages up to 100 V are acceptable, will be cut internally at 15 V.
			Overvoltage protection:	Up to approx. 200 V
			Galvanic insulation:	Available (shares ground voltage with according TTL input)
			Signal type:	Single-ended (asymmetrical) or Differential (symmetrical)
			Sampling rate:	40 MHz
			A-to-D conversion:	10 bit
			Input filter:	Connectible low-pass filter 100 kHz
			Common mode rejection:	Connectible
			Lower cut-off frequency:	0 Hz (common mode rejection not active) 10 Hz (common mode rejection active)
			Upper cut-off frequency:	1 MHz
	digital	4 x rotational speed (TTL)	Input voltage range:	0 V / 5 V (TTL)
			Frequency range:	0 Hz … 1 MHz
			Galvanic insulation:	Available (shares ground voltage with according analogue input)
Output	digital	2 x 5 rotational speed (TTL)	Output voltage range:	0 V / 5 V
			Galvanic insulation:	Available (shares ground voltage with according analogue input) All outputs are galvanically insulated from inputs and supply voltage.
			Max. output frequency:	2.5 MHz @ 500 Ω load
			Short-circuit-proof:	Fatigue endurable
			External voltage protection:	0 V to 5 V, fatigue endurable
Interfaces		USB 2.0	For configuration of the speedBox	

Control and visualisation PC:			
Mains voltage	110 V / 230 V		50 – 60 Hz
Max. power consumption	400 W		
Size	19“ rack	4 U	D 474 / W 446 / H 178
Weight	Approx. 14 kg		
Compliance	CE compliant		
Operating temperature	0°C … +55°C		
Software	Windows 10; configuration-, monitoring- and evaluation-module; delta-ANALYSER firmware		
Options	Connection to test bench master computer		

Images delta-ANALYSER V2

Figure 15: delta-ANALYSER V2 rack version

Figure 16: speedbox

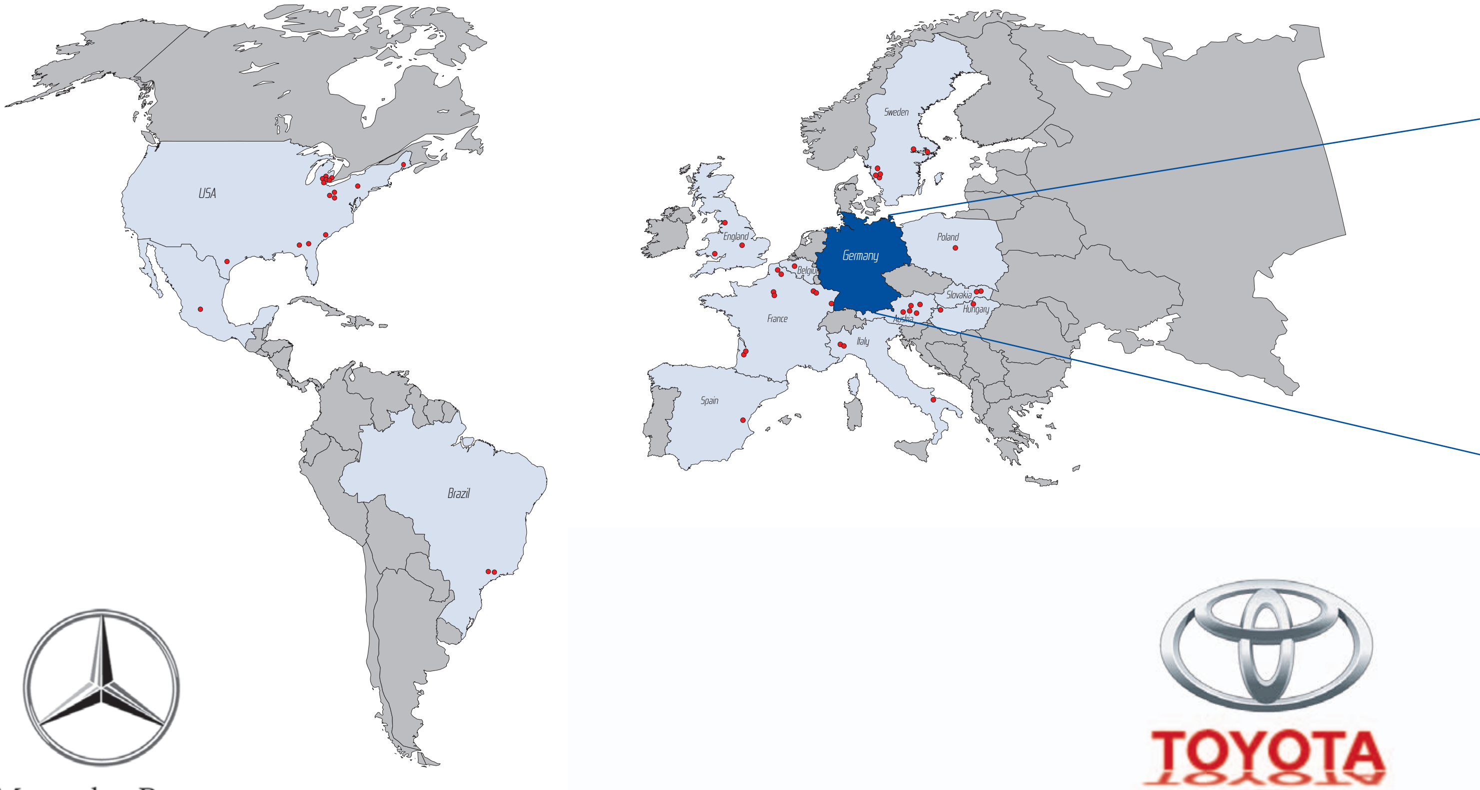
Easy Connect Box

The EasyConnect Box reduces the cables that lead from the test stand to the delta-ANALYSER. It consists of two units. There is a test stand module that bundles, processes and relays the signals. There is also a rack module that receives the signals from the test stand module and passes them on to the corresponding inputs on the delta-ANALYSER.

Each EasyConnect Box can be connected to up to 4 structure-borne sound sensors and two speeds. In the test stand module, a separate speed control unit is included. The speed signal is galvanic isolated from the delta-ANALYSER. Two cables lead from the test stand to the delta-ANALYSER and are filled with the prepared speeds as well as the acceleration signals of the structure-borne sound sensors.

Figure 17: Easy Connect Box

Referenzen (Auszug)



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GETRAG

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BMW

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antonov plc	APL	APS	ATESTEO	Audi
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BMW	BorgWarner Turbo & Emissions Systems	BOSCH BoschEngineering	BOSMAL	BRP
BUGATTI	CAERI	CATARC China Automotive Technology & Research Center	CATERPILLAR	cetim
CHANG FENG MOTOR	CHANGAN 长安汽车股份有限公司	CHEVROLET	CNGC	Chongqing TIEMA Industries Corporation
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GRAZIANO Trasmissioni	Great Wall	handtmann Ideen mit Zukunft.	HONDA	HORIBA Explore the future
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KONTEC	KS KRISTL, SEIBT & CO	KST.	LAND ROVER	LBF
LIEBHERR	THE LINDE GROUP Linde	LOTUS	Lubrizol	MAGNA
Mahindra	MAHLE	MAN	MBtech Mercedes-Benz technology	MILLBROOK
MINI	MTK Motorentechnik Kolb GmbH	mtu Power. Passion. Partnership. Tognum	National Motor vehicle Quality Supervision and Inspection Center	NISSAN
نیرومحرکه NMI	PANHARD	pankl PANKL RACING SYSTEMS GROUP	PATAC	PORSCHE
PSA PEUGEOT CITROËN	PTS	PUNCH Powerglide	Red Bull Racing FORMULA ONE TEAM	RENAULT F1 Team
RENK	ROLLS RR ROYCE	S&T Dynamics	SAAB	上海汽车变速器有限公司 Shanghai Automobile Gear Works
SAIC 上汽集团 SAIC MOTOR	SCANIA	SCHAEFFLER		GM 上汽通用五菱 SGMW
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