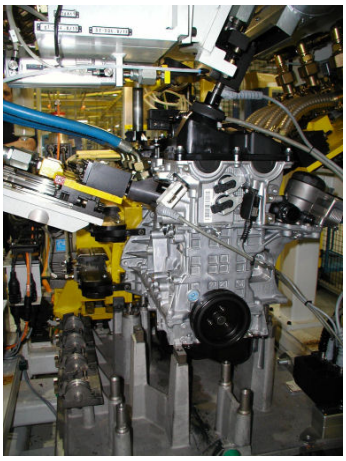
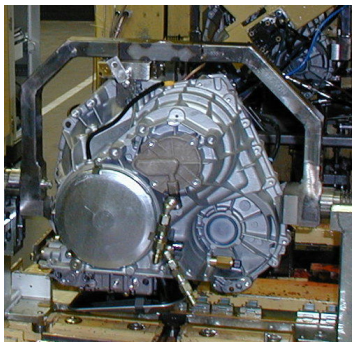
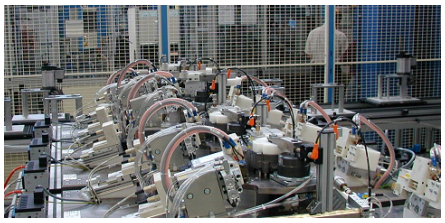
SAAB

ANOVIS

SOLUTIONS FOR END-OF-LINE TESTING AND EARLY DETECTION OF DAMAGE







SOLUTION FOR END-OF-LINE TESTING

INTERNAL COMBUSTION ENGINES

ANOVIS performs fully automatic checks during cold tests and hot tests on diesel and petrol engines.

Our extensive experience, originally acquired with three- to eight-cylinder automobile engines, has now been successfully applied to commercial vehicle engines and static plant.

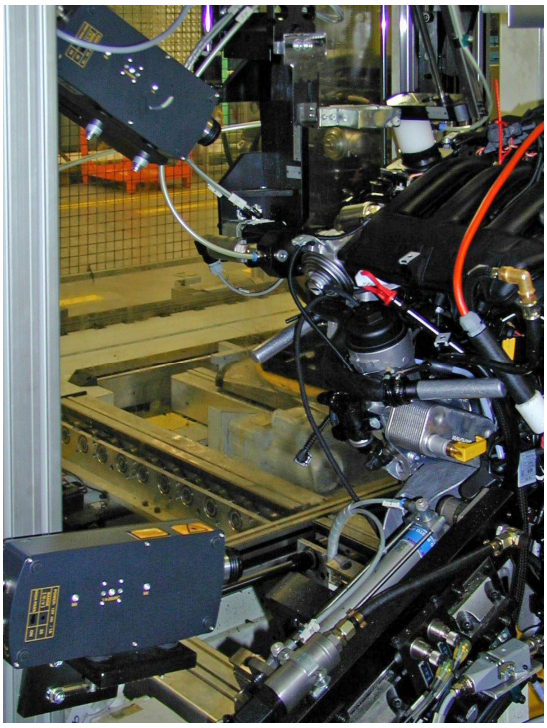
Examples of our process-secure fault detection, under volume production conditions include:

- missing connecting rod bearing shells
- imbalance (crankshaft, differential gear shaft, turbocharger)
- gear teeth defects (gear meshing, damaged gear teeth)
- defects in chain drives (chain screeching, damaged sprocket teeth, chain tensioning device)
- camshaft defects (chatter marks, damage to bearing surfaces)
- defects in valve operation (abnormal valve clatter, noises from rocker arms and/or trailing arms)
- abnormal noises (pistons, turbocharger, bearings)
- defects in oil and high pressure pumps
- additional uses: test bench monitoring, including drive mechanisms, braking systems and bearings, operator safety issues.

The illustration shows a cold test field in an end-of-line (EoL) testing environment: vibration signals are being recorded and analysed in parallel with the function test.

Two laser vibrometers are used as sensors on the test bench shown. Other tests benches are equipped with accelerometers at adjustable pick-up points. Microphones too are increasingly being used in optimum positions to record noises emitted by chain drive mechanisms or turbochargers. Dynamometer speeds available at the test bench can create vibration frequencies of up to 10 kHz; with an engine speed of 1.500 min^{-1} you can evaluate the 400^{th} order.

By measuring directly on the engine, we are also able to detect low-energy ‘quiet’ defects in a process-secure manner.



Our engine testing customers include:

AUDI Györ (H)

BMW Hams Hall (GB), Landshut (D), Munich (D), Shenyang (PRC), Steyr (A)

Daimler Bad Cannstatt (D)

Daimler Nutzfahrzeuge (Trucks) Mannheim (D)

General Motors - OPEL Kaiserslautern (D), Joinville (BRA),

Kymco (Taiwan)

Mahle Powertrain (GB)

MAN Nutzfahrzeuge (Trucks) Nuremberg (D)

Porsche Stuttgart (D)

Skoda (CZ)

VM Motori (I)

Volkswagen Chemnitz (D), Salzgitter (D), Changchun (PRC), Shanghai (PRC), Silao (MEX), Sao Carlos (BRA)

TRANSMISSION SYSTEMS

ANOVIS performs fully automatic checks during the production of automatic, CVT and manual transmission systems.

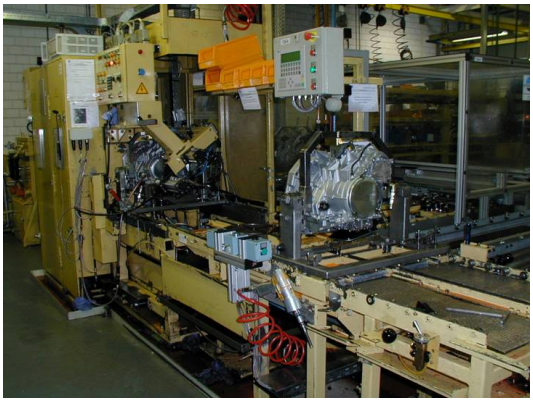
Automated acoustic testing has been performed on transmissions for many years. Noise (air borne noise) and vibrations (structure borne noise) are recorded and evaluated. Transducer types and location are selected in relation to the objective of the test and analysis methods applied, and have an effect on the test bench and environmental conditions.

Examples of our process-secure fault detection under volume production conditions include:

- gear teeth defects (gear meshing, damaged gear teeth)
- imbalance (gear wheels, shafts, clutches)
- defects in shafts (chatter marks, damage to bearing surfaces)
- defects in torque converters (chatter marks/flat areas, damage to bearing surfaces)
- oil supply defects (damage to bearing surfaces or the pump housing)
- bearing defects (damage and undulations on bearing surfaces)
- abnormal noises (including rattling or chattering noises)
- additional uses: test bench monitoring, including drive mechanisms, braking systems and bearings

We use microphones and/or probe tipped accelerometers. The relevant frequencies measured are up to 10 kHz, and in some cases up to 20 kHz.

We recommend that signals are recorded directly on the transmission casing for reliable detection of low energy “silent” defects.

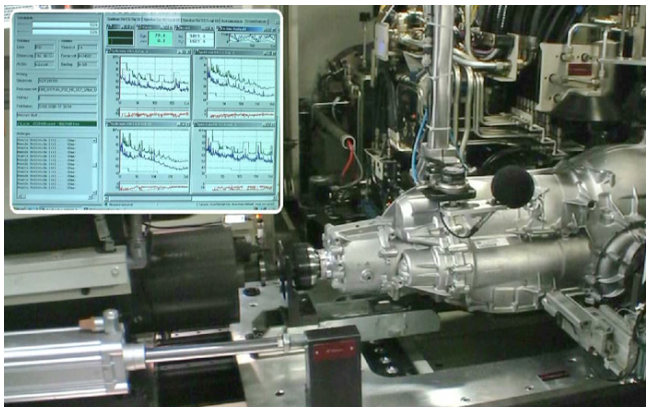


The illustration left shows part of a CVT transmission test bench in the EoL testing environment: vibration signals are being recorded and analysed in parallel with the function test.

The illustration below shows a part of an automatic gearbox test bench. Since noise is recorded and sound pressure level is evaluated, the test chamber is acoustically encapsulated.

Our transmission testing customers include:

Batavia Transmissions (FORD) Batavia (USA)
Chrysler (USA)
Punch Powertrain Sint Truiden (B)
Punch Powertrain (PRC)
Skoda Mladá Boleslav (CZ)
ZF Getriebe Saarbrücken (D)
ZF Getriebe Brandenburg (D)
ZF Passau (D)
ZF Transmissions Shanghai (PRC)
ZF Transmissions USA



ELECTRIC MOTORS

ANOVIS performs fully automatic checks during the production of drive and servomotors, together with many applications where modules contain motorised drive mechanisms, including

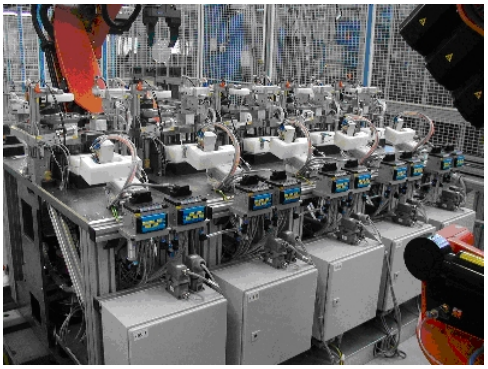
... in the motor vehicle sector: adjustable covers, control units, window lifts, air conditioning units, complete vehicles, steering column adjustment, electric steering systems, seat structures,

... in other sectors: white goods, electrical engineering (switches/relays).

Examples of our process-secure fault detection under volume production conditions include:

- imbalance (shafts, gear wheels, power train)
- gear teeth defects (gear meshing, damaged gear teeth)
- defects in shafts (chatter marks, damage to bearing surfaces)
- bearing defects, pump defects
- belt drive noise
- relay energising
- shift noise
- abnormal noises
- additional use: test bench monitoring, including drive mechanisms, braking systems and bearings, personnel safety.

We use microphones and/or probe tipped accelerometers. The relevant frequencies measured are up to 10 kHz, and in some cases up to 20 kHz.

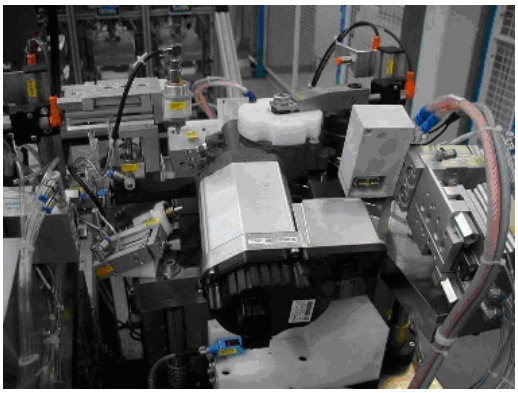


The illustration left shows a fully automated test cell for steering support motors. A robot performs motor handling. Several test beds are integrated within the test cell; each test bed operates independently from the others.

The illustration shows part of a steering system motor in the EoL testing environment: vibration signals are being recorded and analysed via accelerometer pick-up points.

Our electric motors and motor driven components customers include:

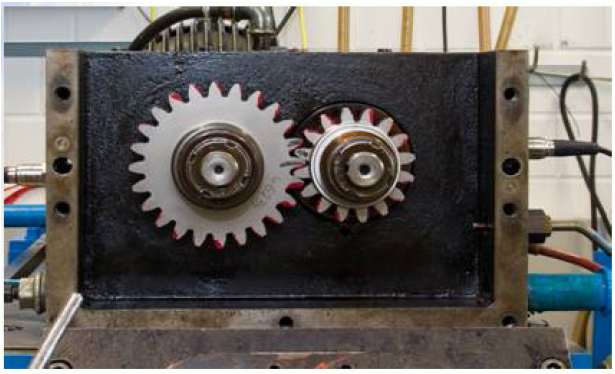
AMK Kirchheim/Teck (D)
Behr Bad Neustadt (D)
BSH Berlin (D)
IMS-Morat Donaueschingen (D)
Siemens Munich (D)
Siemens VDO (D)
STIWA Attnang (A)
ThyssenKrupp-Presta (D,F,USA)
Volkswagen Dresden (D)
Weber Dillenburg (D)
ZF Lenksysteme (D, PRC, SK)
ZF NACAM Bremen (D)

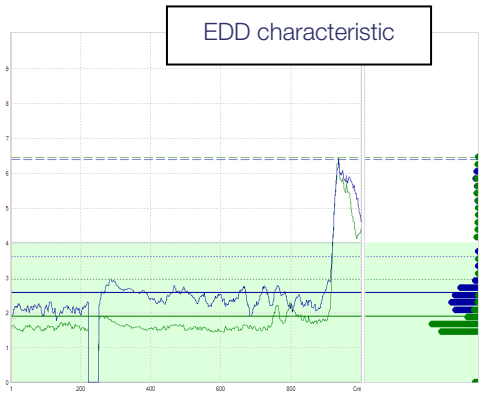


SOLUTION FOR ENDURANCE TEST MONITORING

SELF-LEARNING SYSTEM FOR EARLY DETECTION OF DAMAGE (EDD)

ANOVIS-EDD is our patented solution for early detection of damage on the endurance run test bench for engines and transmission systems. The objective of early stage damage recognition is a rapid shutdown of the test bench if a fault occurs. In this way, sequential faults on the test specimen and damage to the test bench should be prevented. A high degree of process reliability and a limited number of parameter assignments are required on the test bench.





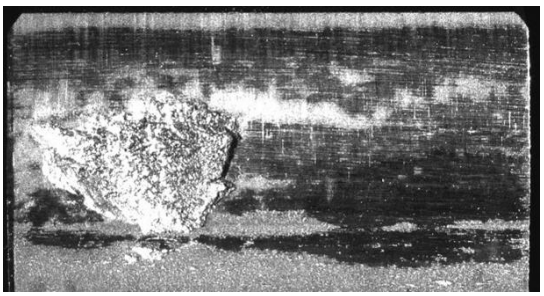
ANOVIS-EDD features the following essential properties:

- analyser function for display, post-processing and audio playback
- time varying signal storage for subsequent offline analysis
- scalable number of measurement channels up to a maximum of 75 kHz
- straightforward connection of commercially-available vibration and noise sensors
- straightforward connection to the test bench control system

EARLY RECOGNITION OF PITTING IN THE BACK-TO-BACK TEST BENCH

Pitting is a surface irregularity caused by break out of material particles at areas close to the surface at the tooth flank. The pitting test is a method to determine the load carrying capacity of pitting. It is our task to detect incipient pitting in endurance tests in a back-to-back test bench and to stop the test run (typically a few weeks), if possible depending on surface-oriented damage criteria.

ANOVIS-Pitting-Detect allows to detect incipient pitting a short time before first break out of tooth flank material becomes visible. The damage criteria are adjusted empirically.



ANOVIS-Pitting-Detect uses statistical methods to evaluate structure born noise measured synchronously with the shaft rotation speed. Important is the self-adaption of the method to the referring measurement scenario, so that laborious calibration or reference measurements become obsolete. The required measurement equipment can easily be added to present back-to-back test benches

SYSTEM CONCEPT FOR OUR SOLUTIONS

SYSTEM CONCEPTS – AT A GLANCE

Vibration analysis provides support during the automated end-of-line (EoL) test on the production line. In a few seconds of measurement time, assembly errors and component defects, together with miscellaneous distinctive (noise-related) characteristics in internal combustion engines, transmission systems or electric motors can be detected: objectively, reproducibly and in a process-secure manner. Vibration analysis is regarded as an extended measurement and testing procedure. This method is fully justified by its great success in detecting relevant faults which would otherwise remain undetected using traditional methods.

A variety of analysis procedures are available for the time and frequency sectors. Order analysis assists greatly with fault diagnosis to component level by making it possible to evaluate periodical events that are synchronous with the angle of rotation with very high precision.

For the definition of a “suitable” system we have to consider some customer specific requirements. Aspects of organisation, staff availability, technical skills and manufacturing process should be taken into account for the “best” choice of system concept suitable for the plant and its test bench operators. It is a matter for our consultancy, to explain the different approaches with their advantages and drawbacks.

The different system concepts use identical ANOVIS hardware and software modules, and, essentially, identical analysis methods; they are independent from the transducer selected, but they vary significantly in the corresponding system configuration. Main selection criteria are related to system operating, calculation and maintenance of abnormality tolerances and costs. Here follows a short overview of the different system approaches which are explained in detail later in this brochure.

ANOVIS-Lite, the “intelligent sensor”. ANOVIS is used as a measurement channel in the test bench. ANOVIS calculates pre-defined test phases measurement values and curves. These values and curves will be transmitted to the test bench measurement software and evaluated in a similar way to torque or oil pressure signals. The operator does not need any skill in operating ANOVIS and defines abnormality limits via the standard test bench measurement software.

ANOVIS-Chameleon, the “black box”. ANOVIS is a self-learning system at the test bench. The features (quality criteria) are pre-defined; abnormality limits will be calculated and maintained automatically. ANOVIS transmits the assessment result including abnormality information (defect information) to the test bench. The operator does not need deep knowledge of ANOVIS.

ANOVIS-Professional, the analyser. ANOVIS calculates and assesses pre-defined features. ANOVIS transmits the assessment result including abnormality information (defect information) to the test bench. An operator has the capability to change system configuration and parameters, and to visualise measurement curves, statistics, etc. directly at the test bench. A good knowledge of ANOVIS system operation and signal processing theory is required.

ANOVIS-Portable, our portable system. If an ANOVIS system is to be moved between various test benches, we recommend ANOVIS-Portable which is easier to handle by virtue of its weight and size. The system comprises a notebook PC and a DIN rail module (see “Hardware” section). A suitable test bench control is required for automated test performance. The system can be configured for all concepts: -Lite, -Chameleon and -Professional.

ANOVIS-Mobile, prepared for vehicle measurements. ANOVIS-Mobile is essentially identical to ANOVIS-Professional; the differences are in hardware configuration, which take into account specific requirements for in-vehicle measurements such as power supply provision.

All the system concepts described use configuration and parameter data and files which include measurement and test specifications. The design of test specification is critical for the success of testing, and can be performed and optimised by an experienced operator or by a Saab Medav Technologies technician. We have many years of experience in vibration and acoustic testing.

TRANSDUCER CONCEPTS

AT A GLANCE

It is essential to customise the choice of transducers to suit each specific application and to take into account any restrictions and environmental conditions. End-of-line testing is usually a “comparative measurement”; with this in mind we have some degrees of freedom in transducer selection. The table below provides an overview of some aspects which should be considered.

Transducer	Physical Measure	Reasonable bandwidth	Calibration	Advantageous applications	Drawback
Microphone	(Air) Pressure	10 to 20 kHz Many standard sensors are available	By the use of a piston-phone Available Automated or manually	Measurement of the sound audible by humans Defect causes less vibration but a lot of noise, e.g. belt drive	Sometimes reduction of external noise required
					
Probe tip (contact to test specimen)	Acceleration	Variants up to 10 kHz available	By the use of a shaker Available Automated or manually	Engines, transmissions, … If feedback of mass is non-critical (engines, transmissions…) Low costs	Mechanical application (adaptation) of sensor Space available for mechanical handling and at the test specimen If feedback of mass is critical (light-weight test specimen)
					
Laser vibrometer (contact-less)	Velocity (acceleration by differentiation of velocity)	10 to 20 kHz various types available	Not necessary through prime calibration (wave length of the laser beam)	If contact with test specimen impracticable, laser vibrometer can be displaced up to 2 metres away from test specimen. Reasons may be: No space for mechanical adaptation device (e.g. test bench with through-passing test specimen) or engines with many aggregates, cables etc. In general, if feed-back of mass is critical	Requirements for a ground, reflective surface Accurate positioning of laser and specific distances Additional module from Saab Medav Technologies to achieve process reliability Relatively expensive
					

The transducer types mentioned are available world-wide and have been installed by us at many test benches. The measurements performed are reliable and satisfy all demands made by the operators.

In addition to the transducers mentioned in the table above, we use accelerometers which are fixed (screwed) permanently to the test bench, with the objective of monitoring its most critical components such as bearings, shafts and dynamometers.

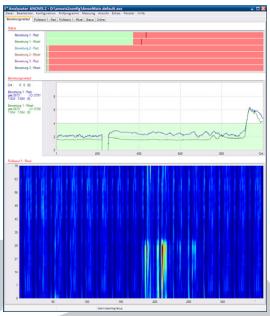
Each measurement channel of the ANOVIS system can be calibrated separately. Therefore a mixture of sensors (microphones and probe tips) can be connected to ANOVIS. ANOVIS supplies ICP power for each channel, configurable by software.

SYSTEM TECHNOLOGY

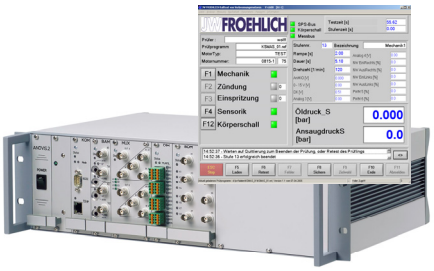
ANOVIS – VERSATILITY IS THE KEY

ANOVIS (**A**coustic **NO**ise and **VI**bration **S**ignal analyser) has been commercially available for some years. A large number of systems supplied to numerous customers from various industrial sectors are today working around the clock to fulfil stringent availability and flexibility requirements. At Saab Medav Technologies, we are committed to the continued development of hardware, software and, most importantly, analysis functions. Based on our ANOVIS system platform, we now offer a range of system applications for the online and offline analysis of vibration signals, and airborne and structure-borne noise.

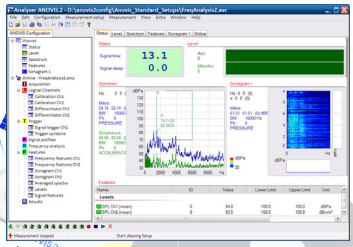
With the increasing integration of research and development (R&D), quality assurance (QA) and production, experience has shown that in the interests of efficiency, the same measuring system should wherever possible be used for the various working priorities. Due to a variety of secondary conditions, this is a difficult requirement to satisfy; the type of universal analysis system required by designers may overload system support engineers in the production environment. Conversely a measuring system for the production environment, with predefined measurement and evaluation functions, cannot offer sufficient flexibility to the design department. Moreover, handling complex all-in-one systems requires specialist training; something which, in today's production environment for vibration analysis, is seldom supported.



Endurance run monitoring
performance testing
early detection of damage



Test bench system



QA laboratory
system

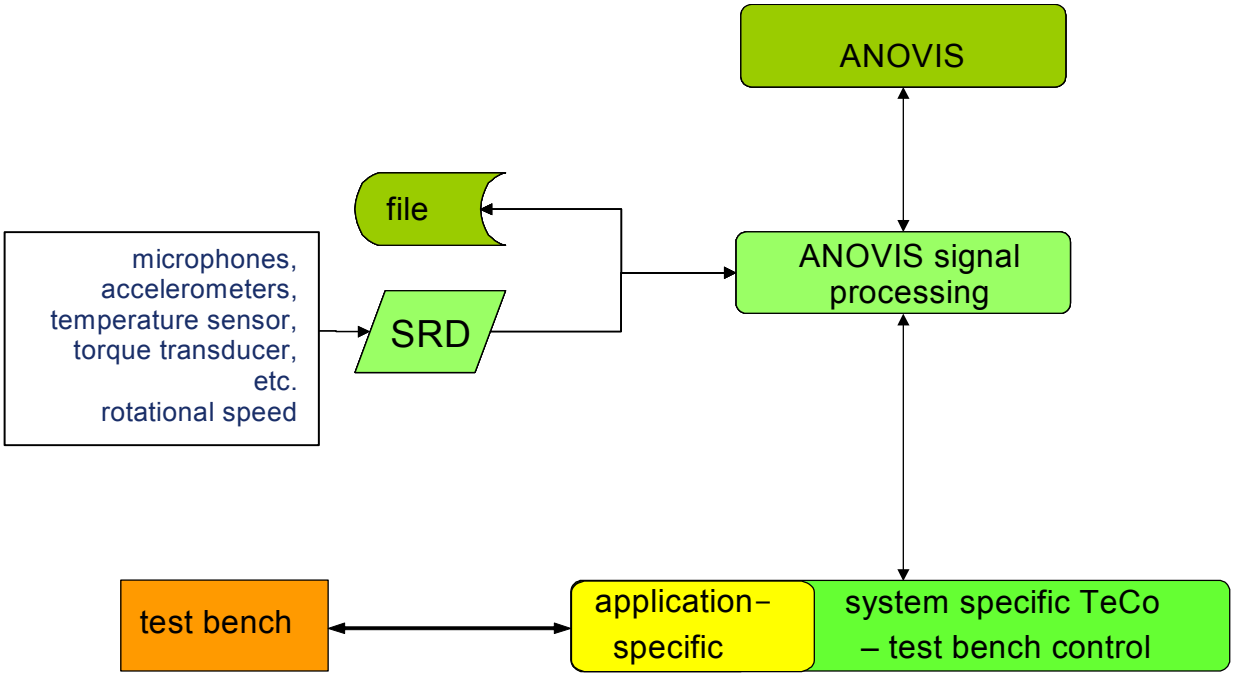
Mobile system

By using a standardised system platform that is configured as tailor-made solutions for the individual functional sectors, ANOVIS is ideally suited to promoting collaboration between them, by exchanging data and results in a straightforward manner, thereby reducing working time and cost. Responding to individual requirements is what makes our ANOVIS system so attractive to a wide range of users.

ANOVIS-Lite and ANOVIS-Chameleon are favoured configurations for the test bench. ANOVIS-Professional fulfils requirements for laboratory (offline + online) analysis, e.g. to describe test specifications or for reporting, and for the mobile system.

We supply our systems in the context of ‘solutions’, inclusive of sensors, automation and the creation of test specifications, as well as in the form of a ‘tool’. The complete system technology is also accessible to OEM users.

ANOVIS hardware and software are in modular form and are configured for individual applications. The software concept is described below.



The basic application represents the mathematical core of the system. It contains the various analysis and evaluation procedures. Each procedure is accessible as separate switchable modules, which we call “flowlets”. The range of functions required for any given task is implemented by switching the appropriate flowlets (configuration). Configurations are stored in setup files. Typical ranges of functions include: single-channel FFT analysis with evaluation of selected frequency lines via threshold values; dual-channel order analysis with evaluation of various level responses via boundary curves, based on three different reference shafts. Any number of evaluations can be configured simultaneously.

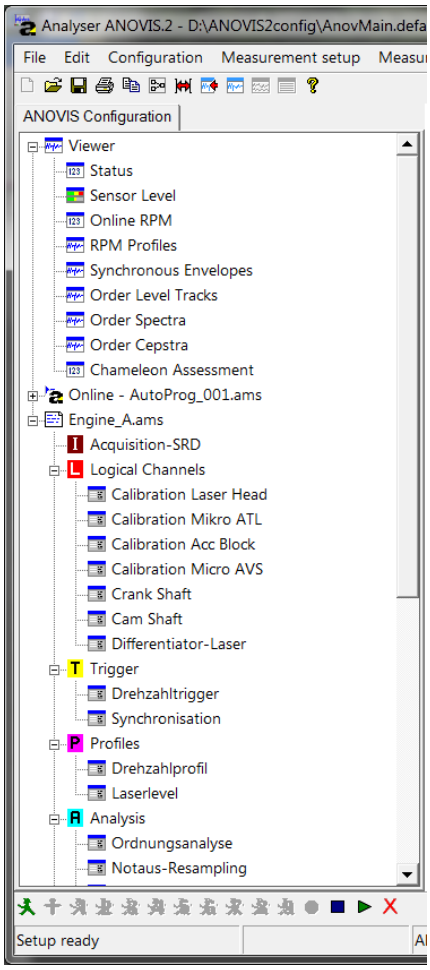
The signals to be evaluated are either recorded online, via the SRD (Signal Recording Device) signal recording software, or they are accessible offline in the form of files. Vibration signals (airborne noise and structure-borne noise sensors), trigger signals (e.g. rotational speed) and operating data (e.g. temperature and torque signals) are recorded and analysed.

Signals (raw data) recorded via the SRD, as well as the results of analyses can be stored in files. In addition to ANOVIS formats, CSV, XML, MATLAB and ASAM file formats – together with the WAV format for audio playback on a PC – are also supported.

Parameters are assigned to the configured evaluation procedures via user-friendly dialogue boxes. These parameters are also stored in the setup files.

The ANOVIS Analyser module is required for the parameterisation and configuration of ANOVIS. Training in operating the system is required for competent handling of the ANOVIS Analyser module. Users wishing to configure their own analysis procedures must be familiar with digital signal processing. The ANOVIS Analyser module supports the display of measurement curves, evaluation results, operating states and the input of parameters. The various curve and result representations are also configured and stored in the setup files. In this way, standard display configurations can be defined for different measurement tasks.

The ANOVIS Analyser can be used online and offline to perform comprehensive frequency and time domain analyses. It can also be used to create test programmes and to compile reports and presentations. Operation is based on typical Windows applications.



ANOVIS configuration (left):

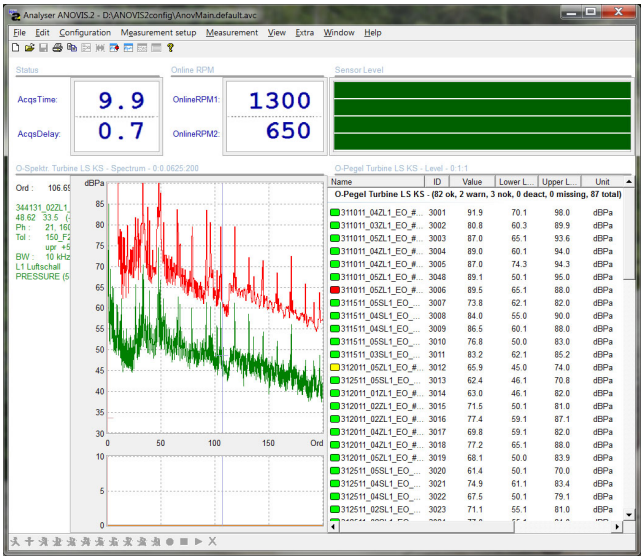
The existing configurations for signal processing and viewer are displayed as a menu tree. The information is stored in a setup file.

The ANOVIS system features file-orientated storage in structured file directories, classified by product group, product version, calendar day, layer etc. - an arrangement that has proved effective in practice. Results and the raw data (time varying signals) can be stored. The data can be backed up as ‘circular buffers’ (for example: the last 30 days, then deleted) or configured for (automated) filing.

Typical management functions include setups, measurement data and the outputs from a higher-ranking database system. In many cases, this ‘production database’ has already been introduced into the production plants. By means of TeCo, we are able to support data transfer to the master computer or direct to the database server. There is a growing demand for the storage and filing of raw data.

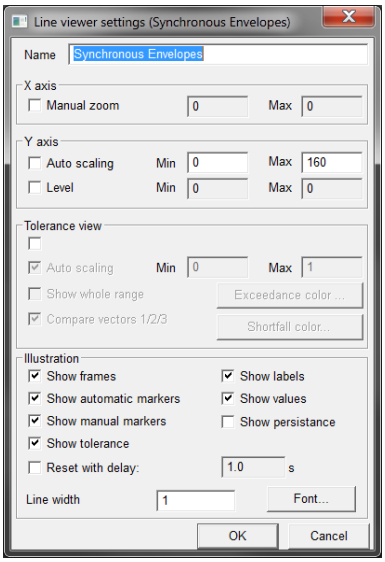
TeCo (**Te**st bench **Co**ntrol) is our name for the software interface between ANOVIS and an external control system. Automated data acquisition and evaluation is necessary for test bench operation. The protocol for loading a type-dependent test specification, control of measurement phases and transfer of measurement data is defined jointly with the client. The physical interface is also determined. Typically, communication is via TCP/IP, UDP, RS232, PLC, Profibus or any other interfaces that are supported as standard by PCs or via remote control commands.

Only limited expenditure on implementation is likely to be required in order to support new protocols and interfaces, since the system is able to differentiate between ‘system layer’ and ‘application layer’. The application layer transposes the application-specific into the generalised structure within the system.



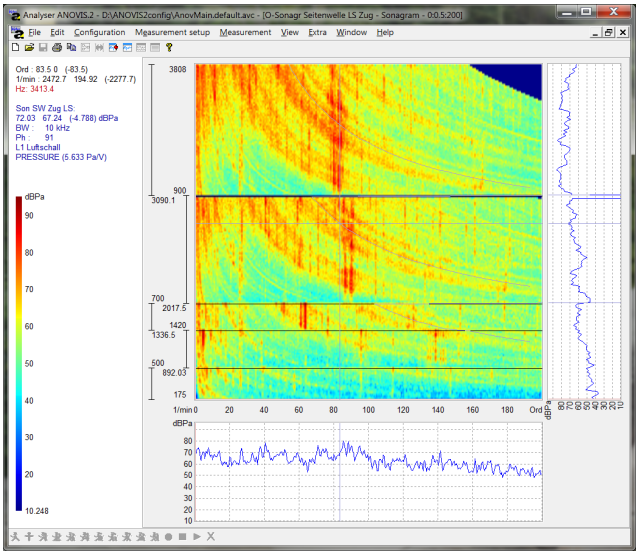
Display of the results:

The results of test specifications can be displayed as graphics or rows of data, with indication of tolerance violations.



Viewer configuration:

Results, status conditions and graphics are displayed in viewers. The viewers are configured by means of panels.



Multi-Sonagram display:

With sonagram displays, the cursor is used to specify areas in which level responses and spectra can be recorded simultaneously.

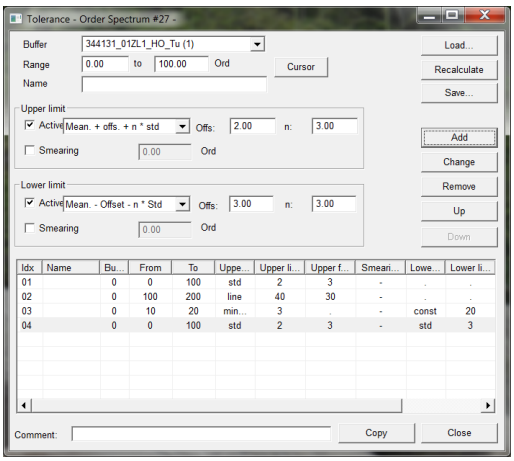
A speech control interface, which supports remote control of the ANOVIS system, is available for the mobile system. In addition, current measurement values are output in the form of speech.

Evaluation of the measurement data commences as soon as sufficient measurement data are available. The results are transferred to the host computer either at the end of a measurement phase or at the end of the complete test.

While the measurement is in progress, status factors – such as rotational speeds or modulation of the sensor channels – are displayed.

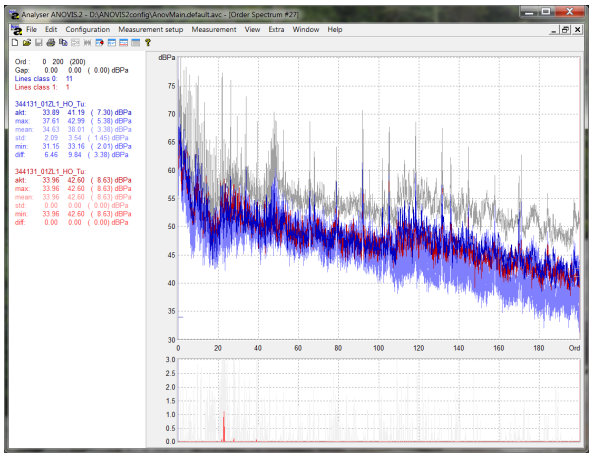
A variety of statistical aids is available for determining boundary values and curves.

Once the database has been selected, the corresponding measurement curves are loaded. Using simple dialogue boxes, boundary curves are calculated over the entire area or sections of the reference axis. Tolerance violations are directly displayed.



Boundary curves calculation:

Upper and lower boundary curves based on a variety of standard procedures are defined using dialogue boxes. These can easily be refined.

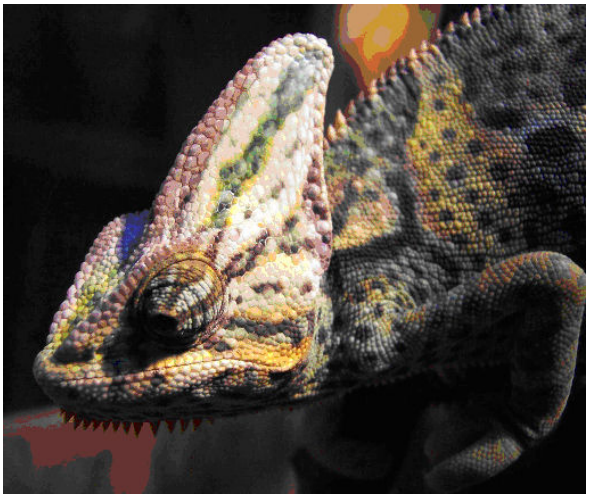


Tolerance scheme and its evaluation:

Boundaries (grey) and actual measurement curves (good<->blue; poor<->red) are displayed in the relevant viewer. Tolerance violations are automatically evaluated and displayed.

Users of the Chameleon process are provided with special support for configuring boundary values and curves. Features of the Chameleon process include:

- The task of configuring abnormality boundaries, as described above, is automated.
- Tolerances, etc. are automatically adapted to the current process design.
- The adaptation is documented.
- There are a number of implementation options for the adaptation rules (fixed boundaries, fixed tolerance ranges, maximum adaptation areas, for each individual factor).



ANOVIS SRD - HARDWARE MODULES FOR STATIC USE

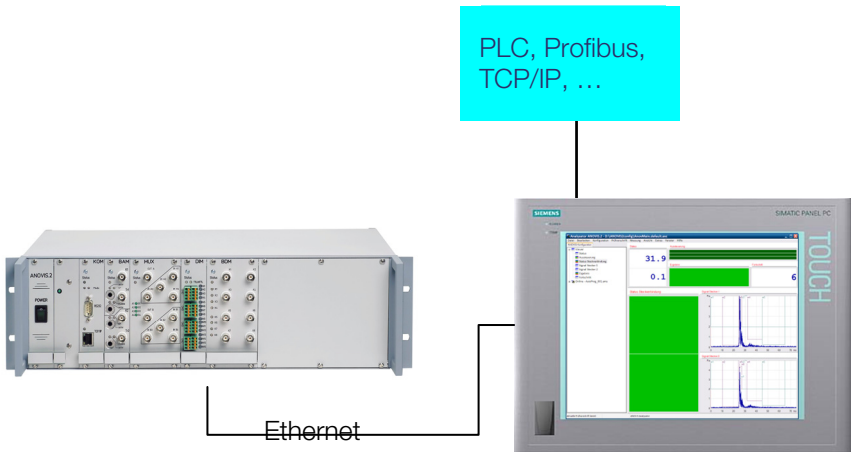
ANOVIS SRD (**S**ignal **R**ecording **D**evice) has been designed for test bench solutions and takes account of the associated requirements: flexibility in terms of the scalability of measurement channels – even for high bandwidths, support for a variety of machine interfaces, high-precision tachometer recording for order analysis (digital resampling) and mechanical design variants for installation on top hat rails or in the form of a 19-inch rack unit.

Software is used to configure the hardware parameters. No manual controls are fitted to the SRD.

ANOVIS systems are application-specific and consist of existing hardware and software modules. In this way, cost-effective solutions can be devised without incurring development risks, within short project implementation periods.

A complete system includes the remote ANOVIS SRD signal-recording device and a measurement PC. The required number of signal and trigger channels can be combined in duplex stages in modular form on the ANOVIS SRD. Add-on modules provide interfaces to peripherals or support cost-effective, hard-wired solutions for resource sharing or the production of alternative versions.

ANOVIS SRD is connected to a PC via an unoccupied network connection (Ethernet). Windows operating systems are supported. The PC can be either an existing measurement or master computer on the test bench or a separate PC.



COM – Communication module, at least 1 module required

BAM – Base module with 2 analogue and 2 trigger inputs, scalable in modular form

OPD – Operating data recording module, optional

DIM – Digital-in-module, optional

MUX – Multiplex unit, optional

Technical parameters for the basic system	BAM – Base module, maximum 7 modules (synchronous) per COM
	2 vibration channels, synchronous; 24-bit resolution; sampling rate between 3.2 kHz and 192 kHz; DC – 75 kHz bandwidth per channel; input voltage ranges ±10 mV (SNR > 60 dB), ±20 mV (> 65 dB), ±50 mV, ±100 mV (> 75 dB each), ±200 mV, ±500 mV, ±1 V, ±2 V, ±5 V, ±10 V (> 85 dB each); DC or AC link with 75 Hz or 150 Hz high-pass filter; optional add-on +5mA ICP current source, signalled via LED, ICP error signalling via LED (sensor short-circuited, no sensor connected)
	2 rotational speed channels, 10-bit resolution, 48 MHz sampling rate, input voltage range ±42V; DC link; 6 kHz, 60 kHz and 20 MHz low-pass filters; TTL output; adjustable trigger thresholds and trigger skirts, LED status indicators
	COM – Communications module Ethernet interface, 10/100 MByte, UDP, TCP/IP, user-definable; RS 232 output; 8 MByte real time memory
Technical parameters for optional modules	OPD – Operating data recording module 8 channels, 12-bit resolution, 230 V AC, voltage-stable; bandwidth 1 kHz (per channel); input voltage ranges ±1 V, ±10 V (SNR > 60 dB); DC or AC link with 20 Hz low-pass filter; LED status indicators
	DIM - Digital-in module 16 input channels, TTL, HTTL, 1000 V AC, voltage-stable; adjustable trigger threshold (8-bit), 3.2 kHz sampling frequency; LED status indicators
	MUX – Multiplexer module 2 times 4 on 1 changeover switch for vibration, rotational speed or operating data channels; paired changeover
Construction	Versions in enclosures for mounting on top hat rails (see photo) or as 19-inch 3HE rack unit; each without fan; dustproof
Power supply, power consumption	19-inch rack unit: 230 V 50-60 Hz Top hat rail version: 24 V, external
	Typically 570 mA for the dual-channel system
Ambient conditions	Ambient temperature: 0 to 40 °C Protection class: IP50/52 (on the front panel, using cover panels over the unoccupied sockets)

ANALYSIS AND EVALUATION FUNCTIONS - SUMMARY

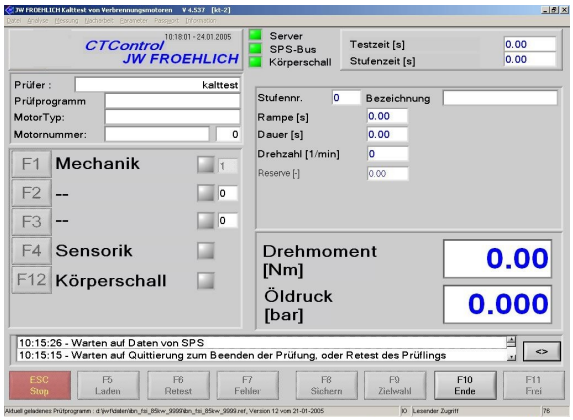
Analysis functions	• Order analysis (max. 800 orders, min. 1/128 order resolution, max. 12,800 order lines, angle-synchronous resampling; linear and quadratic interpolation of the resampling points), any number of virtual reference shafts • FFT analysis (max. 32,768 lengths) • Individual, cumulative, harmonic and range levels, together with their level responses (either by order or by frequency, time, rotational speed or operating cycle) • Synchronously averaged time signal • Envelope via Hilbert transformation • Window functions (Hann, Taylor, Rectangular, etc.) • Crest factor, performance, mean value, variance, dispersion, minimum, maximum • A-weighting, differentiator (for converting `velocity' to `acceleration' for example) • Ghost order analysis • Rapid shutdown in the event of major errors • Pre-emptive damage detection for continuous run monitoring • Angle recording (if an OT signal is available) • Engine analysis via operating cycle
Evaluation and classification processes	• Tolerance band • Chameleon process (adaptive boundary values) • Diagnostics cursor, dual classifier, neural networks
Display module	• Value, polyline, sonogram, alarm user interface, modulation display
Miscellaneous functions	• Signal flow and viewer configuration • Time varying signal storage (between 0 and 100% of the signals, separately adjustable for different quality grades) • Trigger conditions (measurement phases with START-STOP, time trigger with START + duration or rotational speed trigger) • Calibration (manual or automatic) • Audio playback (WAV files) • Tracking markers • Bound cursor, harmonic cursor, hyperbola cursor • Support for reports • MATLAB support • ASAM interface (ATFX format) • Q-DAS interface • Definition of different user levels • Process and machinery capability • Comprehensive help texts
Measurement computer requirements	• PC with the following minimum specification: 2.5 GHz CPU clock, 8 GB of RAM, 500 GB hard disk, additional Ethernet port for the signal recording device, Windows operating system, Microsoft Office Report Generation package
Languages	German, English, French, Spanish others on request

ANOVIS-LITE, -CHAMELEON OR -PROFESSIONAL.WHICH SYSTEM IS THE RIGHT ONE?

By ANOVIS-Professional, we mean the system configuration comprising the base module, the ANOVIS Analyser and the TeCo. This system configuration can be used to perform online and offline analyses; the signal processing function can be configured and parameters can be assigned to it. Exploiting these opportunities requires intensive system training and familiarity with signal processing.

The ANOVIS-Lite system configuration is based on a different concept. ANOVIS-Lite is an ‘intelligent sensor’, which records and analyses the vibration signals and determines predefined quality characteristics. ANOVIS-Lite, as a measuring facility on the test bench, handles automated signal evaluation and the calculation of measurement curves. This information is displayed and evaluated via the measurement or control software installed in the test bench. In-depth knowledge of analysis functions or familiarity with operating the ANOVIS system is not required. Nonetheless, the high-performance ANOVIS signal processing procedure, including order analysis is used.

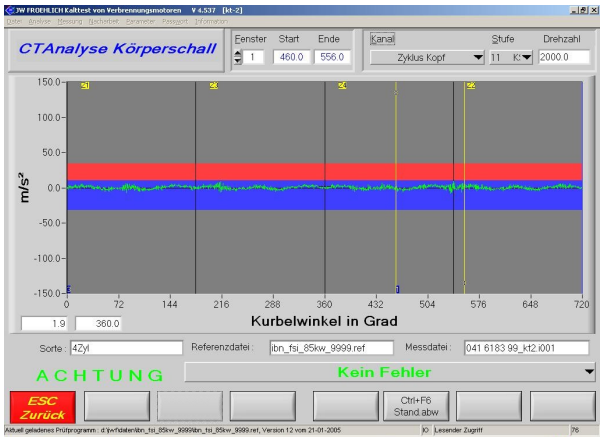
A user of the “ANOVIS-Chameleon” system configuration has the advantages of the ANOVIS-Lite system, in that no need deep system knowledge is required, plus the added benefit that all measurement curves are assessed. ANOVIS-Chameleon calculates measurement curves and automatically applies tolerances (abnormality limits), which it calculates itself and which are optionally adapted and documented. The benefit is the easing of the operator’s burden.



ANOVIS-Professional and ANOVIS-Lite can easily be integrated into the measurement software in the test bench. In the illustration shown on the left, the structure-borne analysis is integrated as a test module into the existing test sequence. The operator has the option of displaying additional information about the structure-borne noise test. With ANOVIS-Professional, the ANOVIS user interface is used and with ANOVIS-Lite the software itself provides the display (see illustration below).

With ANOVIS-Lite, the measurement curves and results are displayed using the functions accessible from the software in the measurement computer. This software also specifies the operating and evaluation options for the measurement curves calculated by ANOVIS-Lite. In the illustration on the right, a measurement window is described by the yellow cursor. Tolerance and boundary ranges are marked in blue and red.

We recommend that our clients should use ANOVIS-Lite if they are deploying the automated test function on the test bench but wish to dispense with our special classification processes, such as the Chameleon process. This application is easy and convenient for the operators of test benches. Changes to the analysis functions can be implemented offline via the ANOVIS-Laboratory software and the resultant setup file can be copied onto the test bench.



System overview: ANOVIS-Lite	The ANOVIS-Lite measurement system incorporates a signal recording device (SRD) and basic software. The basic software is installed on a Windows PC. The PC is usually the measurement or master computer on the test bench. If necessary, ANOVIS-Lite can also be installed on a separate PC. The SRD is connected to the PC via an Ethernet link. For each measurement phase, ANOVIS-Lite calculates the predefined quality characteristics. Using the tools introduced into the test bench, the user specifies the tolerances for the selected quality characteristics of a measurement phase and, in test mode, evaluates the relevant characteristics. As far as the factory is concerned, the method of working with the vibration measurement system is identical with the usual 'normal' measurement facilities.
System overview: ANOVIS-Professional ANOVIS-Chameleon	ANOVIS-Professional is a universal analyser that can also be deployed on the test bench for automatic data acquisition and evaluation. The ANOVIS-Professional measurement system incorporates a signal recording device (SRD) and sophisticated analysis, operating and display software. The analysis software is installed on a Windows PC. The PC is usually the measurement or master computer on the test bench. If necessary, ANOVIS-Professional can also be installed on a separate PC. The SRD is connected to the PC via an Ethernet link. For each measurement phase, ANOVIS-Professional calculates quality characteristics and evaluates them. The ANOVIS Analyser functions are used to determine the tolerances and boundary curves. Configuration and parameter assignment of signal flows and viewer displays are supported. ANOVIS-Chameleon uses statistical methods to calculate automatically abnormality limits and to adapt these limits to the process trend. This technique removes significantly the burden from the operator.
Similar hardware and software modules	ANOVIS-Lite, ANOVIS-Chameleon and ANOVIS-Professional utilise the same hardware modules and analysis functions. In automatic measurement mode, the analysis functions are defined and configured via the entries in the setup files. They are executed in the 'Basic Application' system module, which is identical in both systems. Evaluation processes, display options and parameter assignment dialogue boxes are included in ANOVIS-Professional and ANOVIS-Chameleon.
Generating the test specification; ANOVIS-Laboratory system	The test specification is an integral part of the setup, as it contains the information relating to the measurement and test sequence, as well as parameter assignments for the analysis functions. The setup must be accessible in the form of a file on the PC. More than one setup may exist on the PC: depending on the current test specimen, one of them is selected and automatically loaded into ANOVIS. An expert, suitably qualified client or Saab Medav Technologies must compile a test specification. In order to carry out any configuration work that may be required, ANOVIS-Lite users require the appropriate analysis software (the 'ANOVIS-Laboratory-System'). The necessary software components are incorporated in ANOVIS-Professional. The 'ANOVIS-Laboratory-System' is installed on a suitable workstation PC. Once the version-specific test specification has been generated, the user stores the corresponding setups, (for example via the network) on the line-integrated test systems.

ANOVIS-Mobile assists with in-vehicle measurements. The system takes account of operating requirements regarding low weight, long service life and ease of operation. With ANOVIS-Mobile, driving the vehicle and simultaneous measurement by one person becomes a reality.

All the sophisticated and well-proven functions of the ANOVIS-Professional system are accessible in the recording and analysis functionality. Four vibration channels and four rotational speed channels are supported.

The mobile system can be operated via voice control to relieve the driver of a significant workload. Naturally enunciated speech is understood, without any adaptation required on the part of the speaker. A headset with a Bluetooth port is used to input the speech. Selected sets of commands are available while the vehicle is being driven, enabling the driver to perform straightforward operations, such as loading prepared setups, starting and stopping the measurements, selecting viewers and setting markers.

Speech and audio outputs are used to acknowledge operating commands and for the online output of current measurement results, such as marker positions. In this way, the required driving conditions can be obtained specifically and with ease.

ANOVIS-Mobile comprises a notebook (Windows™) and the ANOVIS-SRD-Mobile signal recording device. Both units have independent power supplies.

A headset with a Bluetooth port is required for voice control.

The driver is able to observe the measurement system via remote TFT display located within his field of vision.

Component	Dimensions W x H x D [mm]	Weight [kg]	Current consumption [mA] (typical battery pack endurance)
Notebook	356 x 38 x 256	3	1,000 (4 hr)
ANOVIS-SRD-Mobile	362 x 44 x 266	2.6	1,100 (min. 0.75 hr) [1)]
10.4-inch TFT screen”	251 x 99 x 229	0.75	1,500 [1)]

1) During measurements while the vehicle is in motion, power is supplied from the vehicle’s electrical system. The battery pack in the mobile SRD acts as a bridging function.

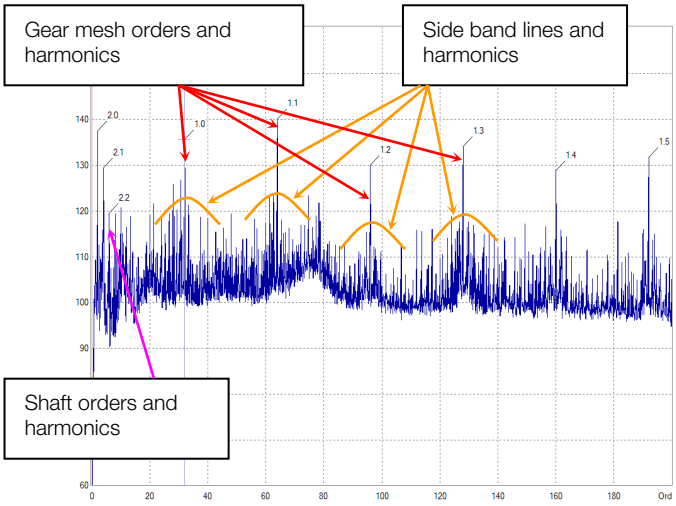
ORDER ANALYSIS – FREQUENCY ANALYSIS SYNCHRONISED WITH RPM

Frequency analysis supports fault diagnostics on rotating machinery. If the shaft of a transmission system is revolving at 3,000 rev/min, the rotational frequency of the shaft is 50 Hz. This is accompanied by numerous additional frequency components that are caused by meshing gear teeth and by bearings. If the rotational speed of the reference shaft changes, the frequencies of these individual components shift according to their step-up ratio to the shaft.

If FFT spectra are then averaged during the changes of rotational speed in order to suppress the noise components, the frequency lines associated with the corresponding mechanical components are blurred. Reliable assignment of frequency line to exciter is no longer possible.

By employing synchronous measurement of the rotational speed, order analysis provides an opportunity to measure the frequency components of the individual exciters regardless of the rotational speed. We use a precise digital resampling process for the order analysis. The method of operation is shown in the box at the foot of the page.

The illustration shows an order spectrum for a typical signal from a transmission system. The order lines caused by meshing gears are clearly shown. Next to these are sidebands that occur at position 1 or in the position of the transmission ratio. These sidebands are particularly valuable for troubleshooting purposes and are calculated at a high order resolution.



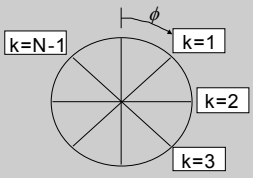
As with the FFT analysis, there are a number of particularly important analysis parameters: the maximum order is dependent on the number of sampling points per revolution, the maximum order resolution is dependent on the number of revolutions of the reference shaft and the window functions employed and the maximum number of order lines is dependent on the FFT length.

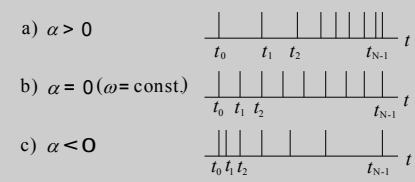
Order analysis can also be performed by externally controlled AD conversion (rpm / rotational speed trigger). In this case very critical rpm variant analogue anti-aliasing filters are required, otherwise significant measurement and analysis errors occur, and a high resolution order analysis cannot be implemented. It should be noted that order analysis is particularly effective in the case of minor variations in rotational speed.

Order analysis

1. Synchronous measurement of rotational speed and vibration signal. The vibration signal is sampled at equidistant time intervals (fixed sampling rate). The rotational speed is measured in the form of tachometer pulses.

2. Calculation of the instants at which the shaft has exceeded an angle increment. For this we use a quadratic interpolation procedure and, in this way, we accurately record constant accelerations of the shaft.





3. Determining the sampling rate for the equidistant-angle support points. To do this, we employ adaptive FIR filters of variable length in order to interpolate the sampling values.

4. Calculation of the FFT on the basis of the interpolated equidistant-angle sampling rate

Saab Medav Technologies is a German company, founded in 1982, with around 85 employees based in Uttenreuth near Erlangen-Nuremberg, and a subsidiary in Ilmenau, Germany. More than 60 engineers and scientists handle projects and design products with the emphasis on the acquisition of information. Digital signal processing and pattern recognition are our core skills. We apply our expertise to solutions in the following applications:

- industrial vibration monitoring and testing technology
- speech recognition
- radio monitoring.
- sensor data fusion systems

The NVH (Noise Vibration Harshness) division concentrates on industrial tasks associated with quality inspection and machinery monitoring, together with related technical design sectors.

We analyse vibrations, which are measured as airborne noise or structure-borne noise.

The highly qualified and experienced engineers at NVH provide support for its clients with a complete range of system technology and services for vibration analysis.

Saab Medav Technologies NVH offers solutions for:

- measurements on 'rotating machinery', including internal combustion engines, transmission systems, electric motors, components with drive mechanisms such as steering support modules, seat structures, air conditioning systems and white goods
- non-destructive component testing on volume production items by means of acoustic resonance testing, for use by forging companies, foundries, sintering companies and producers of ceramics
- process monitoring, for stamping, pressing, hydro-forming, automatic jointing machines and manually or automatically produced cable connectors

Our NVH clients include e.g.:

AMK, AUDI, Batavia Transmissions (FORD), Behr, BMW, Bosch-Siemens-Hausgeräte [domestic appliances], Daimler, Daimler Trucks, Eisengießerei Baumgarte, Fritz Winter, FZG Institute for Machine Elements Gear Research Centre, General Motors/OPEL, GKN, Hirschvogel, Honsel, IMS-Morat, Jopp Automotive, J.W. Froehlich, Krenhof, KWD Karosseriewerke Dresden, MAN, Porsche, Punch Powertrain, Schaeffler-INA, Siemens, Siemens VDO Automotive, Skoda, STIWA, ThyssenKrupp-Krause, ThyssenKrupp-Presta, Toyota, Volkswagen, Weber, ZF Brandenburg, ZF Getriebe, ZF Lemförder Fahrtechnik, ZF Lenksysteme, ZF NACAM, ZF Passau, ZF Transmissions Shanghai

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