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**Siemens PLM Software**

# Simcenter testing solutions for power train engineering

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# Innovative powertrain designs, ever-higher testing demands

Electric powertrains, hybrid engines, start-stop systems and high-tech turbochargers for downsized engines have certainly enhanced fuel efficiency. But this powertrain revolution introduces a variety of new testing issues, including an increased amount of testing for hybrid powertrains that feature more kinds of operations; smaller powertrains that generate much higher torque ripple and torsional vibrations, and transmissions for electric motors that must be optimized for a much wider speed range and will more likely exhibit problems, such as gear whine. All of these issues require fast and accurate solutions.

Practically every powertrain testing team is under tremendous pressure to solve as many issues as fast as possible, preferably all in one test run. To save time designing next-generation powertrains, many teams are turning to advanced Simcenter™ testing solutions for noise, vibration and harshness (NVH), torsional vibrations acoustic and performance engineering. Versatile, intuitive and fast, Simcenter testing solutions for powertrain engineering from Siemens PLM Software give engineers the right tools to solve next-generation powertrain issues.
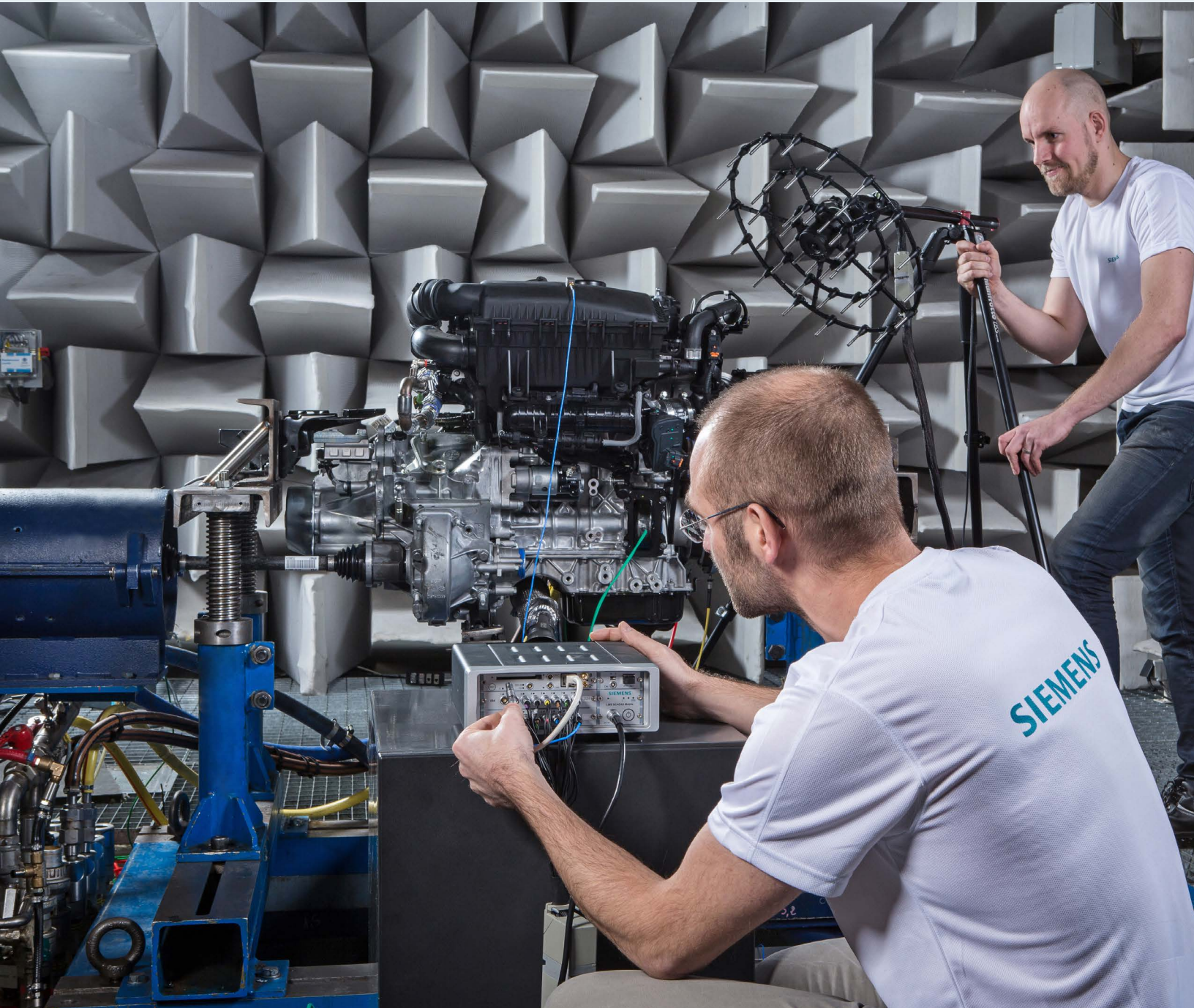
# A complete, intuitive and versatile multi-attribute NVH testing solution

With a completely integrated hardware and software solution dedicated to powertrain engineering, Simcenter testing solutions for powertrain engineering provide in-depth insight without making compromises on ease of use.

Measuring all attributes from the same Simcenter SCADAS™ hardware and processing them with a common Simcenter Testlab™ software platform is an incredible asset for NVH engineers. You do not lose time with cumbersome data exchange between different software packages. All sensors are perfectly synchronized by design. All data is available on a common software platform for real-time or offline post processing and reporting.
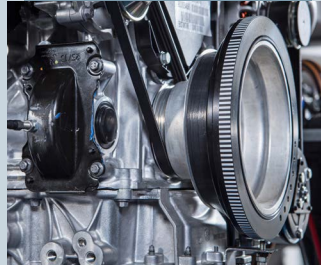
Simcenter testing solutions offer a unique combination of testing efficiency and versatility on a single tool. We offer you a complete engineering solution for:

- Fast, accurate and semi- or fully-automated operational NVH testing

- Multi-attribute functional performance testing, allowing you to test attributes such as torsional vibrations of rotating shafts, real-time combustion analysis, access to digital buses and balancing of drivelines shafts during the development of the powertrain

- Acoustic powertrain testing and analysis: you can acquire the sound power according to either International Organization for Standardization (ISO) or in-house standards. Sound quality metrics are provided to quantify the loudness, roughness and tonality. A wide range of acoustic source localization techniques are provided, including sound intensity and acoustic arrays

- Testing for improved simulation: front-load data into the simulation process to provide test-based load input data for 1D- or 3D-simulation models, as well as for validation of these models

- Powertrain integration without compromising on NVH or comfort thanks to a wide and scalable range of solutions, including transfer path analysis (TPA) and in-field NVH testing

- Component vibration testing to validate the durability and performance of components under tough conditions, replicating real-life loads
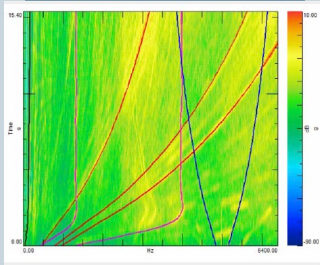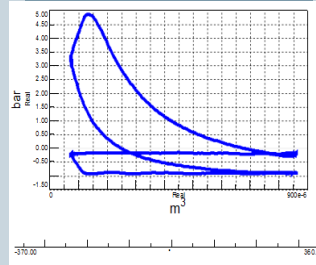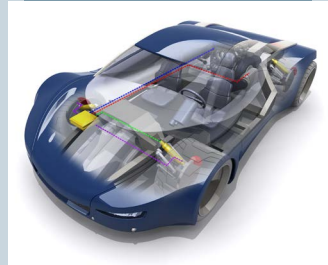
| NVH analysis | Torsional vibration analysis | Online angle domain/ combustion analysis | ECU communication CCP / XCP |
|---|---|---|---|



**Simcenter SCADAS hardware and Simcenter Testlab software**

Because the engine control parameters and engine combustion performance directly impact NVH, being able to measure additional information using one hardware and one software solution is a huge asset for any NVH engineer:

- Simcenter SCADAS hardware combines the functionalities of four separate systems used on the powertrain test bench into one data acquisition system

- Simcenter Testlab software combines general NVH, torsional vibration, combustion analysis and ECU communication within one solution

# Optimize your operational NVH testing productivity

A major part of powertrain NVH testing consists of operational behavior assessments. For instance, measurements in the function of rotational speed and torque enable you to capture the full signature of a test specimen. Often a standard step in the development process, such as in the context of target setting or validation, these tests tend to be fixed and repetitive. Not surprisingly, the top priority is to be able to blindly execute these tests.

Simcenter SCADAS hardware and Simcenter Testlab signature testing software provide you with a unique integrated platform for fast, reliable, accurate and repeatable operational NVH measurements.

Simcenter SCADAS offers a scalable, high-performance hardware platform that provides all the signal conditioning required for powertrain testing. With its unique workflow-based interface, Simcenter Testlab sets new standards for ease-of-use, productivity and data consistency. The software guides the user through the steps of a test campaign, suggesting optimal settings for measurement and analysis. A template-driven approach allows performing often-repetitive tasks in a semi- or fully-automated way from setup to report.

The seamless integration of Simcenter Testlab software with Simcenter SCADAS hardware accelerates measurement setup, and delivers maximal performance while enabling optimal data quality.

## Simcenter SCADAS: taking efficiency to a higher level

There is an Simcenter SCADAS data acquisition and signal conditioning system to match your exact requirements: from extremely light pocket-size data acquisition systems for low-channel field recording to battery-operated, fan-less mobile units and autonomous smart recorders, to high-channel-count laboratory systems that are ideal for use in a test bench control room.

Simcenter SCADAS systems are versatile, all-in-one multitaskers that can handle all types of applications. Thanks to its versatility, you can connect any type of input sensor for powertrain testing. Default voltage and integrated circuit piezoelectric (ICP) conditioning allow measuring anything from acceleration or sound pressure to voltage. Additionally, with charge-based, bridge or coder input conditioning you can customize test setups to suit your wishes. All data on the engine control units (ECUs) can be acquired through controller area network (CAN) bus and Flexray input modules in parallel with other inputs.

Using Simcenter SCADAS hardware advances reliable, high-quality, accurate signal processing. It provides you with 24-bit analog to digital conversion (ADC) technology, a 150-decibel (dB) dynamic range and sample rates up to 200 kilohertz (kHz).

Simcenter SCADAS offers a scalable, high-performance hardware platform that provides all the signal conditioning required for powertrain testing:

- Voltage
- Current
- Vibration (ICP or charge)
- Sound pressure
- Pressure
- Binaural
- Speed
- Torsional speed
- CAN and OBD-II
- FlexRay
- Strain
- Torque
- Temperature
- GPS
- Video, etc.

## Simcenter Testlab Signature Testing: built-in productivity

Simcenter Testlab Signature Testing enables you to acquire accurate rotational speed and angular position data. It is a solution for obtaining operational data for any rotating component of the powertrain, and contains unique features that maximize efficiency of repetitive measurements.

A user-oriented workflow guides you through the measurement process: set up, calibrate and validate all connected sensors to your Simcenter SCADAS hardware; process and validate the acquired data in real time, and save user-specific attributes within the measurement. Thanks to a template-based approach, you can define fixed measurement sequences according to company-specific procedures. Templates include measurement settings, predefined user attributes, display layouts and automatic postprocessing and reporting.

Seamless integration with test bench controllers using Simcenter Testlab Windows Automation allows you to automate test sequences without requiring the onsite presence of an operator or test engineer. When repeating test conditions for data averaging, Simcenter Testlab Run Data Averaging and Comparison

Organizer enables you to automatically display and update the average curves between runs. Simcenter Testlab Batch Reporting lets you close the loop with automated reporting of large amounts of data in predefined print formats.

The versatility of Simcenter Testlab reduces the number of test systems required on the powertrain test bench and brings all information together in one system. Not only do you access to any type of NVH attribute, but Simcenter Testlab combines this functionality with torsional vibration, combustion-related data and vehicle-bus data.

## Simcenter Testlab Signature Testing: scalability at hand

Simcenter Testlab features a wide variety of standard processing tools that can be used in real time during the measurement, including waterfalls, octaves, order and frequency cuts, overall levels and sound quality metrics. Simcenter Testlab Order Tracking provides you with laser-sharp order sections and order maps based on synchronously sampled data in parallel with the default fixed sampled data.
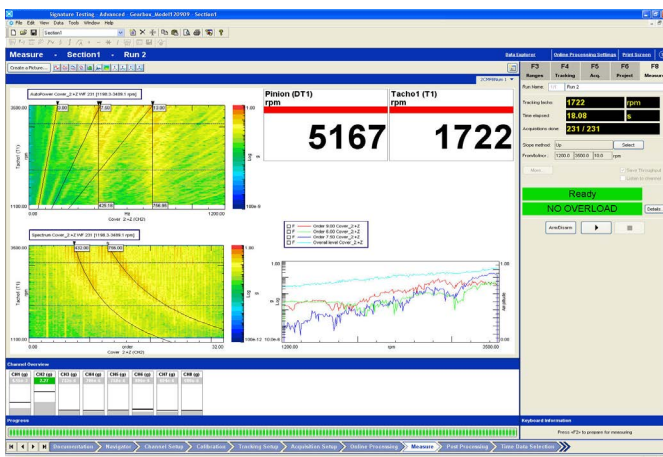


Real-time data processing and validation with Simcenter Testlab Signature Testing.
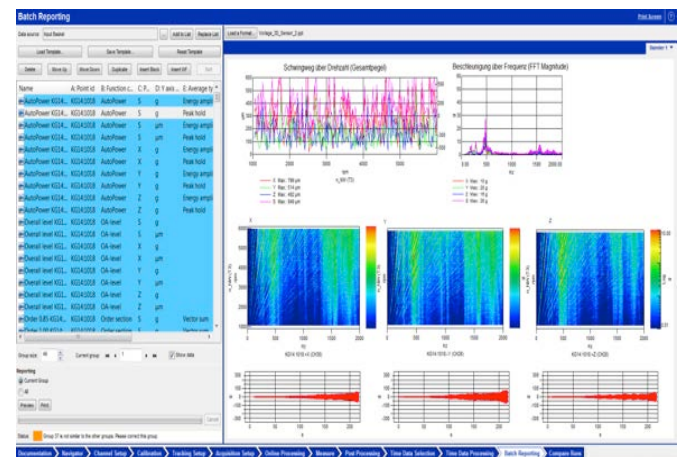


Automatic report generation with Simcenter Testlab Batch Reporting.
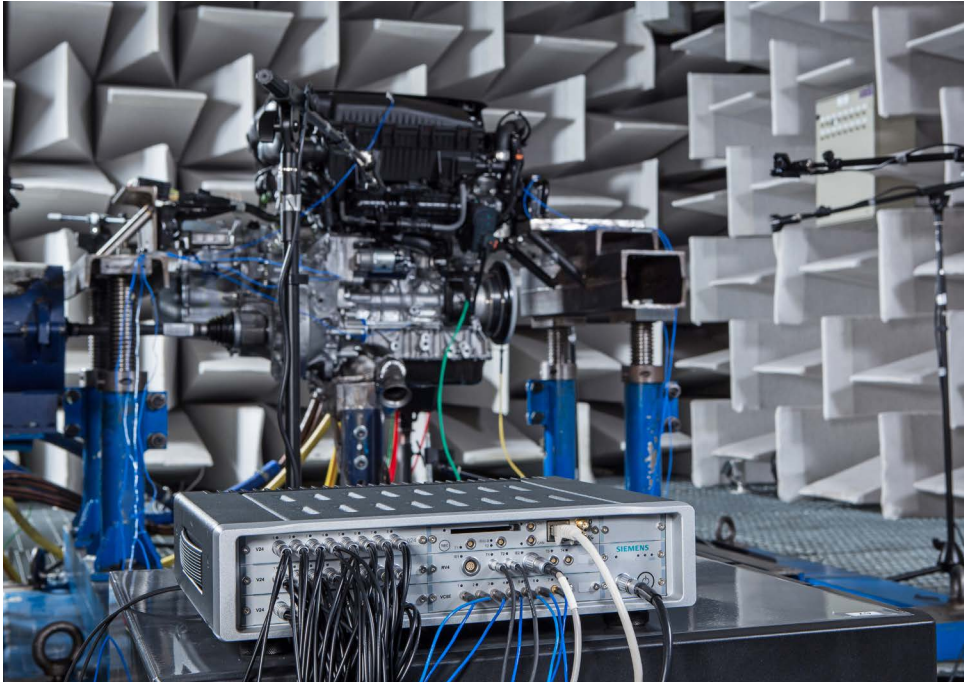
Define your own customized formulas and metrics to cover in-house test procedures such as calculations of sound power from a set of acquired microphones. Any channel available on CAN or Flexray busses connected to your Simcenter SCADAS hardware can be accessed at the click of a button. Simcenter Testlab lets you analyze vibrations of rotating shafts and visualize them with Simcenter Testlab Operational Deflection Shape Analysis. This allows you to gain insight into the deflection of the powertrain or its components, but it can also prove helpful when tracking test setup errors.

With Simcenter Testlab Offline RPM Extraction you can easily extract the rotational speed from acquired microphones or acceleration data. That is most useful when it is difficult or time-consuming to instrument a tacho, such as for turbochargers.
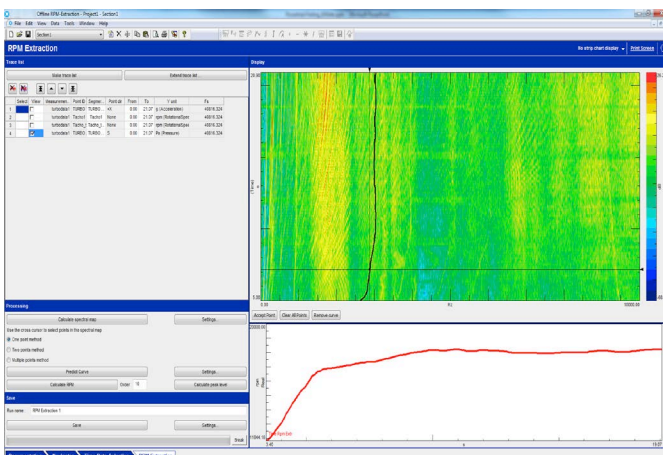


Extract rotational speed without instrumenting a tacho sensor with Simcenter Testlab offline RPM extraction.
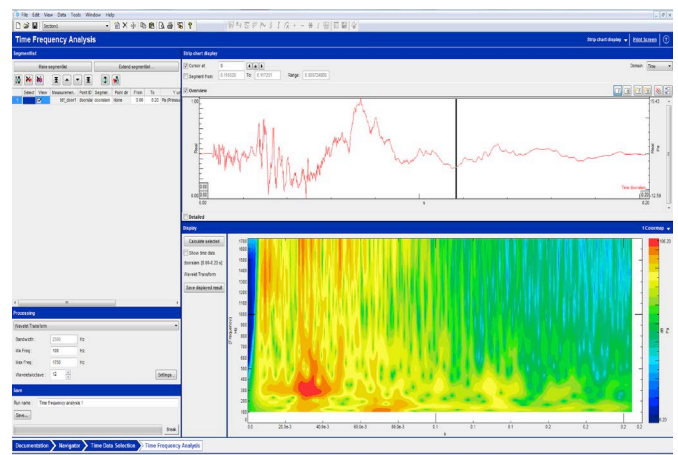


Assess the frequency content during fast transients with Simcenter Testlab Time Variant Frequency Analysis.

# Benefit from early-stage performance testing and advanced engineering

To gain insight into why a powertrain shows certain behavior, you often have to rely on advanced testing and analysis that goes beyond classical operational NVH testing. Simcenter testing solutions for powertrain engineering allow you to test functional performance attributes during the development of the powertrain. There are endless possibilities: from visualizing operational behavior by means of operational deflection shapes and acquiring torsional vibrations of rotating shafts or analyzing real-time signals within the combustion cycle of the powertrain, to performing combustion analysis and balancing the driveline shaft.

### Time variant frequency analysis

For short duration or transient signals, understanding the time-frequency characteristics of the signal is a must. A typical application is the assessment of frequency content of injection system ticking noise signals. The disadvantage of classical fast Fourier transform-based analysis is that it has limited time resolution. Simcenter Testlab Time Variant Frequency Analysis allows you to assess the frequency content of transient signals by means of either short-time fast Fourier transform (FFT) or continuous wavelet transform.

### Shaft balancing

Unbalances can potentially reduce performance and NVH comfort in a vehicle. Simcenter Testlab allows you to tackle this challenge by balancing rotating shafts. Balancing is not only of interest so you can quantify and remove unbalances from the powertrain or driveline. It can also be used to introduce a well-controlled unbalance to assess its impact on NVH performance. Simcenter testing solutions enable you to combine both NVH measurements with the balancing procedures in a single system.

Simcenter Testlab supports both single- and dual-plane balancing to allow compensation for static and dynamic unbalances. An intuitive interface guides you step-by-step through the process of removing unbalances or introducing a controlled unbalance for engineering purposes. And to assess the impact of the modifications you've made, the balancing procedure can be followed by additional operational tests.

### Torsional vibration analysis

Simcenter Testlab Signature Analysis software offers you a complete solution for accurately measuring the torsional variations of single or multiple shafts. Typical applications are the assessment of crankshaft vibrations, torsional dampers or gearbox transmission errors. The software allows you to extract order sections from fixed sampled frequency spectra as well as from data sampled synchronously with rotations per minute (RPM) for watertight order cuts.
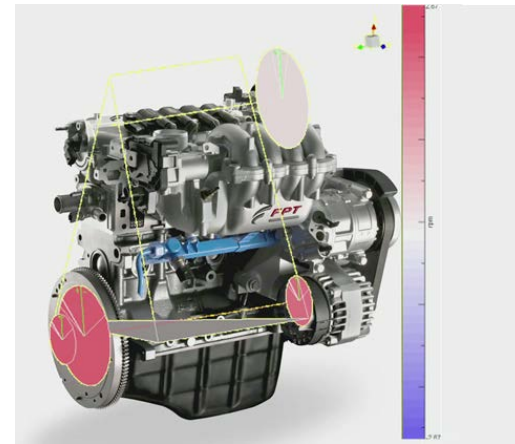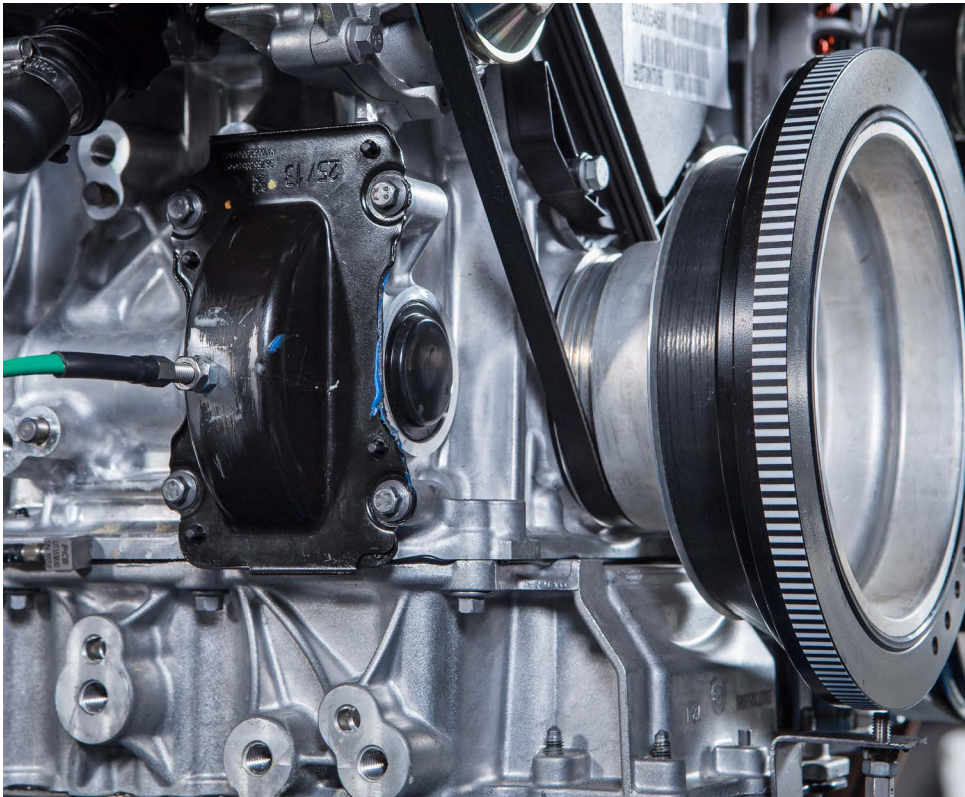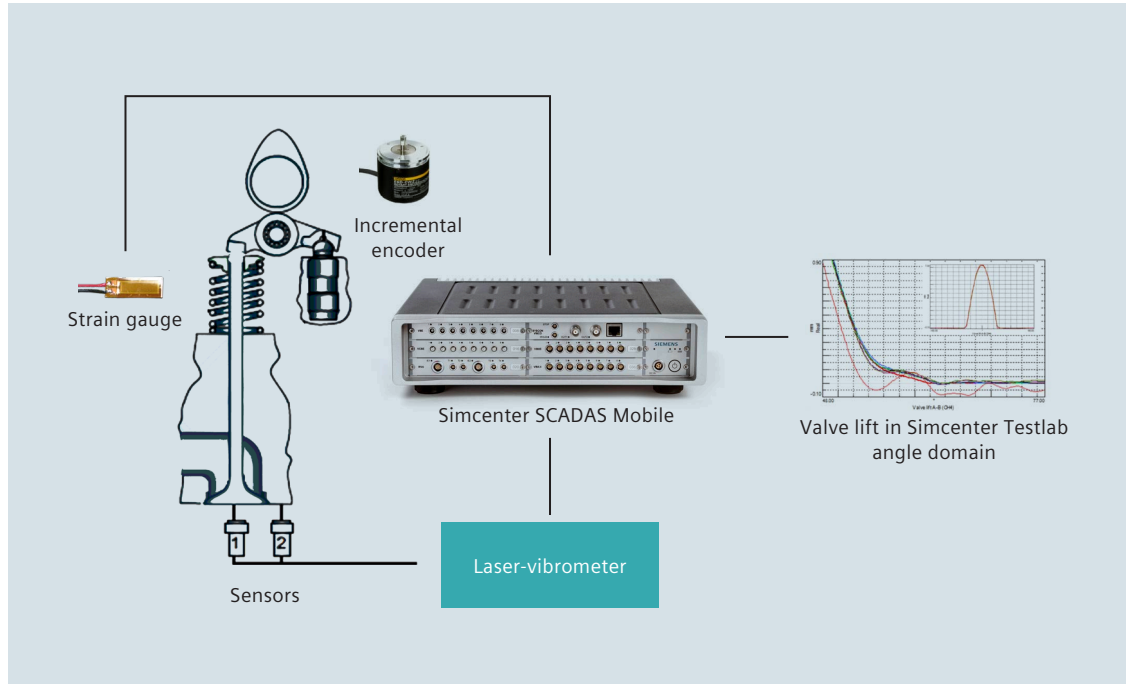
Accurately measure and visualize torsional vibrations for any type of sensor with Simcenter Testlab Signature Testing and Simcenter Testlab Operational Deflection Shape Analysis.

Simcenter SCADAS systems feature two high-performance tacho inputs, including direct current (DC) or ICP power supply for the sensors. Simcenter SCADAS RV4 input modules allow you to increase the number of tacho inputs with four additional inputs each. Different types of tacho inputs are supported up to one megapulse per second, including analog unconditioned pulse streams, digital transistor transistor logic (DTTL) pulse streams or incremental encoders. All tacho pulse streams are translated into angular velocity and displacement time histories that can be further processed in real time or offline.

Simcenter Testlab provides enhanced algorithms for an automatic and reliable correction of pulse train imperfections. This allows you to trace missing pulses, double pulses or butt joint errors of zebra tape. To correlate torsional vibration phenomena with other NVH-related problems, you can simultaneously record tacho channel signals with other data such as acceleration, pressure or strain. With Simcenter Testlab Operational Deflection Shape and Time Animation, you can animate all the phenomena in a geometry model to generate new insights.

Optimize the performance of the engine valve train with Simcenter Testlab Angle Domain.



Strain gauge

Incremental encoder

Simcenter SCADAS Mobile

Sensors

Laser-vibrometer

Valve lift in Simcenter Testlab angle domain

**Valve-train analysis**

Simcenter testing solutions allows you to analyze the valve-train performance in detail. You can easily connect the camshaft's incremental encoder for angular positioning to the Simcenter SCADAS RV4 module. The Simcenter SCADAS VB8 module lets you connect, for example, a laser vibrometer that measures the valve displacement or strain gauges positioned on the valve springs.
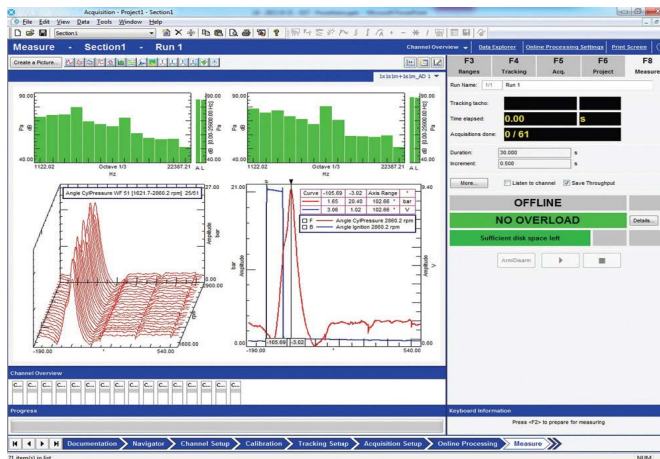


View in real time the combustion parameters, such as p-v diagram in preparation of a sound power measurement with Simcenter Testlab Angle Domain Acquisition.

Simcenter Testlab Angle Domain Processing enables the calculation of all metrics to quantify valve performance. Typical examples include kinematic and dynamic valve lift, velocity or acceleration, valve opening duration, valve bounce and durability-related processing such as Goodman analysis and spring fatigue factor.

### Angle domain testing

With Simcenter Testlab Angle Domain Analysis software you can synchronize and sample data according to the angular position of shafts; for example, the crank shaft angle of the engine in real time and during measurement and postprocessing. This allows you to analyze any measured signal on the powertrain in relation to its timing in the combustion duty cycle. Typical applications include combustion analysis, valve train timing optimization, or analysis of noise related to certain events within the combustion cycle, such as combustion noise and piston slap.

The Simcenter SCADAS RV4 input module lets you connect any coder sensors for measurement of angular positions. It can be freely combined with any other type of input module to provide signal conditioning for additional quantity measurements, such as voltage, charge, ICP, stain or angular velocity.

All acquired signals are digitally resampled toward the angle domain within Simcenter Testlab Signature Testing and Analysis and Simcenter Testlab Angle Domain Processing. You can determine the angular reference either manually or automatically, for instance, by means of a missing pulse on the coder signal or any reference pulse signal. Individually measured channels can have different offsets, which allow analyzing multiple cylinders at the same time. It is also possible to calculate statistical values within each combustion cycle or in even smaller windows or gates within the cycle. And with a broad range of metrics definitions at your fingertips, you can effortlessly set up customized test and analysis procedures.

### Combustion analysis

With Simcenter Testlab Combustion Analysis you can measure engine cylinder pressure within the angle domain and accurately calculate cylinder volumes. You thus gain valuable insights into the performance of a powertrain in addition to classical operational NVH measurements.

You can connect both the cylinder pressure sensor and the coder for crankshaft angular positioning to Simcenter SCADAS hardware. Simcenter Testlab Combustion Analysis automatically removes the drift on the cylinder-pressure sensor due to thermal shocks (pegging). Both the absolute pressure reference and polytropic compression method are supported for this. Simcenter Testlab enables you to visualize the pressure volume (P-V) diagram and calculate the engine mean effective pressure (MEP), including the indicated mean effective pressure (IMEP), pumping mean effective pressure (PMEP) and net mean effective pressure (NMEP). Standard statistical analyses, such as peak-pressure measurement, angle of peak pressure and rise rate, are available and provide the freedom to define more advanced user-specific metrics as well.
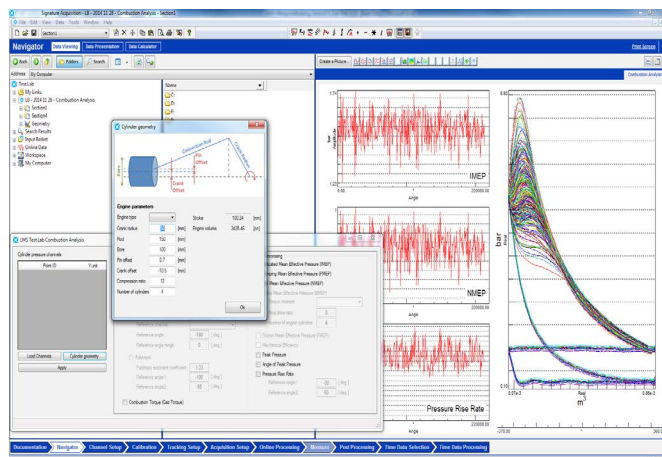


Gain insight into the engine combustion performance with Simcenter Testlab Combustion Analysis.

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# Meeting your acoustic objectives

Simcenter Testlab Acoustics provides highly integrated tools for test-based acoustic engineering, covering acoustic testing domains such as assessment of acoustic power, localization of noise sources and sound quality assessment.

Our solutions fully support powertrain sound power tests based on free-field microphones according to ISO 3745 and ISO 3744 or other in-house standards. Alternatively, you can opt for sound intensity scanning measurements (ISO 9614). Although more time-consuming, this method provides insight into where the sound is being radiated.

Advanced methods include the use of Simcenter acoustic microphone arrays to localize noise radiation. They have the additional advantage of allowing source localization for transient applications and runups. A range of advanced processing tools provide accurate results for a wide-frequency range, produce insight into the sound power of the powertrain and allow for sound-source ranking.

## Sound quality testing

Simcenter Testlab Sound Quality features calibrated binaural sound replay and jury testing as well as a wide range of sound quality metrics to quantify powertrain quality. Since electrified powertrains may produce lower noise levels, but not necessarily boast higher sound quality, these metrics become more important. Supported sound quality metrics include:

- Loudness (ISO 532B) or time varying loudness based on the German Institute for Standardization (DIN) 45631 standard
- Sharpness (DIN 45692, Zwicker, Aures) based on loudness or time varying loudness
- Modulation metrics (fluctuation strength, roughness, modulation maps, etc.)
- Tonal metrics (tone-to-noise, tonality, prominence ratio, pitch, etc.)
- Speech-related metrics (articulation index and speech interference level)
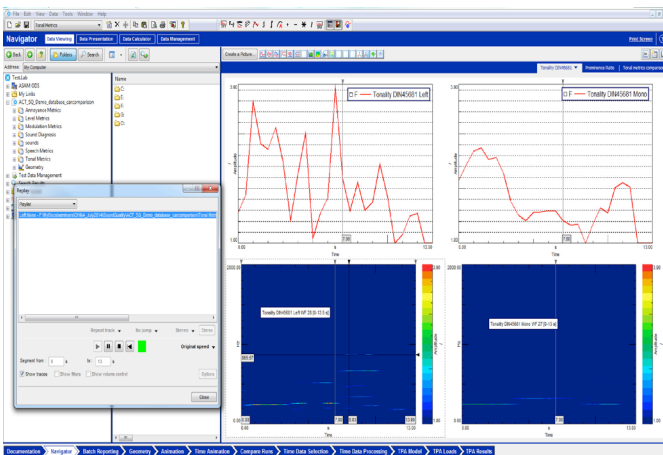


Replay, filter and view data in real time with Simcenter Testlab Sound Quality.
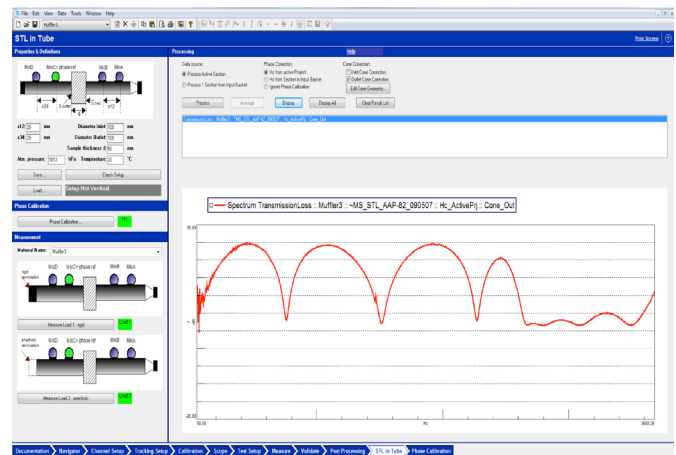


Quantify the acoustic absorption of after-treatment systems with Simcenter Testlab Sound Transmission Loss.

Localize the sound sources in real time with Simcenter Testlab High Definition Acoustic Camera.

## Sound transmission loss

Simcenter Testlab Sound Transmission Loss allows you to measure the sound transmission loss of components, such as exhaust systems, using an impedance tube and four microphones.

**Key highlights**

- Step-by-step guidance through the process

- Support of amplitude and phase calibration

- Noise-free results thanks to superior four-microphone transfer matrix method

- Correction for errors from conical adapters connecting the exhaust to the tube

- Results include sound transmission loss, anechoic reflection, transmission, absorption and acoustic impedance

## Sound source localization

Simcenter Testlab High Definition Acoustic Camera is a highly versatile sound source localization solution. It allows you to localize both stationary and transient sounds, and the advanced algorithms providing detailed results over a wide frequency range make it a powerful tool for use on powertrain and component benches.

**Key highlights**

- Analyze stationary noise and powertrain runups

- Scalable range of arrays to optimize between cost and maximum frequencies (up to 20 kHz)

- Superior dynamic range (>10 dB) over the main frequency range

- Irregular near-field acoustic holography provides high spatial accuracy down to 100 hertz (Hz)

- Quantitative results: sound power calculation for selected zones on the hologram, allowing sound source ranking and comparisons between different measurements

- Reference-based coherence processing for localization of noise coherent to a reference channel

- Noise localization for engine orders

- Separation of noise map into combustion and mechanical noise contributions

# Frontloading key design descisions early in the process

Engineering teams try to get as much work done as early as possible in the development process by means of simulation. This helps to frontload key design decisions so you can design powertrains right the first time.

However, virtual models have no value unless they accurately represent real life. This requires high-quality models and accurate load data.

Direct operational measurements are often required to validate and compare the output from simulation models. Simcenter Testlab offers an extensive range of visualization and processing tools that support fast and easy validation of the data generated by simulation models by means of comparison with test data.

To validate computer-aided engineering (CAE) simulation models, experimental modal models are required. Simcenter Testlab structures solutions provide all you need to derive reliable modal models. They are needed for the validation and improvement of the CAE

models, but can also be used for creation of hybrid models that combine test- and simulation-based modal models as an assembly in Simcenter simulation software.

The Simcenter Testlab rigid body properties calculator allows you to extract essential parameters from frequency response function (FRF) measurements, such as center of gravity, moments and principal axes of inertia when rigid body characteristics are too complex or inaccurate to calculate.

By using Simcenter Testlab Transfer Path Analysis you can derive engine-mount forces, including internal forces within the powertrain, valuable input in as a simulation model.

Simcenter Testlab Structures provides all the tools and functions required for experimental modal analysis. It includes tools to reliably measure FRF sets according to many different excitation methods, such as impact and random excitation (including shaped excitation).



Obtain a crystal-clear stabilization diagram for modal parameter selection with Simcenter Testlab Polymax.
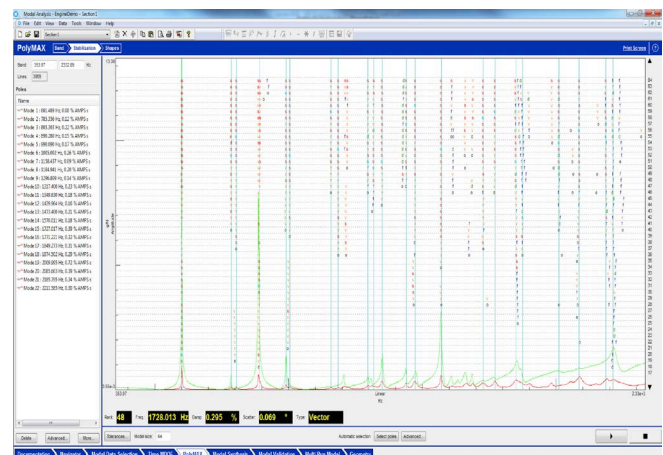
Frontload crucial design decisions thanks to systems simulation.

The self-aligning Simcenter Qsources shakers can be set up in no time for shaker-based excitation, significantly reducing preparation time and increasing accuracy.

Simcenter Testlab Modal Analysis allows you to manually or automatically select modal parameters from a clear stabilization diagram that gives insight into modal parameters of both low- and highly-damped components, resulting in fast and reliable modal models.

**Key highlights**

- Fast, efficient and accurate

- Workflow-based approach

- Geometry-based channel setup avoids instrumentation mistakes

- Wide range of excitation techniques (impact to shaker) for both linear and nonlinear components

- Range of self-aligning Simcenter Qsources shakers for fast and reliable FRF modal acquisition

- Simcenter Polymax for clear stabilization diagram for fast and reliable modal parameter selection

- Wide range of tools to validate and compare modal models, such as macrosynthetic (MAC) matrix

- Direct link to Simcenter simulation software for modal updating of CAE models

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# Integrating powertrains without compromise



Listening to path contributions with Simcenter Testlab TPA Synthesis.
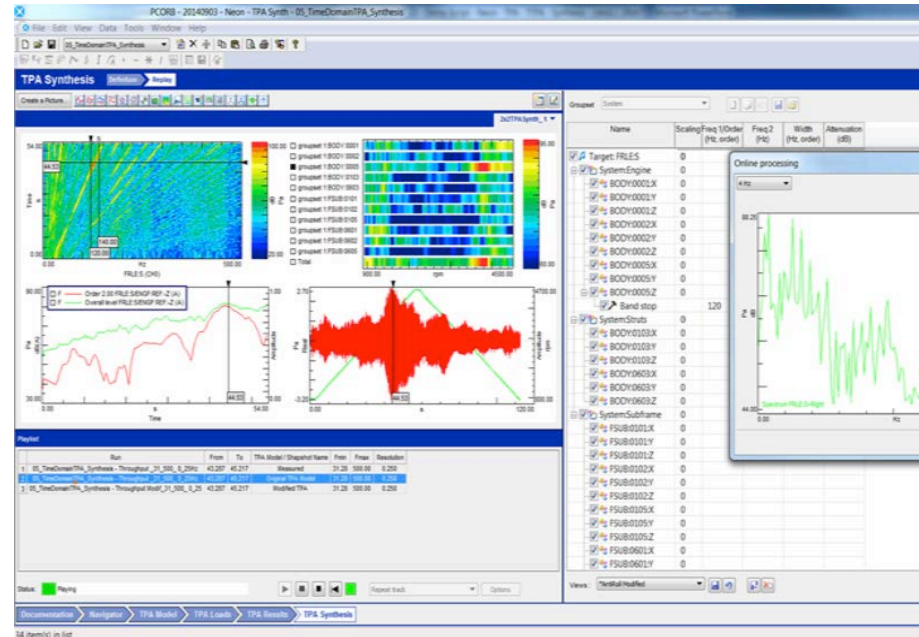
Downsized powertrains generate much higher torque oscillations, which leads to increased seat and steering wheel vibrations. Further, vehicles need to be optimized for transient operations more than ever before, and NVH performance becomes increasingly important during these events. Simcenter testing solutions for powertrain engineering enable you to improve in-vehicle NVH comfort in relation to the powertrain. Not only does this allow troubleshooting, but you can also predict and avoid NVH issues proactively before integration.

**In-field target setting and validation**
Designed to support fast, on-the-spot noise and vibration troubleshooting, Simcenter SCADAS XS is an ideal tool for in-vehicle NVH performance assessments. Simcenter SCADAS XS provides the ideal size and measurement performance for optimal mobility.

- Small enough to fit into a pocket, with battery autonomy up to six hours
- Record with Simcenter Testlab in standalone mode or using a tablet
- Template-based recording

Simultaneously process up to 12 voltage/integrated circuit piezoelectric (ICP) channel inputs, including dual rotations per minute, Global Positioning System (GPS), controlled area network and onboard diagnostics-II, digital binaural head and the Simcenter SCADAS 3D Binaural headset.

### From troubleshooting to root-cause analysis

Simcenter Testlab Transfer Path Analysis provides you with a systematic approach to pinpointing critical, structure-borne or airborne energy paths between powertrain and in-vehicle targets. A wide range of processing techniques safeguard accuracy when test and analysis times are scarce. Transfer path analysis (TPA) breaks down targets into source path contribution; for example, the engine and body contribution. Clear, graphical result displays facilitate the understanding of path contributions. Once the TPA model is built, you can easily modify loads and transfer paths to evaluate their impact on the target.

Simcenter Testlab Time Domain TPA allows you to analyze transfer paths during transient events, revealing individual time contributions for each transfer path that needs to be targeted. For low-frequency phenomena, the use of strain sensors in addition to the classical accelerometer indicators is fully supported.

Simcenter Testlab TPA Synthesis focuses on powertrain noise reduction and allows you to assess the impact of modifications on in-vehicle acoustic comfort. While replaying, you can freely toggle between multiple TPA models, allowing target setting and easy comparison of multiple-design modifications.

### Advanced structural and acoustic exciters for comprehensive noise and vibration testing

TPA requires a large amount of transfer functions to be measured and thus calls for efficient measurement tools. Simcenter Qsources structural exciters allow you to measure TPA functions more efficiently and accurately. They can be used to acquire FRFs, TPA, modal testing or driving point measurements. A choice of different sizes covers virtually any application and frequency range. The shakers are self-aligning, feature high-power density and can be set up quickly as they can be glued directly to the structure even on locations that are very difficult to access.
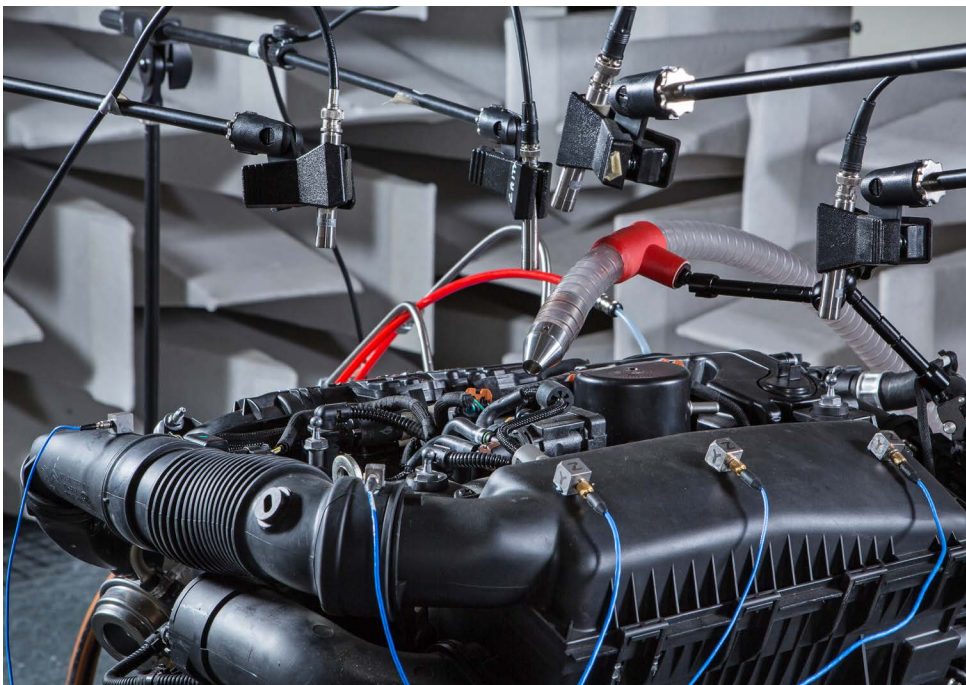


Efficiently and reliably acquire noise transfer functions with Simcenter QSource mid-frequent volume velocity source.



Regardless of location, quickly measure accurate transfer functions with the self-aligning Simcenter QSource miniature shaker.

# Validate component performance with cutting-edge vibration testing

The powertrain and most of its components have to pass a sequence of vibration tests. The exposure to vibratory loads is described in different standards and can involve multiple test scopes such as functional or endurance tests. Simcenter Testlab Dynamic Environmental testing supports all required excitation techniques. In addition, it provides you with the capability to define your own testing profiles and specifications.

### Complete solution for shock and vibration testing

Simcenter Testlab Dynamic Environmental Testing software supports both single and multi-axial vibration testing. Advanced, real-time control algorithms enable the test item to be subject to the appropriate vibration levels.
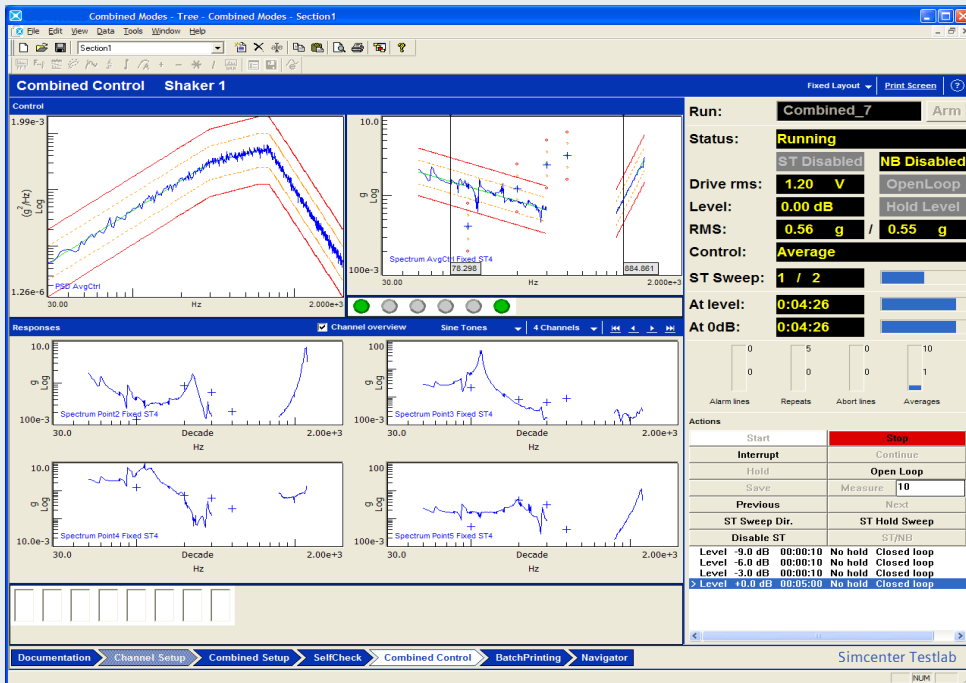
The Simcenter Testlab Random Control workbook enables reliable, accurate and fully random excitation that matches a predefined power spectral density (PSD) profile. You can control the kurtosis of the excitation signal and make lab tests much more representative of operational conditions. The excitation signals (with the given PSD profile) are enriched with peaks or spikes that can be measured in real circumstances and better represent reality.

With Simcenter Testlab Sine Control you can perform reliable sine sweep excitation. Simcenter Testlab Tracked Sine Dwell lets you excite the test subject at a fixed frequency for a certain time or for a specified number of cycles. Any combination of random and multi-sine excitations is possible with Simcenter Testlab Combined Modes.

### From standards-based to tailored testing

Each component experiences dynamic loads differently. Design, materials and different vehicle applications all define a dynamic environment. Make sure that a component is tested according to the right vibration levels by tweaking your own testing profiles with Simcenter Testlab Mission Synthesis. Simcenter Testlab Mission Synthesis allows you to define test specifications for random and swept sine vibration testing from data measured while the component is

Perform reliable and representative component vibration tests with Simcenter Testlab Random Control.

in operation. The resulting test specifications are tailored to the specific case and ensure that the test induces the equivalent of operational life damage in an accelerated way.

Multiple field-recorded acceleration loadings of the component (missions) are analyzed for fatigue by means of maximum response spectrums and fatigue damage spectrums. A new testing profile is derived for vibration testing after extrapolating the fatigue to its total lifetime and applying some safety margins.

Although tests are usually specified and conducted one axis at a time, this is not representative of the reality in which excitation happens simultaneously in all directions. Similar to the multi-poster used in durability tests, with Simcenter Testlab MIMO Random it is possible to perform multi-axis vibration tests in which the specified target is a PSD.

# NVH testing in the age of powertrain electrification



Changing the RPM axis annotation of the waterfall spectrum for a hybrid powertrain is a one-click operation using Simcenter Testlab.
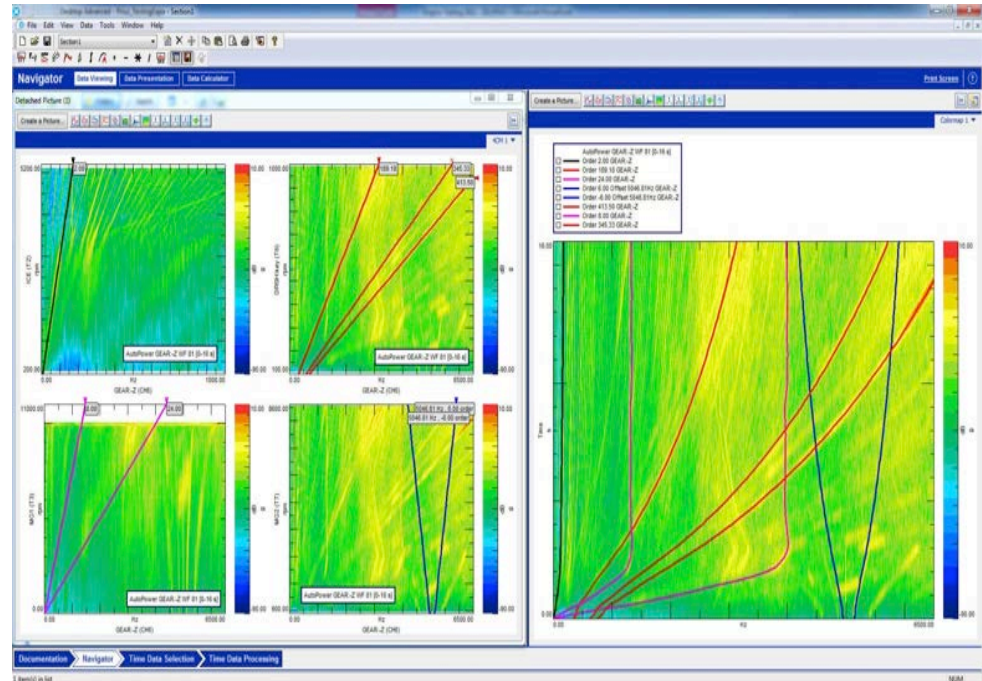
The trend toward hybrid and fully electric vehicles generates new challenges in NVH optimization. Although the sound level of an electric motor is far lower than that of a classical combustion engine, the sound quality is not necessarily better. Electric motors are known to generate a lot more high-frequency tonal sounds, which are perceived as annoying by drivers and passengers. The sound field typically features higher orders and high-frequency off-zero orders generated by the power electronics. Moreover, completely new noise phenomena, such as the noise produced by battery cooling systems, need to be dealt with.

Simcenter Testlab provides the functionality you need to analyze all orders including new, high-frequency off-zero orders. The software supports a wide range of sound quality metrics, some of which are particularly interesting for quantifying the presence of tonal sounds. Typical examples of these metrics are tonality, prominence ratio, sharpness and/or combinations of them.
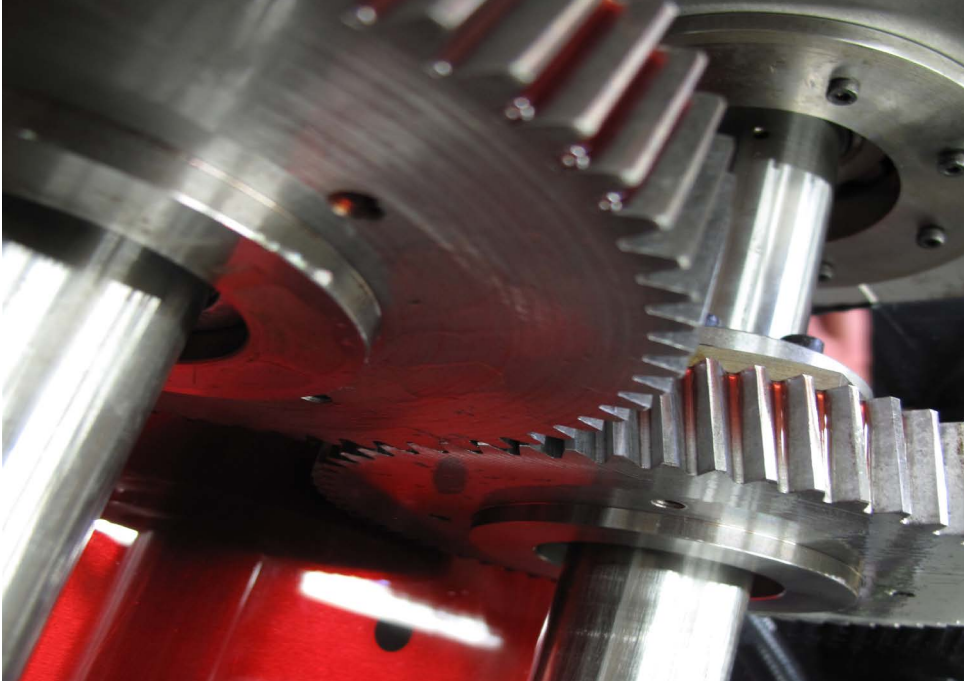
Remove gear whine by accurate transmission error measurements using Simcenter Testlab Signature Testing.

The NVH behavior of hybrid powertrains is in many cases more complicated since it is a result of multiple rotating sources. A parallel hybrid with a power-split device, for instance, consists of a combustion motor running in parallel with two electric motors. This generates many crossing orders and it can prove difficult to link the orders to the correct source. With Simcenter Testlab it takes one click to change the RPM annotation on the waterfall and link the orders to the right source. And with methods such as TPA, you can easily quantify the sound sources from inlet and outlet ducts from the system.

Electrified powertrains have raised the bar for the transmission. Higher rotational speeds can lead to high-frequency whining noise. With Simcenter testing solutions, you can accurately measure and analyze the transmission error and acquire test data to validate and improve simulation models.

**About Siemens PLM Software**
Siemens PLM Software, a business unit of the Siemens Digital Factory Division, is a leading global provider of software solutions to drive the digital transformation of industry, creating new opportunities for manufacturers to realize innovation. With headquarters in Plano, Texas, and over 140,000 customers worldwide, Siemens PLM Software works with companies of all sizes to transform the way ideas come to life, the way products are realized, and the way products and assets in operation are used and understood. For more information on Siemens PLM Software products and services, visit www.siemens.com/plm.

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