LMS Test.Lab Structures
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Straight-to-the-point structural engineering
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Structural testing used to be a long and complex process involving quite extensive trial-and-error and time-consuming test setups. This is no longer the case. With LMS Test.Lab Structures and the LMS SCADAS system, test engineers perform large-scale modal surveys in hours rather than days. They can focus on identifying root causes of vibration problems and apply powerful analysis tools to explore the best solution for practically every structural weakness. Renowned for its modal testing experience – from impact testing of small structures to large-scale campaigns using hundreds of measurement channels, LMS continues its tradition of cutting-edge expertise and maximal testing efficiency with LMS Test.Lab Structures.

From troubleshooting to virtual model validation...

Structures are test-characterized for many different reasons using methods of varying sophistication and complexity. Engineers can quickly pinpoint and correct a vibration problem by simply identifying structural resonances and dominant forcing mechanisms, or by plotting the structural deformation pattern at a specific frequency. To really understand the structural dynamics in detail, engineers turn to modal analysis to characterize measured force inputs. These modal models can be used to validate and update existing finite element models or used directly as the basis for design modification or multi-attribute studies.

...covered in an integrated testing solution

Since every testing department works differently, LMS Test.Lab Structures offers a fully scalable solution and covers the broadest application scope. Highly flexible, LMS Test.Lab Structures is suitable for a wide variety of applications and differing levels of expertise. So whether a structural dynamics expert needs to make an in-depth review of a system’s structural behavior or a new operator needs to set up a basic test, every LMS Test.Lab Structures user will be able to get the right results to answer mission-critical questions – exactly on time. Testing departments can fully protect their system investment, as LMS Test.Lab Structures can easily be expanded and tuned to their changing needs. Starting with impact testing, users can extend their solution with modal analysis, MIMO testing or operational modal analysis capabilities.

Designed for testing efficiency

Minimal test preparation time

Especially for high channel-count structural tests, the actual measurement time is minimal compared to the preparation time. That’s why LMS Test.Lab Structures offers various time-efficient shortcuts in setup preparation, like customized patch panels, direct data reading from TEDS-enabled sensors, notification of an ICP channel open-circuit condition or troubleshooting tools for cabling and sensor problems.

“It is designed to significantly reduce required test time so technicians and facilities can work much more efficiently – a vital necessity with hyper-speed product development cycles.”

Rapid geometry definition

Test engineers rely on animated mode shape displays to review test results and draw first conclusions from their test campaign. But reliable and informative mode shapes require correct wire frame models. LMS Test.Lab Structures offers different ways to create these wire frame models in the most efficient way. You can define your geometry via Excel-like tables, import geometry via UFF, LMS CADA-X, CAD or FEA, copy/paste geometry information from Microsoft Excel, or create your model from stored TEDS transducer geometry information. Alternatively, LMS Test.Lab Structures helps you measure geometric coordinates with a hand-held probe or through digital photographs.

Step-by-step guidance

LMS Test.Lab Structures guides users though the entire measurement process with clear-cut control parameters and automatic online displays. LMS Test.Lab Structures can suggest valid test setup parameters as well as handle customized or company-specific templates. This workflow guidance lowers the threshold for technicians and occasional users, guarantees measurement consistency and overall process efficiency.

Modal analysis made easy

A step-by-step guide

LMS has translated the formerly complex modal analysis process into a logical sequence of experience-proven steps, each embedded in a dedicated LMS Test.Lab worksheet. Through its workflow-based user interface, LMS Test.Lab helps users capture the right type of test data – from modal parameter calculation to analysis validation – faster and easier than ever before.

Mode shapes in a few simple steps

LMS Test.Lab Structures handles the three main modal analysis steps in an automatic way. LMS Test.Lab automatically collects all relevant test data while the user selects a frequency range for analysis. Then,
with a single mouse-click, the system poles are determined using a curve-fit in that frequency range. After that, the system calculates the mode shapes associated with all physically significant poles, including global residues and all modal coefficients.

**The right results - right from the start**

High-quality results have never been so easy to obtain. Users just select the measurements, run the analysis and view the results. That’s it. A single page summarizes all the curve-fits so that any user can easily check that the animated shapes, identified frequencies and damping factors accurately reflect the analyzed structure.

**Achieving the best possible data quality**

**Immediate operator feedback**

High-quality impact measurements require technicians to really concentrate on hitting right: striking the right point, in the right direction, not too hard, not too soft. LMS Test.Lab Structures makes the job as comfortable as possible. The system gives audio feedback on triggering, overload or completed measurements. It automatically rejects overload and double impact, auto-saves valid measurements and automatically increments measurement point IDs. For shaker tests including MIMO FRF measurements, simply push the start button - the system does the rest.

**Measurements you can trust**

Before tearing down the test setup, you need to be sure that all the collected measurements are correct and complete. With built-in checklist and self-check features, LMS Test.Lab Structures practically eliminates the risk of having to redo the test. LMS Test.Lab Structures lets operators inspect large sets of measurement data very efficiently. To guarantee data set completeness, the system highlights missing points and points with input overload. LMS Test.Lab Structures provides complete data annotation for maximum traceability. It stores the complete measurement setup with the measured results. Users can attach digital pictures of the setup details to the measured data, and add personal notes made during the test.
No barriers between acquisition and analysis

LMS Test.Lab Structures can run operational deflection shapes or modal analysis in parallel with the acquisition, providing preliminary modal results while the test is taking place. This helps validate data quality and creates valuable insight on the spot. Mode animation immediately reveals missing measurements, inverted sensor direction, an accelerometer that fell off, or incorrect calibration values. Preliminary mode shapes can show where additional measurement points are required for better resolution, or point to the need for different or additional excitation sites.

Time-saving advanced techniques

For large and complex structures with high damping and/or low response levels, traditional excitation techniques fail to inject sufficient energy into the structure and result in poor quality and noisy FRFs. In these cases, LMS Test.Lab MIMO Swept Sine Testing provides the high-level sinusoidal excitation and the high signal-to-noise ratio required to accurately measure these low response levels, together with the measurement speed of a broadband test. LMS Test.Lab MIMO Stepped Sine Testing lets the front-end control the input force for multiple input and multiple output stepped sine excitation. By controlling the input forces, the MIMO stepped sine technique is perfectly suited for investigating nonlinearity and advanced structural characterization.

No compromises for the expert

Experts appreciate LMS Test.Lab Structures’ arsenal of state-of-the-art parameter estimators that can solve even the toughest structural puzzles.

Least Squares Complex Exponential

Least Squares Complex Exponential (LSCE) is the standard (time-domain) pole-fitting method for both single and poly-referenced (MIMO) applications. LSCE is a proven algorithm that deals with a broad range of structures, providing required efficiency for high modal density.

LMS Test.Lab PolyMAX

The LMS Test.Lab PolyMAX modal parameter identification algorithm has revolutionized the modal analysis process for highly damped structures and tests with noisy data. Its outstanding stabilization properties result in a very straightforward modal identification. LMS Test.Lab PolyMAX is commonly used for operational as well as experimental modal analysis.

LMS Test.Lab Automatic Modal Parameter Selection

LMS Test.Lab Automatic Modal Parameter Selection (AMPS), an expert-level modal parameter selection tool, provides guidance for new users and speeds up the pole selection procedure on the stabilization diagram for complex structures. This tool is also used for operational as well as experimental modal analysis.
Advanced validation techniques

Advanced validation techniques include MAC (auto and cross), FRF synthesis and modal mass calculation, as well as stiffness and damping for physical correlations. Once a validated modal model is available, users can quickly try different modifications using simulation techniques. LMS Test.Lab takes the validation process a step further with smart suggestions for the best modification points. The online FRF synthesis of the modified structure really simplifies modification definition eliminating numerous iteration cycles.

Mastering masses of data

LMS Test.Lab Structures is designed to handle massive amounts of data effortlessly in case of large-scale structural tests and multi-test processes. The measurements as well as the analysis results are automatically assembled, making it easy to select the relevant data and to create a reliable modal model of the entire structure. Dedicated data management assures that input FRFs, processing parameters and analysis results remain properly related, minimizing the risk of subsequent misinterpretation.

Simulation-ready structural testing

Using test data to create and validate simulation models requires a broader scope of test parameters as well as a higher degree of consistency. LMS Test.Lab Structures is designed to master both challenges. It provides rotational degrees-of-freedom, rigid body modes and other realistic factors for the creation of an accurate dynamic simulation model. LMS Test.Lab Structures is designed to provide consistent modal sub-models. It offers tools to validate simulation models, including cross-MAC comparisons with experimental observations, orthogonality checks and comparison between computed-generated responses and actual physical shaker tests.
LMS Test.Lab Impact Testing

Impact Testing is ideal for small structures, especially when boundary conditions are seriously disturbed by shaker attachment. While it requires minimum test preparation time, data harvesting is a tedious process. LMS Test.Lab provides a complete modal testing solution from measuring frequency responses to performing modal analysis using impact hammer frequency response function measurements for simultaneous response channels.

Designed for single operator use, LMS Test.Lab Impact Testing supports automatic active channel detection and calibration. During measurements, the software alerts the operator to unusual circumstances; the resulting data set is automatically discarded without operator intervention. Built-in application knowledge quickly defines acquisition parameters such as trigger parameters and FFT-window selection. Auto-accepting averages help the operator take measurements without keyboard interaction, while having a complete view on all data. Seamless integration with the analysis applications provides immediate feedback to validate data correctness.

LMS Test.Lab Impact Testing can be combined with additional LMS Test.Lab applications for faster data interpretation and analysis.

LMS Test.Lab Geometry can quickly generate wireframe and full 3D visualization of test and analysis results. Once a geometry is made, the roving hammer excitation can be driven by the geometry nodes.

LMS Test.Lab Operational Deflection Shapes and Time Animation provides immediate feedback to validate FRF correctness by on-the-spot animation of the geometry model.

LMS Test.Lab Modal Analysis offers various fast and accurate single or multiple reference parameter estimation algorithms, and a complete set of modal model validation tools.

LMS Test.Lab Geometry, LMS Test.Lab Operational Deflection Shapes and Time Animation and LMS Test.Lab Modal Analysis are available as stand-alone analysis environments or as add-ins to LMS Test.Lab Impact Testing, which provides on-the-spot analysis.

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LMS Test.Lab Spectral Testing and LMS Test.Lab Source Control

LMS Test.Lab Spectral Testing and LMS Test.Lab Source Control provide a productive state-of-the-art modal testing solution for structural excitation by up to 16 shakers or by impact hammer. Frequency response function measurements can be performed for simultaneous channels, all supporting ICP® transducers or any voltage signal, and are IEEE-1451.4 TEDS compatible.

LMS Test.Lab Spectral Testing provides dedicated test setups for multiple shaker FRF tests. Automatic active channel detection provides one-man calibration, while the open-loop cable check and built-in digital scope troubleshoot defective cables and transducers. Specific test setup validation tools perform excitation level balance checks and input force de-correlation validation, while online reference curves help compare current measurements with previous ones or targets. A comprehensive tabular overview of measured FRFs and coherence functions overlays the selected functions automatically in the display while the corresponding measurement points can be highlighted on a geometry wireframe. Missing points and points with input overload during testing can be also automatically highlighted on a geometry wireframe.

LMS Test.Lab Spectral Testing and LMS Test.Lab Source Control can be combined with further LMS Test.Lab applications for faster data interpretation and analysis.

LMS Test.Lab Geometry provides fast wireframe generation and full 3D visualization of test and analysis results. Through TEDS support, geometry creation is further accelerated with the position information from pre-programmed TEDS transducers.

LMS Test.Lab Modal Analysis offers various accurate single or multiple reference parameter estimation algorithms, and a complete set of modal model validation tools. With the clear stabilization diagrams from the LMS Test.Lab PolyMAX parameter estimation algorithm and the automatic modal parameter selection, the analysis process is simplified and operator-dependency of the resulting modal model is eliminated.

Features
- Permits structure excitation by up to 16 shakers in parallel
- Checks the de-correlation of excitation inputs online
- Measures multiple responses in parallel
- Helps compare driving point FRF, point mobility and dynamic stiffness with online reference curves
- Immediate visualization of FRF measurements on a 3D geometry

Benefits
- Reduced test setup time and minimal operator training
- Reduced measurement time and optimized test item availability through high channel count, multiple excitation DOF and on-the-spot analysis and validation
- Immediate measurement validation and analysis guarantee reliable data and results
- Effectively deals with highly damped structures and nonlinear materials
- Easy traceability with full documentation, data management and reporting

Online reference curves help compare driving point FRF, point mobility and dynamic stiffness.

Immediate measurement validation and analysis guarantee reliable data and results.

Calibration includes automatic active channel detection, open-loop cable check and built-in digital scope to troubleshoot defective equipment.

The scope function helps verify the setup before acquiring data.
LMS Test.Lab Operational Deflection Shape and Time Animation

LMS Test.Lab Operational Deflection Shape and Time Animation provides both mobile and lab solutions to measure and visualize the structural deformation of any test item under operational load. The animated vibration patterns can be analyzed as time-history, or at selected frequencies for different load conditions or tracked against rotational speed or any operational parameters. The solution is seamlessly integrated with other LMS Test.Lab acquisition solutions for gathering time or spectral data during stationary, pseudo-stationary or transient operating conditions, avoiding time consuming data conversion and reducing user errors by making the analysis tool also available as a data validation tool.

Time histories for all channels are directly written to the PC hard disk, in parallel to the online spectral processing, with a throughput performance independent of channel count, acquisition bandwidth or online processing.

LMS Test.Lab Operational Deflection Shapes and Time Animation provides easy navigation and data selection. All data types permit immediate analysis through geometry model animation: scrolling through the time axis like a slow motion camera or highlighting behavior at specific frequencies like a stroboscope. Any analyzed vibration pattern can be stored for future detail analysis or reporting purposes.

LMS Test.Lab Operational Deflection Shapes and Time Animation can be combined with further LMS Test.Lab applications for faster data interpretation and analysis.

LMS Test.Lab Spectral Testing helps define channel and acquisition parameters and multi-reference spectral processing functions. In all stages, the user receives feedback on the parameters defined for maximum validation of the test setup before the actual testing starts. During the measurements, any processing function can be monitored online and combined with any reference curve on the same display.

LMS Test.Lab Standard Signature Testing measures and processes stationary and tracked spectral data and enables repetitive measurements from a pre-defined template in which layouts and measurement settings are specified. Narrow band spectra are acquired during run-ups, run-downs or sequences of both, at user-controlled time or rpm intervals, or may be averaged during stationary operating conditions. Online processing and visualization cover different formats.

### Features
- Real-time monitoring of the acquisition progress
- Animation of 3D geometry from all angles
- Easy scroll through axes using "movie" or "stroboscope" displays at fixed operating conditions
- Deformation pattern recording at critical time and/or operating conditions
- Seamless test analysis integration with optional simultaneous analysis tools

### Benefits
- Provides effective and reliable laboratory or in-field data analysis
- Reduces calibration and orientation errors and increases productivity through on-the-spot validation and analysis
- Fast visual diagnosis with 3D animations
- Fast standard reporting with "single button" operation
- 3D animation of time data provides increased engineering insight in transient vibration behavior.
- Online feedback on measurement progress and quality.
- Stationary data is brought to life by animating the geometry immediately after the run to visualize what is really happening.
- Fast diagnosis with visualization of deformation at peak levels and most critical operating conditions.
LMS Test.Lab Modal Analysis

LMS Test.Lab Modal Analysis offers various fast and accurate single or multiple reference parameter estimation algorithms. The FRFs are gathered and automatically organized to give a comprehensive view of the available data and facilitate FRF selection/de-selection. Various sum and mode indicator functions help stabilization diagram interpretation and pole selection. The solution offers a complete set of modal model validation tools. The scrolling FRF synthesis automatically synthesizes FRFs and updates displays, without any user interaction, for fast and in-depth modal model validation.

LMS Test.Lab Modal Analysis provides all the tools and functions required for experimental modal analysis. It includes tools to easily create FRF sets, perform modal parameter estimation in a fast and easy way on these FRF sets, validate the modal model using different methods and compare the original FRFs with synthesized ones. A worksheet-by-worksheet procedure guides the user through the basic steps.

For multiple patch measurements, the multi-run modal analysis provides an easy method to solve potential data inconsistency issues between patches. Multi-run modal analysis provides a dedicated processing of modal test data that was obtained through different sets of measurements. This acquisition technique is widely applied when a limited set of accelerometers needs to be relocated to measure all response points of the structure. In such a case, FRF inconsistencies could affect the modal parameter estimation quality. Multi-run modal analysis automatically accounts for potential data inconsistency between runs when extracting modal frequencies and damping as well as during the subsequent mode shape calculation.

For complex structures, LMS Test.Lab PolyMAX provides a state-of-the-art modal parameter estimator and expert-like automatic modal pole selection (AMPS) facility. Combination of these tools provides fast and user-independent results. LMS Test.Lab PolyMAX is available as an add-in to LMS Test.Lab Modal Analysis.

**Features**
- Analysis data in acceleration, velocity and displacement format
- Calculate/show sum of FRFs and mode indicator function such as CMIF
- Modal parameter estimation based on LSCE method in 3 steps
- Automatic damping value correction when FRF measurements use exponential window
- Wide range of validation tools such as modal assurance criterion, modal phase collinearity, mean phase deviation
- Data inconsistency rectification with multi-run modal analysis

**Benefits**
- Complete solution for modal analysis, optimized for ease-of-use
- State-of-the-art modal parameter estimation delivers clear stabilization diagrams, reducing complexity of pole selection and number of processing iterations
- Yields user-independent modal models

The software offers a powerful acquisition and analysis solution for both novice and experienced users.

The geometry workbook provides full 3D visualization of test and analysis results.

Through crystal clear stabilization diagrams, the structural analysis of a printer is simplified.

The software provides a wide range of validation tools such as modal assurance criterion.
LMS Test.Lab Operational Modal Analysis

LMS Test.Lab Operational Modal Analysis provides an in-operation testing solution for modal parameter identification, starting from user-selected segments of time data measured on a structure in operating conditions. Time histories are measured with the LMS Test.Lab Parallel Time Recording option of acquisition applications. Any subset of this time data can be used as a reference for the operational modal analysis to obtain optimal reference locations of all excited modes. The hardware configuration can be adapted for either in-vehicle tests or tests of large objects such as bridges, buildings and airplanes.

Time histories for all channels are directly written to the PC hard disc, simultaneously with the online spectral processing and a throughput performance independent of channel count, acquisition bandwidth, or online processing.

LMS Test.Lab Operational Modal Analysis extracts modal parameters from response time measurements and further provides a modal model validation tool set, data synthesis and mode shape visualization. The solution offers a convenient overview of all input time histories, and helps easy selection of specific data segments.

LMS Test.Lab Operational Modal Analysis can be combined with other LMS Test.Lab applications for faster data interpretation and analysis.

With the clear stabilization diagrams from the LMS Test.Lab PolyMAX parameter estimation algorithm and the automatic modal parameter selection (AMPS), the analysis process is simplified and operator-dependency of the resulting modal model is eliminated.

LMS Test.Lab Spectral Testing gives feedback on defined parameters, with maximum validation of the test setup before the actual testing starts. During measurements, any processing function can be displayed and monitored online, while additional information such as rotational speed can also be checked.

When performing operational modal analysis on structures with rotating components, such as helicopters or rotating machinery, component harmonics could influence the test results. With the LMS Test.Lab Harmonic Removal add-in, the harmonic contents from the time data can be filtered out.

LMS Test.Lab Operational Deflection Shapes and Time Animation, LMS Test.Lab Operational Modal Analysis and LMS Test.Lab Geometry are available as stand-alone analysis environments or as add-ins to LMS Test.Lab Spectral Acquisition.

**Features**

- Online spectral analysis while recording continuous time data
- Cross-spectra analysis
- Embedded test setup definition
- Parameter estimation on any user-selected data segment
- High channel count for high performance

**Benefits**

- ‘Operational’ modal parameters deliver extra information on modes to study resonance changes during operating conditions
- Immediate validation of throughput measurements on screen
- Requires minimal operator training
- Yields user-independent modal model
- Easy traceability with full documentation, data management and reporting

In civil engineering, the dynamic properties of bridges are studied to consider the effects of traffic and wind induced vibration.
LMS Test.Lab MIMO Sine Sweep Testing

LMS Test.Lab MIMO Sine Sweep Testing provides a complete solution for FRF-based modeling of large and complex structures that are difficult to excite with sufficient energy. It uses broadband excitation techniques and its applications range from measuring frequency response functions for path contribution analysis, point mobility measurements of component attachment points to complex stiffness measurements of mounts and bushings.

By exciting the structure with a sweeping sine, LMS Test.Lab MIMO Sine Sweep Testing combines the high signal-to-noise ratio of sine excitation with broadband testing measurement speed. During MIMO testing, multiple sine sweeps with different phase conditions between the averages give correct frequency response functions. Accurate sine extraction results in leakage-free response spectra, while a system identification step prior to the sine sweep helps control excitation levels and increase the dynamic range of the 24-bit A/D converters. Harmonic distortion spectra and excitation level control following a reference profile provide insight into the structure’s nonlinear behavior.

LMS Test.Lab MIMO Sine Sweep Testing is designed to measure the structure’s response at different points to a controlled sinusoidal excitation. The solution offers an intuitive way to define channel and acquisition parameters as well as process functions. In all stages, the user receives feedback on the defined parameters, so that the test setup can be maximally validated before the actual testing starts. A system identification procedure helps determine a first system FRF matrix estimate using periodic random excitation and predicts response levels on all channels for the sinusoidal excitation. During the actual measurements, all relevant information can be displayed and monitored online. A specific validation sheet gives an overview of the measured DOFs as well as their position on the structure.

LMS Test.Lab MIMO Sine Sweep Testing can be combined with LMS Test.Lab Operational Deflection Shapes and Time Animation, LMS Test.Lab Modal Analysis or LMS Test.Lab Geometry for faster data interpretation and analysis. The applications are available as stand-alone analysis environments or as add-ins to LMS Test.Lab MIMO Sine Sweep Testing.

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**Features**

- Shaker and transducer verification
- System identification procedure with periodic random test
- Definition of amplitude/phase versus frequency profiles for up to 16 DAC outputs or up to 16 target control channels
- Available measurement functions: FRFs, coherence, autopower, crossover
- High signal-to-noise ratio provides noise-free FRFs
- Leakage-free data acquisition giving correct amplitude at resonance frequencies

**Benefits**

- Fail-safe software with user-defined abort levels protects the test object
- Reduced testing time and optimized test item availability through on-the-spot analysis and validation
- Results in higher quality FRFs, even in situations where broadband excitation fails
- Effectively characterizes highly damped structures and nonlinear materials

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The software provides a complete solution for FRF-based modeling of large and complex structures that are difficult to excite with sufficient energy.

During the measurements, all required functions are displayed online.

Mode shapes visualization gives immediate insight into the root cause of the vibration or acoustical problem of the structure.
LMS Test.Lab MIMO Stepped Sine Testing

LMS Test.Lab Stepped Sine Testing provides a multiple input stepped sine excitation to measure multiple input and output frequency response functions to be used for modal analysis.

By exciting the structure with a stepped sine, LMS Test.Lab MIMO Stepped Sine Testing combines the high signal-to-noise ratio of sine excitation and front-end controlled input force and provides proper excitation on lightly damped structures. During MIMO stepped sine testing, multiple sine sweeps with different phase conditions between the averages present correct frequency response functions. Accurate sine extraction results in leakage-free response spectra, while a system identification step prior to the stepped sine helps control excitation levels and increase the dynamic range of the 24-bit A/D converters. Harmonic distortion spectra and excitation level control following a reference profile provide insights into the structure’s nonlinear behavior.

Up to 16 exciters with different level control types are available. Fixed voltage level on exciters can be used for nonlinearity characterization under open loop conditions. Amplitude and phase control of input forces provide high accuracy in phase control closed loop during the stepping phase by a special MIMO FRF based control algorithm, using singular value decomposition for the FRF matrix inversions. Each control/exciter level can be set at a fixed amplitude, or according to a tabulated reference spectrum.

Frequency ranges are either linear or exponentially incremented. Multiple frequency ranges provide fine frequency resolution around resonances where necessary, and coarse resolution elsewhere to save time. These ranges can be concatenated to obtain concatenated response spectra.

LMS Test.Lab MIMO Stepped Sine Testing can be combined with LMS Test.Lab Operational Deflection Shapes and Time Animation, LMS Test.Lab Modal Analysis or LMS Test.Lab Geometry for faster data interpretation and analysis. The applications are available as stand-alone analysis environments or as add-ins to LMS Test.Lab MIMO Stepped Sine Testing.

Features

- System identification procedure with periodic random test
- Amplitude and force control integrated in the front-end for optimal control loop time
- Reference profile and tolerance for each shaker
- Individual abort level for each channel
- 2 control modes: amplitude, amplitude/phase
- Possibility to use logarithmic or linear x-axis

Benefits

- Fail-safe software with user-defined abort levels and leakage free FRFs
- Highest signal-to-noise ratio
- Best suited to study nonlinear behavior of structures
- Yields highest quality data for modal analysis, ground vibration tests and design modification
- Seamless integration with LMS Test.Lab Modal Analysis solutions
LMS Test.Lab MIMO Normal Modes Testing

LMS Test.Lab MIMO Normal Modes Testing presents multiple input and output phase appropriation techniques. It is designed to measure resonance frequency, damping and mode shapes of a structure. LMS Test.Lab MIMO Normal Modes Testing automatically adjusts amplitude and phase of the forces injected into the structure to tune a single, normal vibration mode. The solution provides manual and automatic resonance tracking as well as force appropriation techniques. The frequency and forcing vector must be identified and applied in such a way that the complete structure vibrates only according to the desired mode and that all acceleration responses are in phase quadrature with the input force vector.

LMS Test.Lab MIMO Normal Modes Testing offers an intuitive way to define channel, acquisition, tuned modes and tuning parameters. In all stages, the user gets feedback on the parameters defined, so that the test setup can be maximally validated before the actual testing starts. Based on frequency response functions measured with either random or sine excitation, users can easily define the force ratio that needs to be applied for each mode. Manual tuning provides manually control of drive frequency and level. Force realization is a special MIMO FRF-based control algorithm using singular value decomposition for the FRF matrix inversions that provides high accuracy of the required force vector. During actual measurements, all relevant information such as Lissajous display, scatter diagram, mode indicator function, animated geometry and time data can be displayed and monitored online.

Benefits

- Direct measurement of normal mode shapes without the need for frequency response functions or modal parameter estimation techniques
- Single mode excitation by controlled force appropriation for enhanced comparison with finite element analysis or other excitation methods
- Most suitable method to study nonlinear behavior of structures by amplitude sweeping
- Precision process centric solution
- Immediate feedback on acquisition and processing parameters

Features

- Excitation with up to 16 shakers
- Pre-test force ratio calculation with extended Asher’s method, mode indicator and inverse mode indication function method
- Automatic tuning based on phase tolerance between master exciter and master response
- Safety limits on maximum acceleration response and maximum exciter level
- Frequency sweep around resonances to determine damping ratio and modal mass using the complex power or force quadrature method

The method is most suitable to study structures' nonlinear behavior by amplitude sweeping.

The software offers an intuitive way to define channel, acquisition, tuned modes and parameters.

Direct measurement of normal mode shapes without FRFs or modal parameter estimation techniques.

Frequency sweep around resonances to determine damping ratio and modal mass.
LMS Test.Lab Ground Vibration Testing (GVT)

LMS Test.Lab Ground Vibration Testing is a complete solution for performing stepped sine and normal modes testing. Together with LMS Test.Lab Spectral Testing, LMS Test.Lab Structures provides excitation capacities ranging from random excitation and swept sine to stepped sine and normal modes, giving engineers an abundance of open loop and closed loop excitation possibilities.

With the V12 acquisition card, the LMS SCADAS III is a very compact system relative to the high channel count. Up to 180 channels can be built on one master frame and up to 204 channels on a slave frame. The combination of master and slave frames provides a distributed system configuration. This reduces the length of the wires and makes the test setup easier.

LMS Test.Lab Ground Vibration Testing has been set up so that channel configuration can be easily carried over from one solution to another. Once the channel setup is defined, all the acquisition applications can share the same configuration; you only have to load the appropriate acquisition tool and fix the corresponding parameters to start the measurements. This significantly speeds up the use of different excitation signals when performing a ground vibration test on an aircraft.

**Random excitation**

Combined with LMS Test.Lab Source Control, LMS Test.Lab Spectral Testing provides a productive state-of-the-art modal testing solution supporting structural excitation by up to 16 shakers. Random, burst random, sine, burst sine, periodic chirp excitation can be easily defined. Random excitation provides the phase separation technique which gives a first analysis of the structure. Modal analysis can be performed right after the measurements. Most modes can already be selected during a random excitation measurement. As a result, the test duration is reduced by one third. The LMS Test.Lab Spectral Testing solution provides more information on this topic.

**MIMO sine testing**

MIMO sine testing provides a multiple input and output swept sine acquisition and a multiple input and output stepped sine acquisition.

By exciting the structure with a sweeping sine over a period longer than one block, LMS Test.Lab MIMO Sine Sweep Testing combines the high sine excitation signal-to-noise ratio with broadband testing measurement speed. During MIMO testing, multiple sine sweeps with different phase conditions between the averages provide correct frequency response functions. Accurate sine extraction results in leakage-free response spectra, while a system identification step prior to the sine sweep helps control excitation levels and further increase the dynamic range of the 24-bit A/D converters. Harmonic distortion spectra and excitation level control following a reference profile provide insights into the structure’s nonlinear behavior. LMS Test.Lab MIMO Sine Sweep Testing provides more information on this topic.

By exciting the structure with a stepped sine, LMS Test.Lab MIMO Stepped Sine Testing combines the high sine excitation signal-to-noise ratio and front-end controlled input force and provides proper excitation on lightly damped structures. Up to 16 exciters with different types of level control are available. Fixed voltage level on exciters can be used for nonlinearity characterization under open loop conditions. Amplitude and phase control of input forces provide...
Benefits

- Reduced test time with easily recoverable channel setup for all acquisition applications
- All applications are built on the same LMS Test.Lab platform
- Fast and easy data reporting
- Immediate data validation without switching between applications
- Reduces test cycles for ground vibration testing
- Seamless integration with LMS Test.Lab Modal Analysis solutions

Features

- Up to 16 exciters
- Open and closed loop control
- Measures transfer functions with random, swept sine, and stepped sine excitation
- Measures resonance frequency, damping ratio and deflection directly with normal mode excitation
- Supports non-linearity study

MIMO normal modes testing

LMS Test.Lab MIMO Normal Modes Testing provides a multiple input and output phase appropriation technique.

It is designed to directly measure resonance frequency, damping and modes shape on a structure. The Test.Lab MIMO Normal Modes Testing automatically adjusts the amplitude and phase of the forces injected into the structure to tune a single normal vibration mode. Manual or automatic resonance tracking and force appropriation techniques are available. The frequency and forcing vector must be identified and applied so that the complete structure vibrates only according to the desired mode and that all acceleration responses are in phase quadrature with the input force vector. LMS Test.Lab MIMO Normal Modes Testing provides more information on this topic.

Harmonic distortion spectra and excitation level control following a reference profile provide insights into the structure’s nonlinear behavior.
LMS Test.Lab Modification Prediction

LMS Test.Lab Modification Prediction evaluates structural modifications (mass, stiffness and damping) of elements such as mass, spring-damper and tuned absorber on the dynamic behavior of a mechanical structure using modal system synthesis techniques. Multiple modifications can be prepared and saved in a modification set.

Based on the modal model (scaled mode shapes identified with experimental or finite element modal analysis) and on the modification element definition, a modal model of the modified structure is calculated. The effect of such a set of modifications on a modal model can be calculated and compared to the original situation.

LMS Test.Lab Modification Prediction is a member of the LMS Test.Lab analysis product family. It can be used both as a stand-alone solution and as an add-in.

**Features**
- Efficiently dissipate vibration energy using a tuned absorber
- Add masses or change local stiffness to move resonant frequencies
- Remove masses at all points and predict accurate natural frequencies
- Predict structural modification effects and global impact of selected modifications without physically changing the structure
- Evaluate alternative design variation without repeated testing

**Benefits**
- Complete solution for modal model modification, optimized for ease-of-use
- Requires minimal operator training
LMS Test.Lab Rigid Body Properties Calculator

When modeling intricate structures, subassemblies, or mechanism dynamics, the subassembly rigid body characteristics might be too complex or inaccurate to calculate. With the LMS Test.Lab Rigid Body Properties Calculator, LMS offers well-known FRF measurement techniques to extract essential parameters such as center of gravity, moments and principal axes of inertia.

Frequency response functions (FRFs) are measured in the same way as in experimental modal analysis. The structure is suspended in free-free condition using a soft suspension. FRFs are measured with standard modal testing equipment: an impact hammer or a shaker, force cells and accelerometers. For the precision of the rigid body properties, 6 different excitation locations and 8 output points (measured in 3 directions) are required. The rigid body properties calculator uses the mass line characteristics of the measured FRFs and the known geometrical coordinates of the measurement points to calculate the rigid body properties. There is no need to first identify 6 rigid body modes with the classical modal parameter identification, since it is usually not possible to perform this task accurately. The calculator is able to compensate for the residual effect of the first flexible modes on the mass line.

Three mass line methods can be defined, using either measured FRFs, corrected FRFs of which the flexible modes have been subtracted, or lower residual terms from a standard modal analysis. These three mass line methods guarantee optimum accuracy and compensation of flexible modes. Optimized data selection capabilities make FRF selection easy and visualization possible and assist users in selecting the frequency band with double cursor on either selected FRFs or sum of all FRFs. The LMS Test.Lab Rigid Body Properties Calculator supports the creation and visualization of geometries, center of gravity and principal axes and the immediate animation of rigid body modes.

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LMS Test.Lab Principal Component Analysis

LMS Test.Lab Principal Component Analysis helps reduce complex noise and vibration problems to more manageable, independent, uncorrelated problems with multiple partially correlated references. These problems range from structure-borne road-noise to the combined effects of air-conditioning compressor and engine noise. By applying singular value decomposition techniques on a multi-reference crosspower matrix, this matrix is decomposed into its principal components, yielding as many single reference sets of crosspowers as there are references. The solution also features other functions such as virtual coherence and virtual spectra. Principle component analysis results can be used for further transfer path analysis.

LMS Test.Lab Multi-Reference Post Processing

LMS Test.Lab Multi-Reference Post Processing offers efficient processing of multiple throughput files with a common set of processing parameters. LMS Test.Lab Multi-Reference Post Processing is supported for stationary measurements such as time data recorded in the spectral acquisition application; autopower and crosspower can be processed. LMS Test.Lab Multi-Reference Post Processing offers multiple input and output FRFs (H1, H2, Hv), partial coherence and transmissibility off-line processing with autopower and crosspower as input.

LMS Test.Lab Signature Throughput Processing

The LMS Test.Lab Signature Throughput Processing host worksheet offers a convenient display overview of time histories, including zoom-in, immediately after completing a measurement using the parallel throughput functionality, without leaving the data acquisition application. The “Processing Data Set” definition functionality organizes and combines recordings for batch processing. A “Quick Spectral Map” provides insight into spectral contents to guide the appropriate processing parameter selection. The software offers efficient processing of multiple throughput files with a common set of processing parameters. Tracking channels can be used to control the time data selection to be processed. It supports trial processing on a limited number of channels and includes batch processing with auto-saving of results. The module also offers a preview of processing results with auto-switching of the display.

LMS Test.Lab Run Data Averaging & Comparison Organizer

The worksheet provides a comprehensive view of all available 2D data (order sections, frequency sections, octave spectra or octave sections) and is designed to compare and average results from various tests very quickly for validation and/or processing. Selected data are immediately displayed via powerful display filling modes in user-defined screen layouts. Embedded navigation supports fast scrolling across functions or measurement points. Individual measurements are included or excluded from automatic average and envelope calculations by tick-box selection. Averages and envelopes can be stored in a project database.

LMS Test.Lab Structures – Options

LMS Front-end drivers
- LMS front-end 8 channels drivers
- LMS front-end 12 channels drivers
- LMS front-end 16 channels drivers
- LMS front-end 40 channels drivers
- LMS front-end 60 channels drivers
- LMS front-end Premium drivers

LMS Test.Lab Run Data Averaging & Comparison Organizer

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**LMS Test.Lab Geometry**

LMS Test.Lab Geometry consists of hardware and software to digitize point coordinates of a test structure. Digitization is done through a hand-held probe with a built-in camera that uses image recognition of reference panels to determine its position in 3D. The calculated coordinates are immediately available in LMS Test.Lab Geometry and the LMS Test.Lab display. It supports measurements of a global axis system as well as Euler angles (transducer orientation). It works extremely well on small and large structures with irregular geometry or high point density.

**LMS Test.Lab Photogrammetric Geometry Definition**

This option within LMS Test.Lab Geometry consists of software to process digital pictures, made with a digital camera from different viewpoints around the test object. The software automatically identifies target points on the pictures and reconstructs the 3D geometry model of the object without any operator interaction.

**LMS Test.Lab Automatic Modal Parameter Selection (AMPS)**

LMS Test.Lab Automatic Modal Parameter Selection (AMPS) is an add-in tool for LMS Test.Lab Modal Analysis and LMS Test.Lab Operational Modal Analysis. The tool automatically selects physical poles in the stabilization diagram. It was developed based on the knowledge and skills of experts who assess stabilization diagrams. Benchmark research positioned it as a guidance tool for novices as well as an advisory tool to speed up the pole selection process for experts in both standard and operational modal parameter estimation cases.

**LMS Test.Lab PolyMAX**

LMS Test.Lab PolyMAX is available as an add-in to LMS Test.Lab Modal Analysis and LMS Test.Lab Operational Modal Analysis. It is an advanced modal parameter estimation technique that offers superior identification of modal parameters. Its main advantage consists in damped structure identification, where more modes can be identified into a higher frequency range. LMS Test.Lab PolyMAX also detects less well-excited modes. Thanks to the clear stabilization diagram, mode selection can be performed in larger frequency bands and with higher confidence. With LMS Test.Lab PolyMAX, an advanced modal parameter estimation technique has been introduced that renders the final modal model user-independent. It is capable of extracting more modal information out of the same data-set as conventional parameter estimation techniques.
LMS is an engineering innovation partner for companies in the automotive, aerospace and other advanced manufacturing industries. With 30 years of experience, LMS helps customers get better products to market faster and turn superior process efficiency into key competitive advantages.

With a unique combination of 1D and 3D simulation software, testing systems and engineering services, LMS tunes into mission critical engineering attributes, ranging from system dynamics, structural integrity and sound quality to durability, safety and power consumption. With multi-domain solutions for thermal, fluid dynamics, electrical and mechanical system behavior, LMS can address the complex engineering challenges associated with intelligent system design.

Thanks to our technology and dedicated people, LMS has become the partner of choice of more than 5,000 leading manufacturing companies worldwide. LMS is certified to ISO9001:2008 quality standards and operates through a network of subsidiaries and representatives in key locations around the world. For more information on LMS, visit www.lmsintl.com.