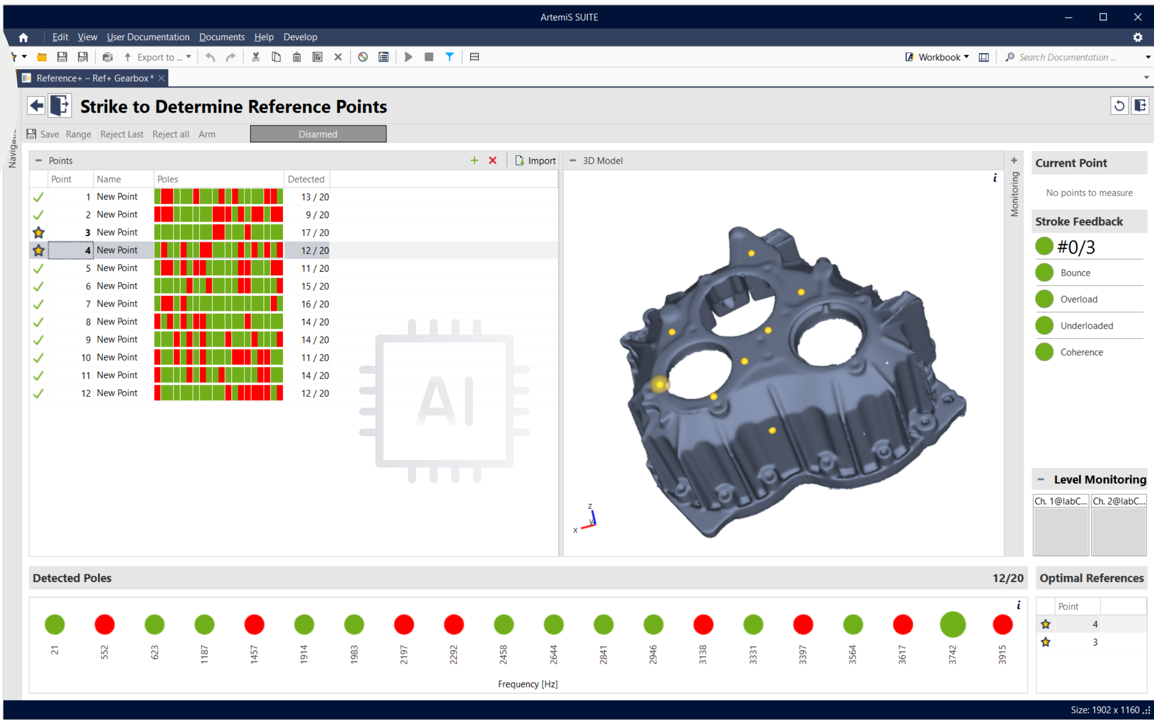
DATA SHEET



ArtemiS SUITE
PRoject

Code 50440

APR 440 Reference+

Perform experimental modal analysis in an easy, streamlined way. Reference+ determines the optimal reference points for experimental modal analyses using artificial intelligence (AI). Along with other innovative automatic features, this eliminates the need for complex interactions, providing a high degree of flexibility at the same time.

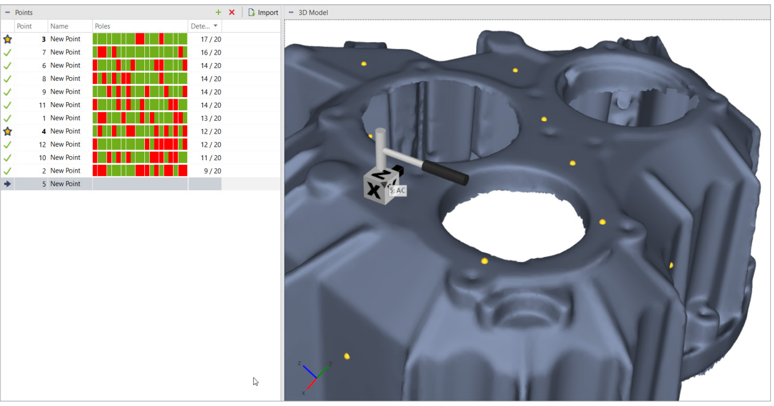
OVERVIEW

APR 440 Reference+

Code 50440

Reference+ forms part of the powerful Structural Analysis Package of ArtemiS SUITE, detecting the optimal reference points for impact measurement. This is one of the most important prerequisites for correct modal analyses, as potential errors are very laborious to correct in subsequent process steps.

The Reference+ workflow is as easy as can be. All you need to do is excite the reference points selected. Without further interaction, the AI-supported algorithms immediately detect the reference points that contain all the necessary modes. This helps you avoid errors, saves time and gives you the security you need to perform your modal analysis quickly and successfully.



KEY FEATURES

- Detecting the optimal reference points for impact measurements using AI
- Achieving reliable results in no time even for inexperienced users (expert knowledge is not required)
- Guided workflow from implementing the measurement system to determining the optimal reference points
- Graphical support in Frontend and Sensor Configuration for reliable measurement setups
- Visual and acoustical feedback for checking the individual excitation strokes (faulty strokes are detected automatically)
- Clearly arranged user interface with result display and control diagrams
- Automatic calculation and evaluation of transfer functions as well as detection of the optimal reference points using the integrated neural networks (manual analysis steps or comparisons with high-quality simulation results are not required)
- Seamless integration into the Structural Analysis Package of ArtemiS SUITE

APPLICATIONS

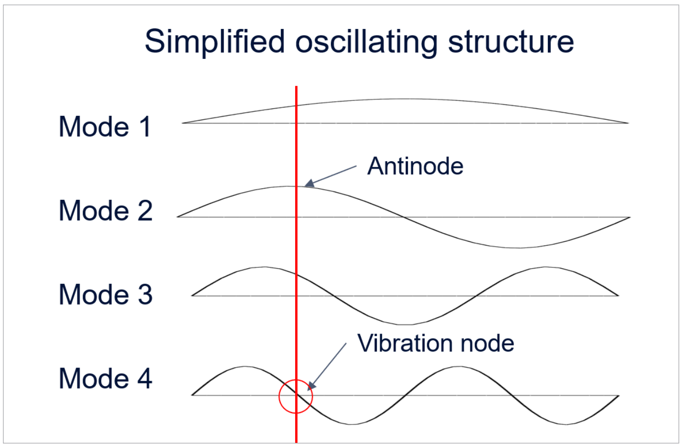
- Experimental modal analyses
- Troubleshooting
- Validation of finite element models

DETAILS

Determination of Optimal Reference Points for Experimental Modal Analysis

Why Selecting References is so Important

One of the most important steps in preparing impact measurements is determining the reference points. The aim in selecting reference points is to sufficiently capture all relevant modes of the selected points. The decision-making process is often based on personal experience, numerical simulations, or visual evaluations of the measurement data. Nonetheless, this is very laborious and prone to errors. Selecting the wrong reference points may result in modes not being found or only being found poorly, which in turn may have negative impacts on the quality of the results. These errors are often only recognized towards the end of modal analyses or, at worst, not recognized at all because the modes do not appear in any transfer function. Making corrections or repeating modal analysis measurements always involves more time and costs.



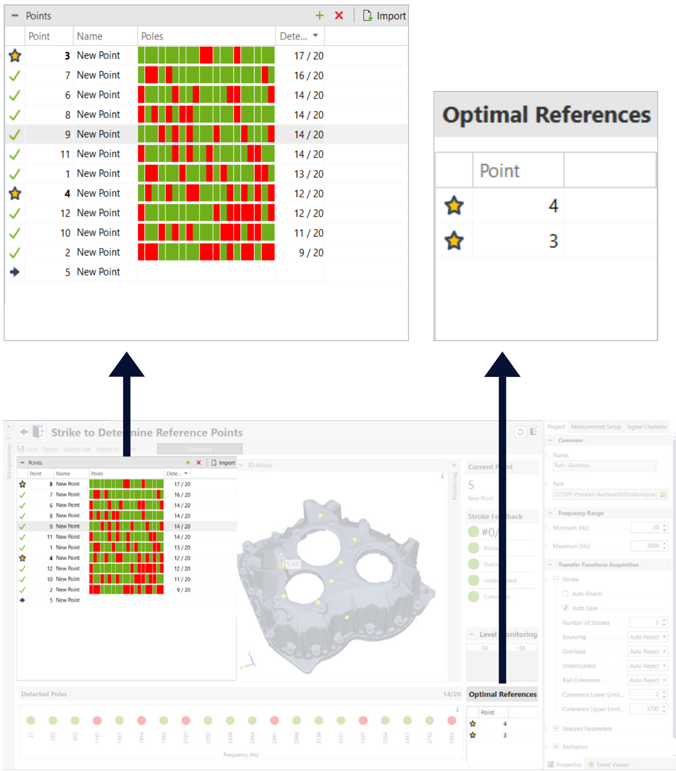
The task of Reference+ is to define reference points in such a way that they are always involved in modes. In the example above, incorrect positioning would result in "Mode 4" not appearing in the transfer functions because there is no deflection.

Determining the Optimal Reference Points Quickly and Reliably Using AI

Reference+ takes a new, innovative approach. When it comes to simpler structures, the artificial intelligence (AI) detects the modes based on a few impact measurements (5 to 10) and determines the optimal reference points automatically and without further interaction. Whether you have little or extensive experience with impact measurements: Reference+ delivers results immediately after each excitation that can otherwise only be achieved through lengthy simulations, for example.

Once all excitations are complete, the Reference+ algorithm automatically determines the optimal reference points without the need for subsequent corrections or simulation results.

There are also enormous benefits for larger and more complex structures. The workflow does not change; only the number of reference points to be examined increases, so the algorithm can detect all relevant modes and determine the optimal reference points.



Reference+ provides an innovative „barcode" display (on the left) for quick interpretation of modal content and direct comparison of the suitability of potential reference points. In addition, a simplified list of optimal reference points (on the right) is immediately available after each stroke.

Three Steps for Determining the Optimal Reference Points

Step One: Frontend and Sensor Configuration

In Frontend Selection, all supported frontends and modules connected via USB or network are shown as graphics. Quick and intuitive drag-and-drop configuration is even possible for larger measurement systems comprising several hundred channels.

Using Offline Frontend, you can virtually configure your measurement system even without existing hardware. All the settings made here can be transferred later once the real measurement system is connected.

Now the software sensors are to be assigned to your measurement system. To do so, you can use the channel list, listing all channels grouped by module. Both an accelerometer and an impact hammer have to be connected and can be conveniently assigned using the Connect Sensors tool window or a Sensor Library. With TEDS sensors on HEAD*lab* frontends, sensor information like the serial number can be retrieved.

Step Two: Determination of Parameters

Using automatic functions, all analysis parameters that are important for determining the optimal reference points can be determined with just a few test strokes.

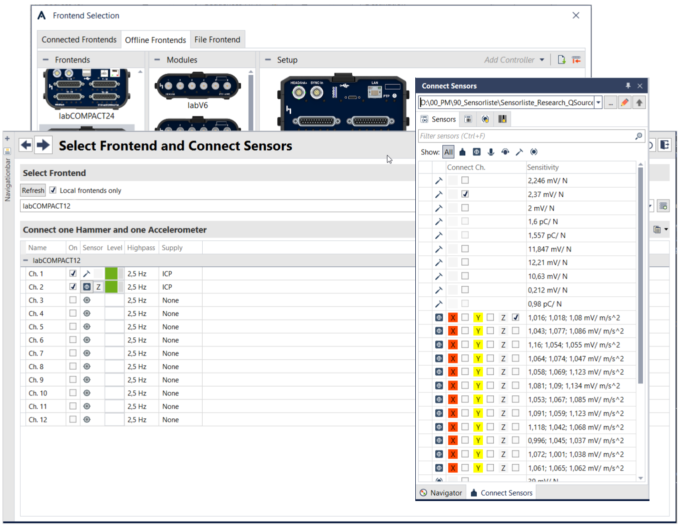
Every stroke is followed by visual feedback in the form of status displays as well as acoustic feedback on the quality of the stroke, so you can achieve the desired results very quickly, even without in-depth specialist knowledge.

The quality control function checks for double strokes between the impact hammer and the excited measurement object, overload, insufficient modulation of the impact hammer, or an overload of the accelerometers. If one of these criteria is violated, the stroke can be repeated. So you can be sure that the quality of all strokes is satisfactory.

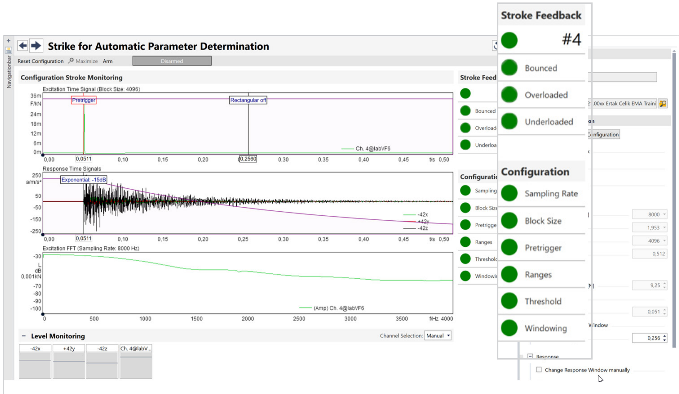
Further feedback is provided on three control monitors showing the excitation time signal, the time signal of the defined reference point, and the FFT spectrum of the excitation, enabling you to draw conclusions about the executed stroke. The level display also shows the current level of both the impact hammer and the reference point.

Step Three: Determination of the Optimal Reference Points

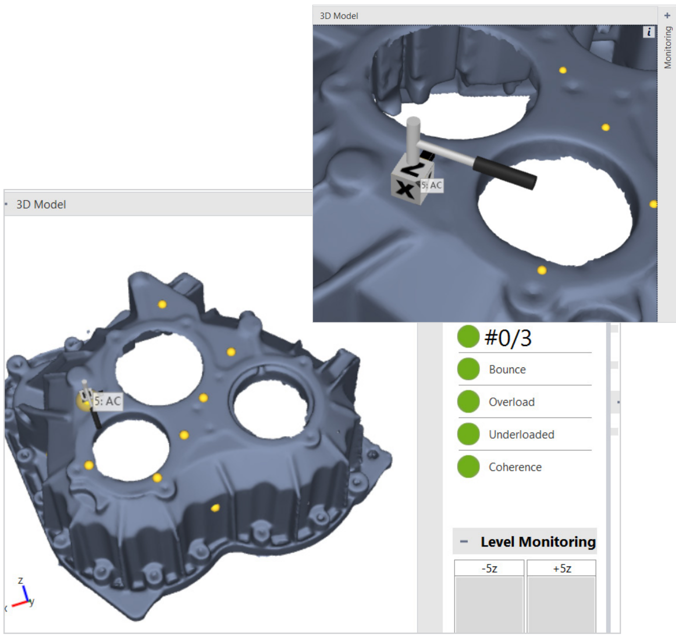
First define the points that are to be excited. It is sufficient to determine 5 to 10 points either manually (without coordinates and degrees of freedom) or with the help of both a Measurement Point Library with points and a 3D model. Using an imported 3D model



Use the frontend and sensor configuration to select the frontend and define the desired sensors. All you need is an impact hammer and an accelerometer.



The assistant-guided function leads you through the standardized parameter determination processes step by step while also performing automatic quality checks with visual and acoustic feedback.



A 3D model can be imported via a Measurement Point Library. All imported points with their positions activated are visualized as spheres in the color of their respective measurement group in three-dimensional space.

that can be zoomed, rotated, tilted, and moved helps you visualize the position of all points in three-dimensional space. Additional points can be easily added or deleted.

The points and their status information are also listed in a table and thus can be processed in a structured way. For the measurement, the impact hammer and the sensor are moved together from one point to the next, so each input inertance measurement can be directly performed in the vicinity of the accelerometer.

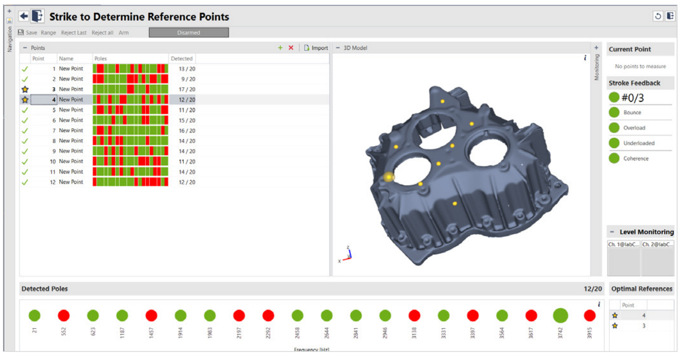
Quality control functions check for double strokes, overloads, and insufficient modulations of the impact hammer, and also monitor coherences. If one of these criteria is violated, you will receive corresponding visual and acoustic feedback, as with the test strokes. The stroke is automatically discarded and can be conveniently repeated without interaction with the computer. Thanks to the acoustic feedback, the focus of the measurement can remain on the reference point to be excited. This enables you to perform the measurement quickly and even without looking at the screen.

Alternatively, you can switch off these automatic functions and specify for each stroke individually whether they are to be used or discarded.

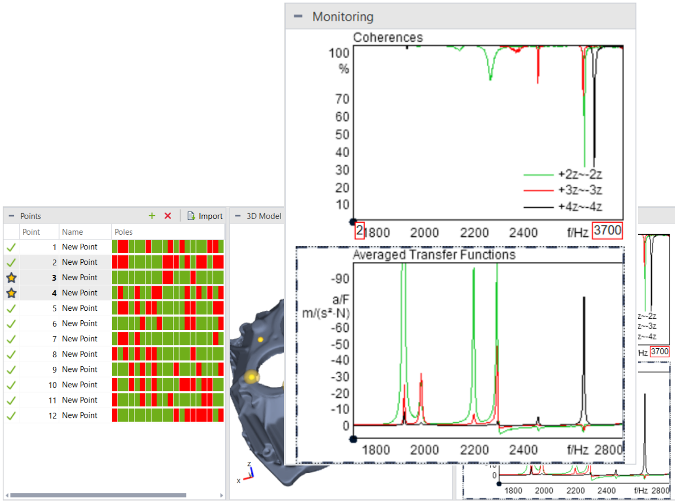
The calculated coherences as well as the averaged transfer functions of all points selected are available in diagrams for further checking.

After each stroke, based on the AI calculations, Reference+ displays all the poles found in the averaged transfer functions together with the respective frequency in a new, color-coded overview. Without further interaction, Reference+ also automatically checks the measured points for the optimal reference points, marking them with a star. In doing so, it accounts for all measurements that have been completed so far.

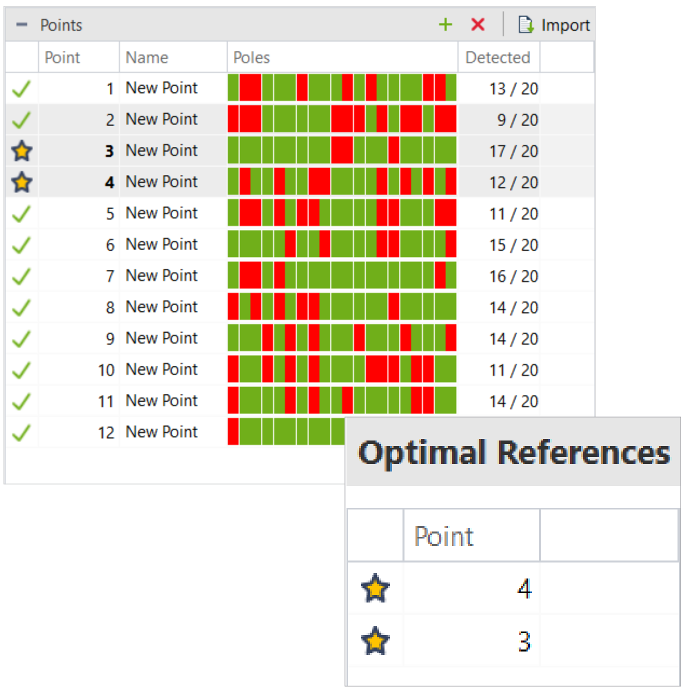
Reference+ provides you with a significant improvement and security for impact measurements without major additional effort. In order not to interrupt the workflow of the experimental modal analysis, Reference+ has been seamlessly integrated into the Structural Analysis Package of ArtemiS SUITE.



After each excitation, the accelerometer and the impact hammer are moved together to the next point until the optimal reference points have been determined from all the points examined.



You have the option of displaying the diagrams with the calculated coherences and averaged transfer functions from all the selected points.



Points

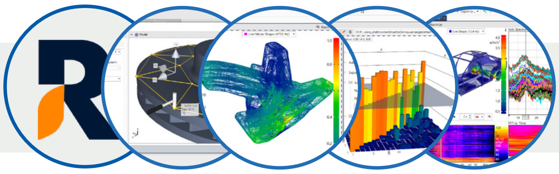
	Point	Name	Poles	Detected
✓	1	New Point		13 / 20
✓	2	New Point		9 / 20
☆	3	New Point		17 / 20
☆	4	New Point		12 / 20
✓	5	New Point		11 / 20
✓	6	New Point		15 / 20
✓	7	New Point		16 / 20
✓	8	New Point		14 / 20
✓	9	New Point		14 / 20
✓	10	New Point		11 / 20
✓	11	New Point		14 / 20
✓	12	New Point		

Optimal References

	Point
☆	4
☆	3

There is another algorithm that compares all the measured points with each other and then suggests the combination that delivers the best possible modal content while requiring the least effort.

ArtemiS SUITE



Structural Analysis Package

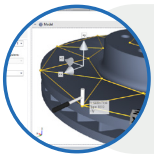
APR 440
REFERENCE+

Determination of the optimal reference points

- Automatic determination of the optimal reference points
- Assistant-guided process with little interaction

Advantages

- Fast results without additional simulation results
- High measurement reliability for both beginners and advanced users



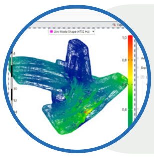
APR 430
IMPACT MEASUREMENT

Impact measurement

- Roving Hammer with fixed reference points
- Roving Accelerometer with fixed excitation points
- Assistant-guided process

Advantages

- Error prevention thanks to quality checks with visual and acoustic feedback
- Fast frontend and sensor configuration
- Intuitive operation



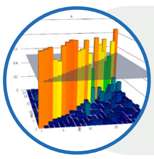
APR 420
MODAL ANALYSIS PROJECT

Modal analysis

- Automatic determination of the model size using AI
- LSCF procedure
- Graphical MAC display

Advantages

- Intuitive, interactive workflow
- Extremely rapid results thanks to semi-automated workflow



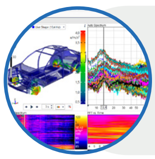
APR 410
SHAPE COMPARISON PROJECT

Deflection shape comparison

- Detection of suitable deflection shapes

Advantages

- MAC matrix / MPC value
- Integration of simulation data
- Intuitive operation



APR 400
OPERATING DEFLECTION SHAPE PROJECT

Operating deflection shape analysis

- Analysis of operating deflection shapes

Advantages

- Easy detection of patterns and anomalies
- Intuitive operation

Scope of Delivery and Accessories

Scope of Delivery

- APR 440 (Code 50440)
  Reference+
  Module of ArtemiS SUITE for determining optimal reference points for experimental modal analyses

Required

- APR 000 (Code 50000)
  APR Framework
  Basis of ArtemiS SUITE

Supported Frontends

- *lab*CTRL II.1
- *lab*COMPACT12 II
- *lab*COMPACT24 II
- *lab*HSU
- SQuadriga III
- SQobold

No longer available:

- *lab*CTRL I.1
- *lab*CTRL I.2
- *lab*COMPACT12
- *lab*COMPACT24
- SQuadriga II

Supported HEAD*lab* Modules

- *lab*VF6 II
- *lab*VF6-Iso II
- *lab*V6HD
- *lab*V12 II
- *lab*V24 II
- *lab*V8x3-Iso II
- *lab*V12-O4 II
- *lab*M6 II
- *lab*CF6

No longer available:

- *lab*V6
- *lab*VF6
- *lab*V12
- *lab*V12-V1
- *lab*V12-V2
- *lab*M6
- *lab*M6-V1

Additional Hardware (Required)

- Impact hammer
- Accelerometer
- Computer / laptop / tablet (Windows)

Structural Analysis Package of ArtemiS SUITE

- APR 400 (Code 50400)
  Operating Deflection Shape Project

  ODS Project can be used to combine operating deflection shapes with 3D and CAD object data to perform detailed structural analyses of the dynamic behavior. In addition, the Time Domain Animation Project (TDA) enables deflections to be analyzed in a time-variant structure.

- APR 410 (Code 50410)
  Shape Comparison Project

  Shape Comparison Project enables deflection shapes to be analyzed and compared. Individual shapes can be analyzed, simulations can be compared with real measurements, and component changes can be evaluated.

- APR 420 (Code 50420)
  Modal Analysis Project

  The powerful Modal Analysis Project can be used to analyze vibration patterns from simulations or test objects of any complexity in an easy and efficient way. This enables thorough examination of the dynamic response without the need for extensive specialist knowledge.

- APR 430 (Code 50430)
  Impact Measurement

  Impact Measurement enables even inexperienced users to quickly and safely perform impact measurements (Roving Hammer/Roving Accelerometer) for structural analyses.

Compatibility Criteria for a Measurement Point Library

(The Measurement Point Library is included in APR Framework)

- A measurement file containing transfer functions and matching the Measurement Point Library, ideally recorded by means of Impact Measurement or the Recorder of ArtemiS SUITE (APR 040 is required).
- Each combination of measured degree of freedom and reference degree of freedom may only exist once.
- Accelerance (acceleration/force, also known as inertance), mobility (velocity/force, also known as admittance), or compliance (displacement/force) must be stored in the channels.

Required: APR Framework (Code 50000)

HEAD acoustics

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