

# Technical Specifications for the ARTeMIS Modal 5

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## System Requirements

ARTeMIS Modal is a software platform designed for Microsoft Windows 64-bit operating systems. To increase speed, it makes use of mathematical libraries from Intel. The help system is web based, so maximum performance is obtained by having an internet connection. Help system can be downloaded to the local computer if necessary.

- Intel® 64-bit processor architecture
- Microsoft® 64-bit Windows 7/10
- Microsoft Internet Explorer 9 or higher
- 4GB of RAM (8GB or more recommended)
- 10GB of available hard-disk space. Since the space requirement is heavily dependent on the ARTeMIS Modal projects stored, 100GB is recommended
- 1,024x768 screen resolution or higher (recommended)
- Internet connection required for installation
- Activation require a license file that will be sent by email.
- The software supports the following license models: Node-locked to a specific computer, locked to a specific USB dongle, locked to a specific license server located on the Local Area Network. In case a license server is used, the licenses can be checked out for a period of up to 30 days for a specific computer that needs to work disconnected from the network.

## Geometry Generator

- Universal File Format (UFF or UNV extension)  
Loads from UFF data sets 15 (nodes), 2411 (nodes), 82 (trace lines), 2431 (trace lines) and 2412 (triangular plate elements). For cylindrical and spherical coordinates additional UFF data sets 18 and 2420 are supported.
- SVS Configuration File Format (CFG extension)
- Object orientated drawing enabling drawing of complex structures using more basic sub-elements each with its own grid plane and coordinate system.
- Drawing options are: points, lines and triangular surfaces. Elements can be drawn using the mouse or by entering information in tables using the keyboard or copy/paste operations.
- Drawing of high level objects both in cartesian and cylindrical coordinate systems.
- Operated through the Prepare Geometry Task.

## Data Input

- Import through either the user interface, SVS Configuration File format, or Universal File Format.
- Universal File Format (UFF, UNV) ASCII as well as binary import of measured time series.
- SVS Configuration File format and data files: Text (TXT and ASC), SVS binary format (BIN), Header File Formats (TEAC HDR, GeoSIG GHF, Diadem, Kyowa), Kinometrics Altus (EVT), MS Wave file format (WAV), Weir Jones format (TAD), VDAS input format (VIF), National Instruments formats (LVM, TDM, TDMS), Matlab Format (MAT), Catman format, SoMAT format (SIE), SAC and MiniSEED seismic formats. In text file format data stored as a matrix with measurement channels stored column by column.
- Unlimited number of channels (tested with 300 simultaneously measured channels).

- Unlimited number of data points in each record.
- Unlimited number of test setups.
- Assign DOF information (measurement nodes and directions) for imported measurement channels using drag-and-drop on the test geometry or using the keyboard.
- Automatic identification of reference channels when using multiple test setups.
- Automatic updating of test geometry and DOF information when modifying geometry in the Geometry Generator.

## Data Output

- Copy/Paste and Print functions for all graphics and tables.
- Modal results: Universal File Format (ASCII) including geometry, one or more modes in each file.
- Modal results: SVS output files, one or more modes in each file (ASCII).
- Modal results: Interface to FEMtools updating software through UFF.
- Animations: Export of AVI movie files to e.g. Windows Media Player or Microsoft Power Point.
- Report generator for easy creation of Microsoft Office documents (Word & Power Point). Require the installation of Microsoft Office.
- SVS Configuration File Format (CFG extension): Geometry and DOF information is written directly in this file along with references to the required measurement files. The measurement files can be saved in text file format (ASC extension), SVS binary format (BIN extension).
- Universal File Format (UFF extension) Geometry saved in UFF data sets 15 (nodes), 82 (trace lines) and 2412 (triangular plate elements). In case of odd sensors directions UFF data set 18 is also saved with coordinate system definitions.
- DOF information and measurements are saved in UFF data sets 58 (ASCII) or 58b (binary) time series format.

## Signal Processing

- Decimation, 1-1000 times, digital anti-aliasing filter, cut-off at 0.8 times Nyquist frequency of decimated signals.
- Filtering: low-pass, high-pass, band-pass, bandstop Butterworth, filter order 1-50 poles, arbitrary cut-off frequencies, test for filter stability.
- Projection Channels. Specify if all cross information of the measurement channels should be used or only between fewer number of channels. Automatic detection of the required number of Projection Channels as well as what channels to pick. Specific channels can as option be selected explicitly.
- Spectral estimation using FFT and Welch's averaged periodogram method. Data segment length: radix-2 only limited by the amount of data, overlap: 66.7 %, window: Hanning. Estimates the full spectral matrix if the Projection Channel option is disabled.
- Common SSI input matrix estimation to be used in all stochastic subspace identification algorithms. Maximum state space dimension is 300. Noise mode suppression through the use of the Projection Channel option.
- Option for reloading original uploaded data.
- Data Presentation of Test Setups: Spectral magnitude and phase, singular value decomposition of spectral matrix, average of full spectral matrix, average of diagonal elements of spectral matrix, coherence of spectral matrix, time / frequency contour diagram. Cursor read out and annotation support on all curves.
- Data Presentation of Reference Data: Spectral magnitude and phase, average of full spectral matrix, average of diagonal elements of spectral matrix, coherence of spectral matrix. Cursor read out on all curves.
- Fast or extended method for automatic detection of peaks of harmonics components in the measurements.
- Manually peak selection tool.
- Reduce peaks tool for reduction of unwanted modes or harmonic components in the measurements.
- Outlier testing and removal tool.
- Operated through the Prepare Data Task.

## Operating Deflection Shapes

- Frequency domain animation of all test setups using multiple references shape estimation.
- Time domain animation of individual test setups.
- Unscaled or scaled animation using phased assigned spectrum with a specific reference.
- Units (displacement, velocity, acceleration) and scaling specified by the user.
- Graphical information on deflections of selected channels.
- AVI movie creation of animations.
- Operated through the Estimation Task as Frequency-ODS or Time-ODS.

## Frequency Domain Modal Analysis

- User choices: Peak picking.
- Frequency resolution: Defined by number of frequency lines in spectral density function.
- Mode shape estimation: Immediate animation.
- Damping: None.
- Patent protected.
- Operated through the Estimation Task as FDD.

## Enhanced Frequency Domain Decomposition Modal Analysis

- User choices: Peak picking, MAC level for identification of spectral peak, time interval for identification of frequency and damping.
- Mode shape estimation: Immediate animation, mode shape estimate improved by frequency domain averaging.
- Frequency and damping estimation: Estimated from free decays corresponding to identified spectral peak.
- Detection of harmonics and removal of their influence from estimated modal parameters.
- Patent protected.
- Operated through the Estimation Task as EFDD.

## Curve-fit Frequency Domain Decomposition Modal Analysis

- User choices: Peak picking, MAC level for identification of spectral peak, frequency interval for identification of frequency and damping.
- Mode shape estimation: Immediate animation, mode shape estimate improved by frequency domain averaging.
- Frequency and damping estimation: Estimated directly from identified spectral peak.
- Detection of harmonics and removal of their influence from estimated modal parameters.
- Patent protected.
- Operated through the Estimation Task as CFDD.

## Stochastic Subspace Identification Modal Analysis

- Basic Method: Data driven Stochastic Subspace Identification.
- User choices: Implementation: Extended Unweighted Principal components, Unweighted Principal components, Principal Components and Canonical Variate Analysis. Estimation: Standard Least Squares or Crystal Clear SSI.
- Model orders: from one mode to the size defined by the common SSI input matrix.

- Stabilization criteria: Natural frequency deviation, damping ratio deviation, mode shape MAC deviation, all limits user defined. For Extended Unweighted Principal components also maximum coefficient of variations for natural frequency and damping ratio.
- Physical mode separation: Damping ratio limits are user defined.
- Select and link: Modes from the models chosen from each test setups are selected and linked using snap functions and editing facilities.
- Uncertainty estimation: In case of Extended Unweighted Principal components uncertainties are estimated for natural frequencies and damping ratios.
- Can estimate negative damping if necessary.
- Can estimate uncertainties of modal parameters.
- Comparison: Estimated model vs. FFT based auto and cross-spectra of measurements.
- Spectral density functions of response and prediction errors between estimated model and measurements.
- Operated through the Estimation Task as SSI-UPCX, SSI-UPC, SSI-PC, SSI-CVA, SSI-UPC-Merged.

## Validation

- Modal Assurance Criterion, MAC diagrams for comparison of mode shapes between same or different estimation techniques as well as between same or different projects.
- Complexity plot and complexity values of mode shapes.
- Simultaneous animation of different mode shapes, side-by-side and overlapped.
- Animation of differences between mode shapes.
- Frequency versus Damping diagrams presenting damping ratios as a function of natural frequencies. Optionally, also confidence ellipsoids (SSI-UPCX).
- Mode import facility using Universal File Format for comparison with e.g. FE modes.
- Operated through the Validation Task.

## Plugin to ARTeMIS Modal Pro - Data Manager Base Module

- Support for Multiple Analysis Sessions.
- External storage with saving and loading of measurements and results for each Analysis Session.
- Historical measurement statistics (Maximum, Minimum, RMS, Median, Mean, Variance, Skewness, Kurtosis).
- Master Session definition, allowing automatic processing across all Analysis Sessions using settings of the Master Session. Includes automatic SSI modal estimation.
- Notification (Alert) services. Visual, sound, email, web service.

## Plugin to ARTeMIS Modal Pro - Automatic File Upload Module

- Automating the data import by specifying a folder to be monitored for new files.
- Automating the Signal Processing of the new files.
- Automatic Damage Detection option if Damage Detection module is present.
- Operated through the Data Acquisition Task.

## Plugin to ARTeMIS Modal Pro - Damage Detection Module

- Importing of multiple sessions i.e. historical data.
- Statistical Subspace-based Damage Detection using two different algorithms.
- Hoteling Control Chart Prediction for unification of damage indicators.

- New Notification system using Email, Web Service, Audio, Popup notifications as soon as new data is available.
- Operated through the Analysis History Task.

## Plugin to ARTeMIS Modal Pro - Modal Parameter History Module

- Historical presentation of natural frequencies and damping ratios.
- Historical export of modal parameters to SVS and UFF file formats.
- Automatic mode tracking based on the estimation of a set of reference modes obtained from a specified set of reference Analysis Sessions.
- Historical presentation of the tracked modes (Drawn interconnected). Natural frequencies and damping ratios - absolute and relative to their reference mode. Modal Assurance Criterion of the mode shapes relative to the mode shape of their reference mode.
- Historical export of tracked modes to SVS and UFF file formats.

## Plugin to ARTeMIS Modal - Data Acquisition Module

- Direct control of National Instrument acquisition module that can be controlled using NI-DAQmx driver.
- Direct control of SINUS Messtechnik Apollo acquisition module.
- Seamless integration with all other tasks in ARTeMIS Modal.
- Direct streaming of measurements to ARTeMIS Modal test setups.
- View acquired time series real-time of user selectable channels.
- On-the-fly calculation of spectral densities and singular value decomposition (SVD) of spectral densities.
- Support IEPE sensors with or without TEDS.
- Multiple recording modes: Manual or triggered start/stop, predefined interval of time, continuous recording mode with optional definition of a ring buffer period in days.
- Works with all versions of ARTeMIS Modal (Basic, Standard, Pro)