

FEMtools™ Modal Parameter Extractor

Advanced Modal Parameter Extraction using Global and Local Methods

The FEMtools Modal Parameter Extractor (MPE) is a FEMtools add-on tool for extracting modal parameters (natural frequencies, mode shapes, modal damping) of a structure from a set of measured Frequency Response Functions (FRFs) or cross power spectra that are computed from response time series (Operational Modal Analysis).

Modal parameters can be used for applications in structural dynamics or to validate and update a finite element model. The extractor can be used interactively or as a component of an automated process for structural health monitoring and evaluation.

Overview

The FEMtools Modal Parameter Extractor module is a tool for extracting modal parameters from a set of Frequency Response Functions (FRFs) or response time series. FEMtools MPE is installed and used as an add-on to the FEMtools Framework or any other FEMtools configuration.

The extractor offers the following key features integrated in a easy-to-use and interactive environment:

- Extraction of modal parameters using an advanced global poly-reference Least Squares Complex Frequency (pLSCF) method or a local curve-fit method
- Automatic or manual pole selection based on a stabilization chart
- Narrow, wide band extraction or multiple bands with combination of poles
- Residues to compensate out-of-band modes
- Extraction of complex or normal mode shapes
- Validation of the extracted mode shapes using auto-MAC, mode complexity analysis, FRF re-synthesis and animated mode shape plots
- Support of multiple measurements setups for operational modal analysis (roving sensors)
- Operation using a interactive applet or command-driven for automation.
- Interactive graphic displays (FRFs, ODS, modes,...)

Import and export of measured FRFs, time series, and modal parameters is done using the Universal File format or custom reader scripts.

When using time series, DSP commands are available to process data and compute cross power spectra.

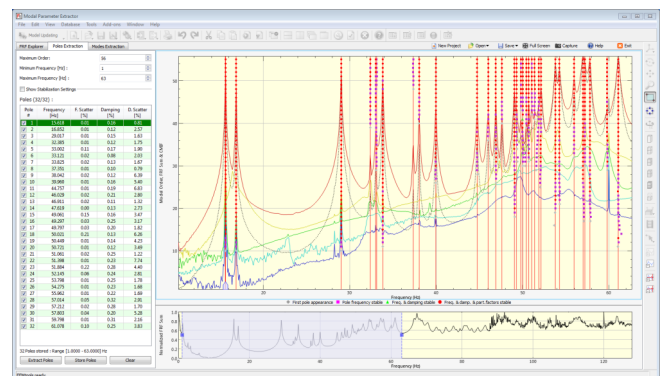
Applications

The FEMtools MPE uses Frequency Response Functions (FRF) for classic input-output modal analysis (EMA) or time series of responses for output-only modal analysis (Operational Modal Analysis; OMA).

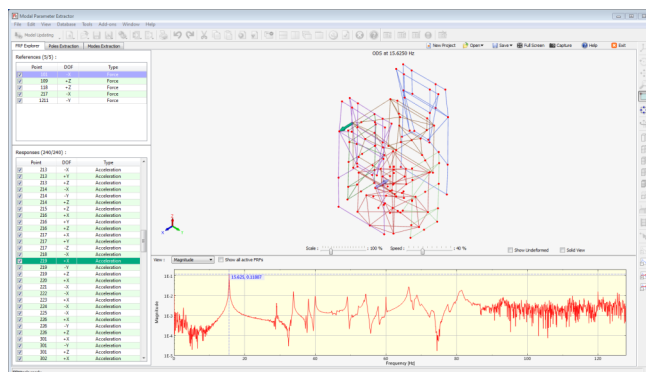
FRFs and time series are experimentally obtained using dedicated hardware and software. For National Instrument frontends, FEMtools DAQ add-on can be used.

Response signals are divided by an excitation signal to obtain FRFs.

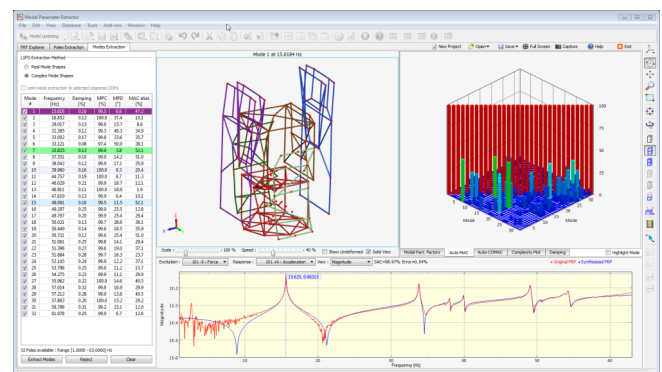
Under operating conditions, the excitation signal is unknown and FRFs cannot be obtained. In this case, FEMtools MPE computes cross correlation spectral functions that are in turn used to extract modal parameters.



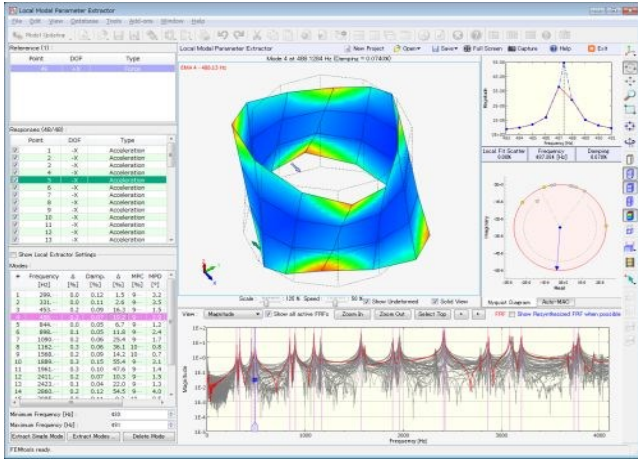
The MPE produces very clean stabilization diagrams.



FRF and reference selection with ODS animation viewer.



Selection of poles and validation of results.

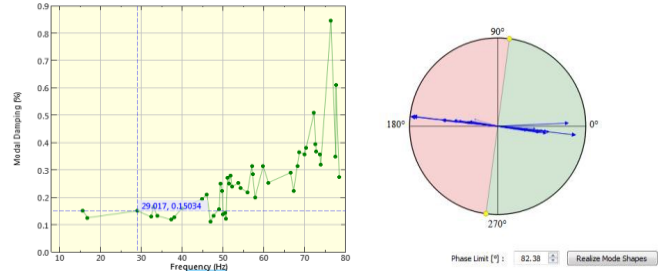


Local curve-fit method for modal parameter extraction.

FEMtools MPE can be used as a standalone tool for modal extractions, or combined with a data acquisition system.

As an add-on to any standard FEMtools configuration, modal extraction can be used in other FEMtools modules for the following purposes:

- Structural dynamics - Dynamic analysis relies on modal superposition of mode shapes for response analysis in time or frequency domain.
- Structural dynamics modification - Predict the effect of changes to stiffness, mass and damping.
- Modal coupling - Simulate the dynamic response of assembled structures, using coupled modal models obtained from test or FE analysis.
- Pretest planning - The modal extraction process can be evaluated using simulated test data as part of a virtual testing process.
- Test-Analysis modal correlation - Comparing reference test modes with predicted modes provides a mean to validate simulation models.
- FE model updating - Finite element models are updated by improving the correlation between reference test modes and predicted modes.
- FRF re-synthesis - Test FRFs can be smoothed by re-synthesis from extracted modal parameters which is recommended if these FRF will be used for FRF-based updating of FE models.
- Rigid body properties extractor - To obtain a better mass line for rigid body properties extraction, the first resonance peaks can be removed from the FRFs. This is done by modal extraction and re-synthesis.
- Material Identification - Identification of material properties using mixed numerical-experimental vibration analysis. Modal extraction provides a way to identify the mode shapes of a test sample.
- Structural health monitoring - Modal extraction is a component of a system for automated monitoring of modal parameters in structures.



Postprocessing extraction results using modal damping curve (left) and modal complexity plot (right).

Benefits

- Powerful - Using efficient algorithms and optimized DSP, modal extraction is fast and can support a very high number of channels.
- Easy to Use - Only minimal user-interaction is required and all functions are combined in a single interactive applet.
- Efficient - Very clear stabilization charts are produced making them suitable for automatic identification of stable poles.
- Reliable - Reliable and stable methods are used for global and local extraction of modal parameters. Out-of-band modes are taken into account to compensate residual effects and improve extraction accuracy.
- Flexible - Modal extraction can be operated manually or used as part of an automated process.

Prerequisites and Licensing

FEMtools MPE requires a separate license that is used together with a license for any FEMtools standard configuration.

Test FRFs for modal analysis and time series for OMA can be obtained with FEMtools DAQ add-on or imported from 3rd party hardware and software.

Services

- Installation, training and customization
- Support by e-mail, phone and support site
- Custom software development
- Project research

Supported Platforms

- Windows 7, 8, 10, 11 (64-bit)
- Linux 64-bit

For more information, contact

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