FEMtools™ Modal Parameter Extractor

Modal Parameter Extraction using an Advanced Polyreference Estimation Method

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 features integrated in a easy-to-use and interactive environment:

- Extraction of modal parameters using an advanced 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 band 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 GUI wizard or automated data processing using scripts
- Interactive graphic displays

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

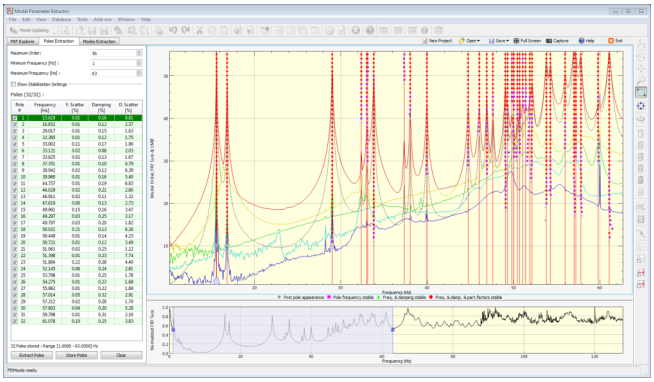
The FEMtools MPE uses Frequency Response Functions (FRF) for classic input-output modal analysis (EMA) or time series of responses for output-only modal analysis (Operational Modal Analysis; OMA).

FRFs and time series are experimentally obtained using dedicated hardware and 3rd party software. The response signals are divided by an excitation signal to obtain FRFs. These FRFs are imported by FEMtools for processing with the MPE.

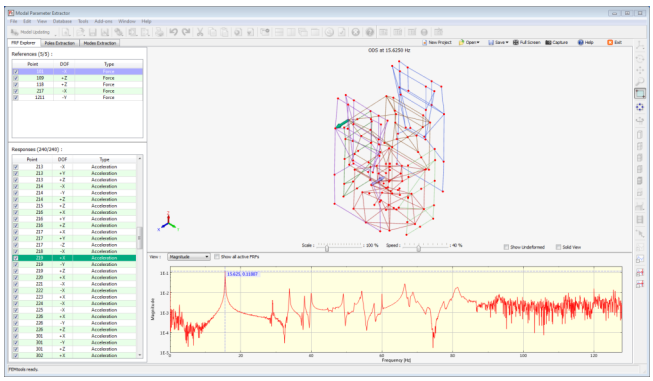
Under operating conditions, the excitation signal is unknown and FRFs cannot be obtained. In this case, FEMtools MPE computes cross correlation spectral functions that are in turn used to extract modal parameters.

FEMtools MPE can be used as a standalone tool for modal extractions, or together with a test system.

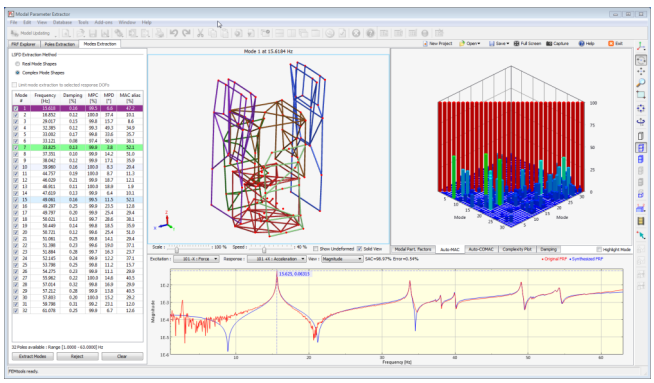
As an add-on to any standard FEMtools configuration, modal extraction can be used in other FEMtools modules for the following purposes:



Ft-MPE produces very clean stabilization diagrams.

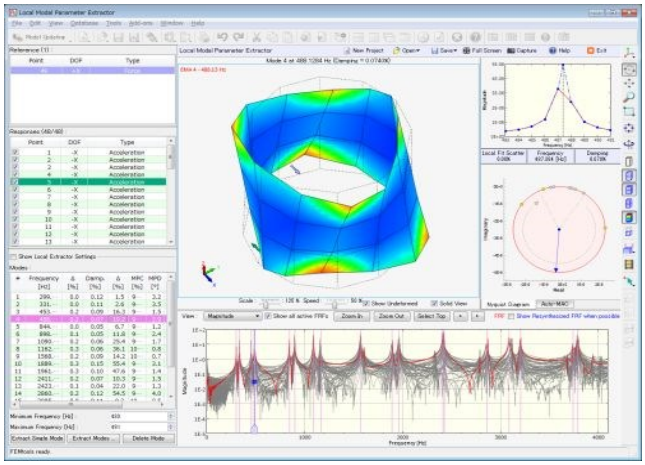


FRF and reference selection with ODS animation viewer.



Selection of poles and validation of results.

FEMtools
simulate > validate > update > optimize

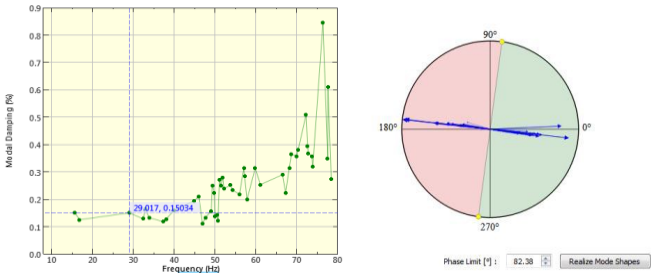


Local curve-fit method for modal parameter extraction.

- **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.

Benefits

- **Powerful** - Efficient algorithms that make the best use of your computing environment. On 64-bit platforms, it is possible to use a very high number of channels and a wide frequency range in a single pass without running into memory limitations.
- **Easy to Use** - Only minimal user-interaction is required. Poles can be automatically selected.



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

- **Efficient** - Very clear stabilization charts are produced making them suitable for automatic identification of stable poles.
- **Reliable** - A powerful polynomial curve fitting method is used that has proven to provide reliable estimates of natural frequencies, damping and mode shapes. 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

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

Test FRFs for classic modal analysis and output-only time series for OMA must be obtained with 3rd party hardware and software.

Services

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

Supported Platforms

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

Licensing

Flexible node-locked or floating licensing, annual or paid-up licenses.

For more information, contact

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