MEscope Application Note 35

Importing Measurements

Requirements for Animation

The following steps are required in order to display shapes in animation on a structure model,

1. Create a Structure Model

1. Draw the model in a Structure window
2. Or import a structure model

2. Import or Acquire Measurements

1. Import time or frequency data into a **Data Block**, or shape data into a **Shape Table**
2. Or acquire data directly from an acquisition front end using an **Acquisition** window

3. Link M#s to the Model

1. Execute **M# Links | Create M# Links** in the Structure window in which shapes will be displayed
2. Or execute **Animate | Create M# Links** in the Animation Source window (Data Block, Shape Table, or Acquisition) from which shapes will be displayed

4. Start Animation

1. Execute **Draw | Animate Shapes** in the Structure window
2. Or execute **Animate | Animate Shapes** in the Animation Source window

Measurement Types

Vibration data is usually acquired by attaching one or more vibration sensors to the surface of a machine or structure.

- Acceleration response is typically measured using an accelerometer
- Velocity is measured using a Laser vibrometer
- Machine shaft displacement is measured using a Proximity probe

While the machine or structure is vibrating, a sampled time waveform is acquired from each sensor using a multi-channel data acquisition system, FFT analyzer, data recorder, or portable data collector. Further signal processing is then performed on the acquired time waveforms, and different types of measurement functions are calculated. In order to display a shape in animation, a ***set of measurements*** must be acquired at all points and in all directions where shape values are desired.

In order to obtain ODS's or mode shapes from a set of measurements, one the following two conditions is required;

1. All data must be ***simultaneously acquired*** from all sensors at all points in all directions
2. ***Cross channel measurements*** are calculated using data that is ***simultaneously acquired*** from two or more sensors

The following types of measurements can be used to obtain ODS's or mode shapes;

- A set of ***simultaneously acquired*** time waveforms
- A set of ***Fourier spectra*** of ***simultaneously acquired*** time waveforms
- ***A single reference set*** of **Frequency Response Functions (FRFs)**. Either the force or the response must be fixed during the test

An **FRF** is defined as the Fourier spectrum of a response ***divided by*** the Fourier spectrum of a force that caused the response.

- ***A single reference set*** of **Transmissibility's**

A **Transmissibility** is defined as the Fourier spectrum of a response ***divided by*** the Fourier spectrum of a ***fixed reference*** response

- ***A single reference set*** of **Cross spectra**

A **Cross spectrum** is defined as the Fourier spectrum of a response ***multiplied*** **by** the complex conjugate of the Fourier spectrum of a ***fixed reference*** response

- ***A single reference set*** of **ODS FRFs**

- An **ODS FRF** is defined as the Auto spectrum of a response ***combined with*** the phase between the response and a ***fixed reference*** response

Time Waveform Measurements

In order to display ODS's or mode shapes from a set of response time waveform, they must be acquired so that each measurement contains the response of the structure at the ***same moment in time.*** To obtain an ODS or mode shape, all structural responses must contain the correct ***magnitude & phase relative to one another for each time sample***

- If all channels of time response data are ***simultaneously acquired***, the responses will contain the correct ***magnitude & phase relative to one another***.

Simultaneous acquisition requires a separate sensor for each point & direction (DOF) of measurement, and a multi-channel data acquisition system that can acquire data from all sensors simultaneously.

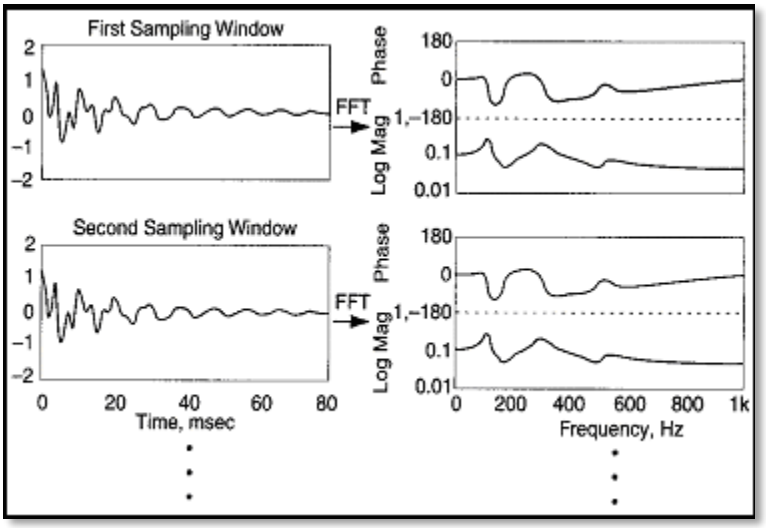
Multiple Measurement Sets

Since a multi-channel data acquisition system that can ***simultaneously acquire*** all channels of data is typically too expensive, data can be acquired a few channels at a time in ***separate Measurement Sets***. Each Measurement Set is created by simultaneously acquiring fewer channels of data.

Repeatable Acquisition

If the time waveforms from all sensors cannot be simultaneously acquired, multiple Measurement Sets of data can be acquired if the following repeatable acquisition conditions are met,

- During ***repeatable*** acquisition, ***approximately*** the ***same time waveform*** is obtained in the sampling window of the analyzer or acquisition system, ***regardless*** of when it is acquired.
- A ***trigger*** is usually required to capture a repeatable event in the sampling window.
- Repeatable acquisition will yield the ***same* Fourier spectrum** of successively sampled time waveforms, as shown below.



Acquisition of a Repeatable Event.

Cross-Channel Frequency Measurements

Several types of cross-channel frequency domain measurements ***don't require simultaneous acquisition of all channels*** of data, and a set of them can be used to extract ODS's and mode shapes.

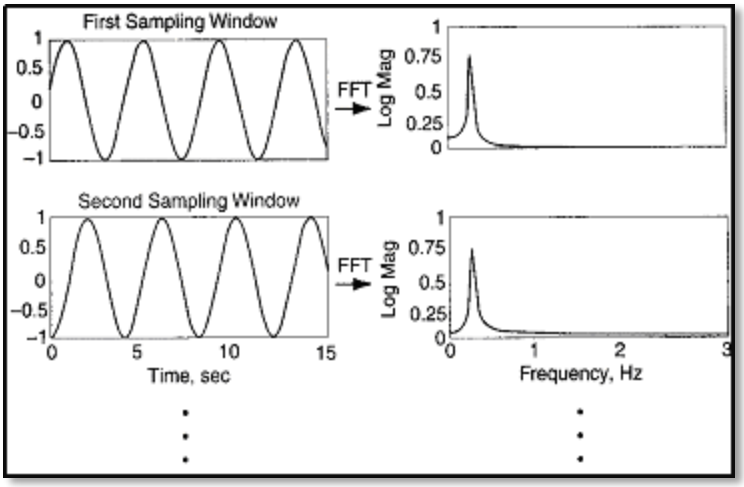
NOTE: FRFs, Transmissibility's, Cross spectra and ODS FRFs are all cross-channel measurements that can be calculated from ***multiple Measurement Sets*** of data.

However, in order to obtain ODS's or mode shapes from a set of these measurements, the structure must remain in a ***steady state*** during the acquisition process.

Steady State Acquisition

A machine or structure is in a ***steady*** (or ***stationary***) ***state*** if the **Auto spectrum** of an acquired signal ***does not change*** from one measurement to the next one.

An **Auto spectrum** is the Fourier spectrum of a signal ***multiplied by*** its own complex conjugate.



Steady State Acquisition.

Cross-Channel Measurements

- FRFs, Transmissibility's, Cross spectra and ODS FRFs are all ***cross-channel*** measurements
- These measurements are calculated between two signals that have been ***simultaneously acquired*** on two acquisition channels
- An FRF requires that a response and its corresponding excitation force be ***simultaneously acquired***
- A Transmissibility, Cross spectrum or ODS FRF requires that a ***roving*** response and a ***(fixed) reference*** response be ***simultaneously acquired***

FRFs

FRFs are ideal measurements for identifying experimental mode shapes because ***each peak*** in an FRF is ***evidence*** of ***at least one mode.***

- A ***set of FRFs*** between a ***single*** excitation point and ***multiple*** response points, or between a ***single*** response point and ***multiple*** excitation points, is ***sufficient*** to identify the mode shapes of a structure.

Operating (Output-Only) Data

- When excitation ***forces cannot be measured***, then ***FRFs cannot be calculated***
- Transmissibility's, Cross spectra, and ODS FRFs ***can be calculated*** from **Operating** (or **Output Only**) data

Transmissibility's

A **Transmissibility** is calculated in the same way as an FRF, but the unmeasured excitation force is replaced in the denominator by a ***(fixed) reference*** response.

- ***At or near*** a resonant frequency, the values of a ***set of Transmissibility's*** is an ***approximation*** of the **operating mode shape.** However, each Transmissibility has a ***"flat spot"*** instead of a ***peak*** at each resonant frequency.

- ***At least one*** Auto or Cross spectrum is needed to locate resonance peaks in order to obtain operating mode shapes from a set of Transmissibility's.

Cross Spectra and ODS FRFs

A **Cross spectrum** or an **ODS FRF *has a peak*** at each resonant frequency.

- ODS's can be displayed from a set of Cross spectra or ODS FRFs, calculated between ***multiple roving*** responses and a ***single reference*** response
- A set of ODS FRFs calculated from acceleration responses can be ***mathematically integrated*** to yield ODS's with units of ***velocity*** or ***displacement***
- With special windowing, ***FRF-based curve fitting methods*** can be used to extract ***operating mode shapes*** from a set of these measurements

Importing a Data Block

Time or frequency measurements can be imported into MEscope from a wide variety of third party disk files. After the data has been imported, it is saved in a Data Block (**BLK**) file as part of the ***currently open*** Project file.

In this example, data from an automotive disk brake rotor will be imported from multiple **Universal File Format (UFF)** files.

- Execute the **Project | New Project** command to create a new Project file
- Execute **File | Import | Data Block** in the MEscope window
- Navigate to the **MEscope \ Vehicles \ Brake Rotor Data** folder
- Choose **Universal File Format (UFF)** in the **Files of Type** list displayed adjacent to the **File Name** text box

All of the files of the type **(UFF)** format will be listed in the dialog box.

Selecting Multiple Files

Some analyzers and data acquisition systems save ***only one measurement*** per disk file. However, in order to define ODS's or mode shapes, ***multiple measurements*** must be imported into ***one*** **Data Block (BLK)** file.

- ***Select*** the ***first*** file in the list by ***clicking*** on its Name in the list box
- ***Scroll*** to the file name of the ***last*** file to be imported
- ***Hold down*** the **Shift** key and ***click*** on the ***last*** file to ***select all*** files in a range of files in the list box, as shown below
- ***Click*** on the **Open** button.

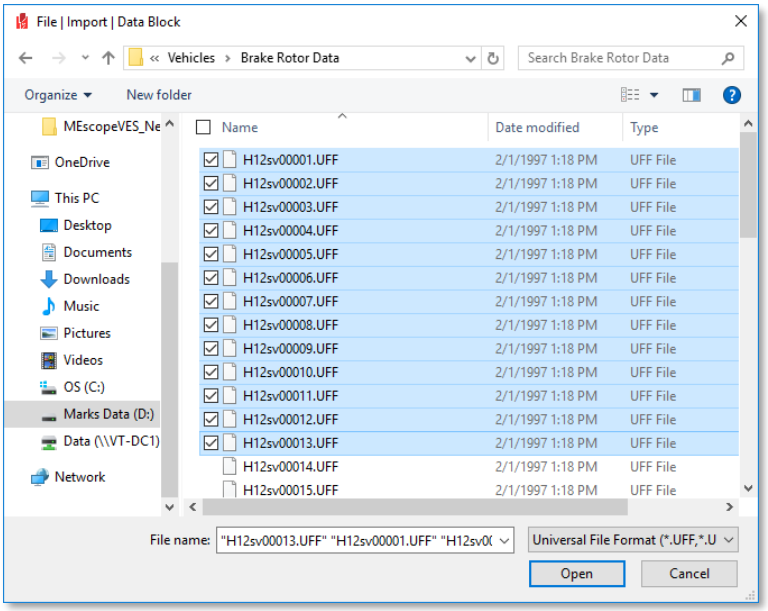
Translate Files Dialog Box

Next, the **Translate Files** dialog box will open displaying the properties of each imported measurement in a spreadsheet.

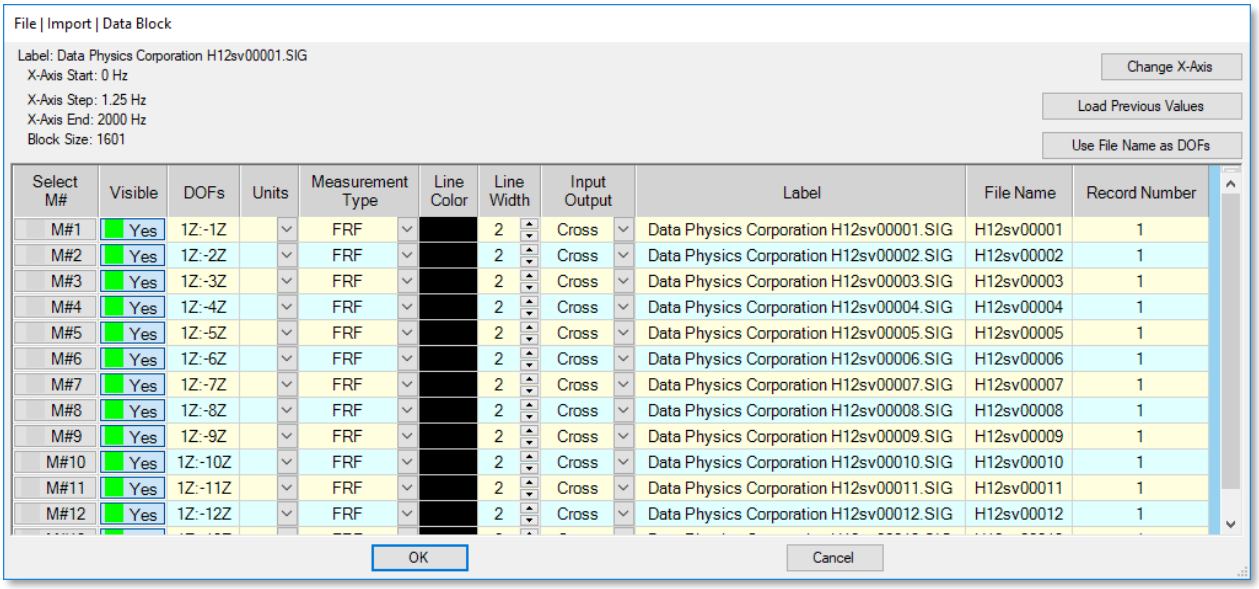
NOTE: All of the measurement properties can be edited in the **Translate Files** spreadsheet or in the **M#s spreadsheet** in the Data Block window after the Data Block has been imported.

- ***Press*** buttons in the **Select** M# column to ***select*** the measurements to be imported. In ***none*** is ***selected***, then ***all*** measurements will be imported.
- ***Press*** the **OK** button to import the measurements into a Data Block file

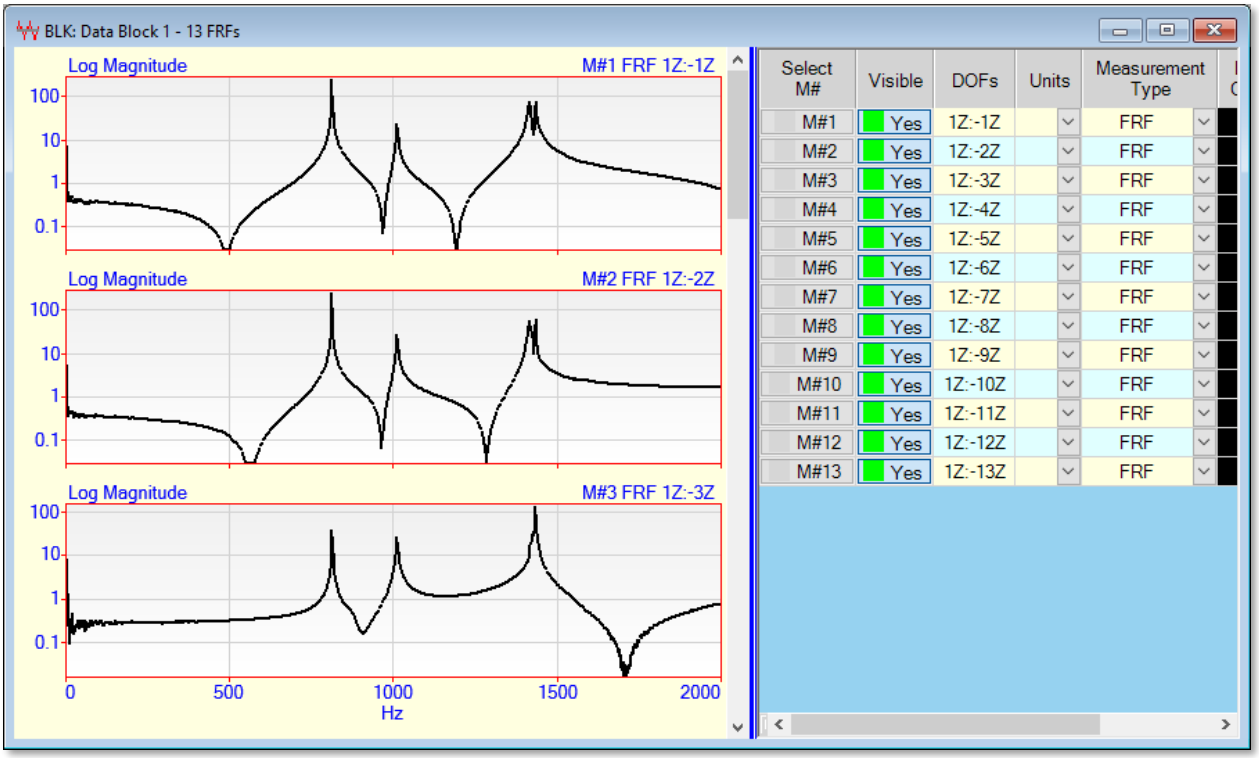
A new Data Block window will open showing the imported data.



Windows Open File Dialog Box Showing Multiple Files Selected.



Translate Files Dialog Box.



Data Block Displaying Imported FRFs

Swapping DOFs

Notice that the DOFs of the FRFs are in ***reverse order***. The fixed Reference DOF (1Z) should follow the colon **(:)**, and the Roving DOFs should be in front of the colon.

- ***Double click*** on the **DOFs column heading** in the **M#s spreadsheet**
- Select **Swap DOFs** In the dialog box that opens, and click on **OK**