ME'scopeVES Application Note #13

Introduction to Modal Curve Fitting

INTRODUCTION

Modal curve fitting is the process used to obtain a set of *modal parameters* (frequency, damping and mode shape) for each of the modes of a structure that is represented in a set of Frequency Response Function (FRF) measurements. A set of modal parameters (with mode shapes *properly scaled*) is also referred to as a *modal model*.

ME'scopeVES contains a variety of curve fitters. Each has particular merit in specific situations. Modal curve fitting is done in three steps. While you may use different methods for each of the three steps, you always use the same basic steps to complete the curve fit.

ME'scopeVES provides a *Quick Fit* command, which curve fits a set of measurements with minimum user intervention. All three curve fitting steps are applied at the press of a single *Quick Fit* button. This same command can also apply different curve fit methods, defined by your selections on the tabs of the Curve Fitting panel.

Modal Test

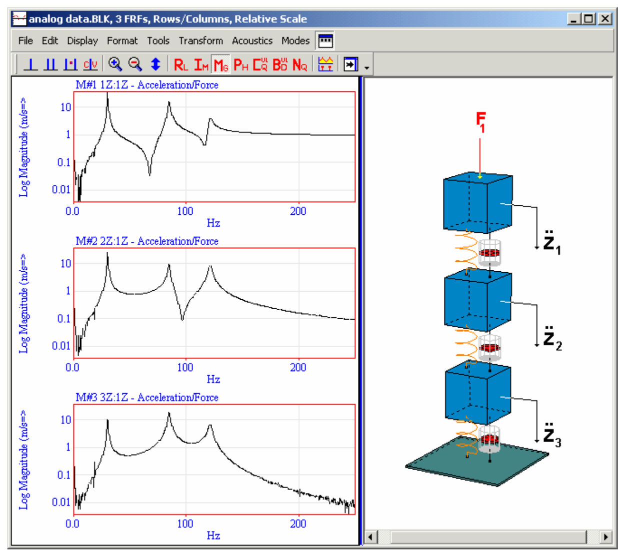
Curve fitting assumes that you have already acquired a set of FRFs from a modal test. In a *single reference* roving impact test you would have mounted a *single accelerometer at a fixed point and direction* (also called a degree of freedom or DOF) on the structure and impacted it at multiple DOFs with an instrumented hammer. Or, in a *single reference* shaker test, the structure would be excited through a *load cell with a shaker at a fixed DOF* and acceleration responses measured at multiple DOFs. In a *multiple reference* test, either multiple fixed accelerometers of multiple shakes would be used.

The steps in this note can be followed using the ***Visual Modal*** package or any package with option ***VES-400***.

GETTING STARTED

A simple spring/mass/damper Structure (**3-DOF.STR**) and a Data Block (**3-DOF.BLK**) of measured acceleration/force FRFs, as shown in the following figure are provided for practice. To access these files:

Execute: **File | Project | Open**.



(acceleration/force) FRFs and Structure model.

- Select **Curve Fitting Introduction.PRJ** from the **More Examples\Application Notes\#13** subdirectory.

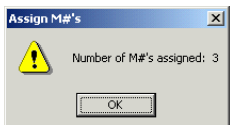
Animating Operating Deflection Shapes (ODS's)

You can animate the **Operating Deflection Shapes** (the forced responses) of the structure directly from the **FRFs**. This will allow you to view close approximations of the mode shapes directly from the FRFs before curve fitting them. To animate the **ODS**'s:

Execute: **Window | Arrange | For Animation**.

Execute: **Draw | Assign | M#'s** in the **3-DOF.STR** window. The **Assignment Methods** dialog will open.

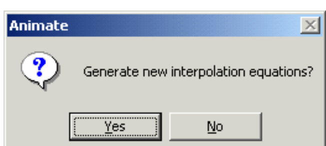
- Select **Match Point Numbers and DOFs** and press **OK**. The **Assign M#'s** dialog will open.



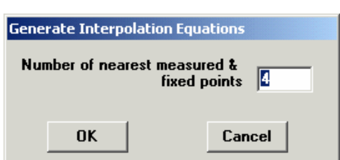
- Click on **OK**

The FRFs (**M#s**) have been assigned to DOFs of the model, and it is now ready for directly animating shapes from the FRFs.

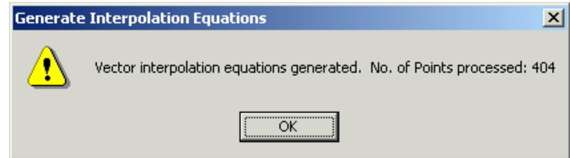
Execute: **Draw | Animate** in the Structure window. The **Animate** dialog will open.



- Press the **Yes** button. The **Generate Interpolation Equations** dialog will open.



- Enter **4** in the box and press **OK**. The **Generate Interpolation Equations** confirmation will open.



- Press **OK**.

> **Note:** You can simply execute the **Draw | Animate** command and the **Draw | Assign M#'s** command would be automatically executed if the model has no animation equations.

ODS Animation will begin.

- In the **3-DOF.BLK** Data Block window, move the cursor to each of the resonance peaks in the display.

At the **30 Hz** peak, the ODS is 'dominated' by the 30 Hz mode shape. The three masses move in phase with one another, with the top mass moving furthest. At the **84 Hz** peak, the next mode shape dominates the ODS. In this shape, the top and bottom masses move equally, but with opposite phases. The middle mass moves less and in phase with the bottom mass. In the mode shape at the **121 Hz** peak, the top and bottom masses move together, while the middle mass moves out of phase.

Execute: **Animate | Draw** to stop the animation.

- Close the **3-DOF.STR** Structure window.

THE STEPS OF MODAL CURVE FITTING

Curve fitting is a data reduction process that converts the dynamic information from a set of FRFs into a set of *modal parameters*. Each mode is defined by its modal *frequency*, *damping* and *mode shape*. The curve fitting process is carried out in three steps.

1. Determine *how many modes* are present in a set of FRFs. This is done by counting the *peaks* in a Mode Indicator Function formed from *all* (or *selected*) FRFs. (Each peak is evidence of at least one mode.)

2. Estimate the modal *frequency* and *damping* of each mode. These *global* properties are found by curve fitting all (or *selected*) FRFs *simultaneously*.
3. Estimate the *residue* associated with each mode for each FRF. Each Residue is a component of the *mode shape*. Residues are found by curve fitting each FRF *individually*.

Note: When peaks cannot be counted, steps **1.** and **2.** are replaced with the use of the Stability diagram. This is discussed in application note #19.

USING QUICK FIT

The **Quick Fit** command is a single-button shortcut that uses the three (previously selected) modal curve fit methods in sequence. It is equivalent to pressing the **Count Peaks**, **F&D** and **Residues** buttons on the three tabs of the **Curve Fitting** panel.

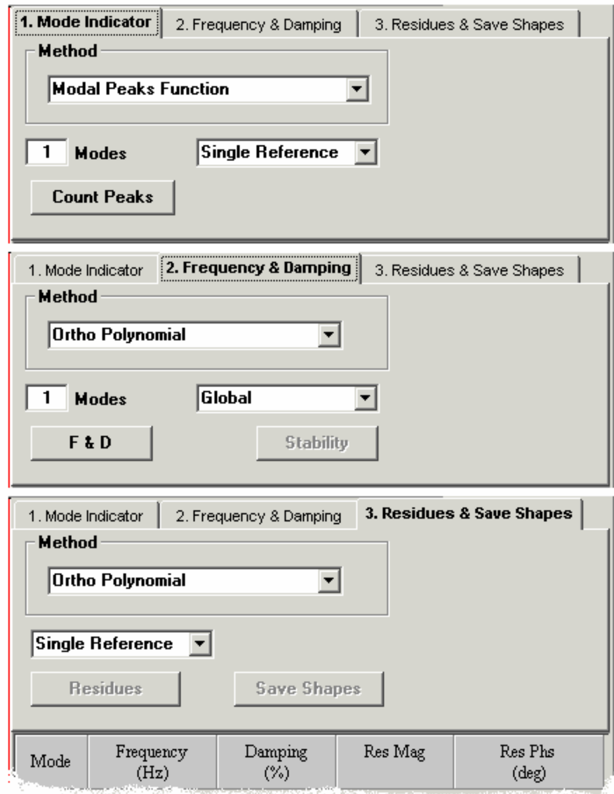
In the **3-DOF.BLK** Data Block:

Execute: **Modes | Modal Parameters** to open the Curve Fitting panel and display the menu of Curve Fitting commands.

- Verify that the selections on the three tabs are the **default** selections as shown below.

Execute: **Curve Fit | Clear All Fit Data** to remove any prior curve fitting data.

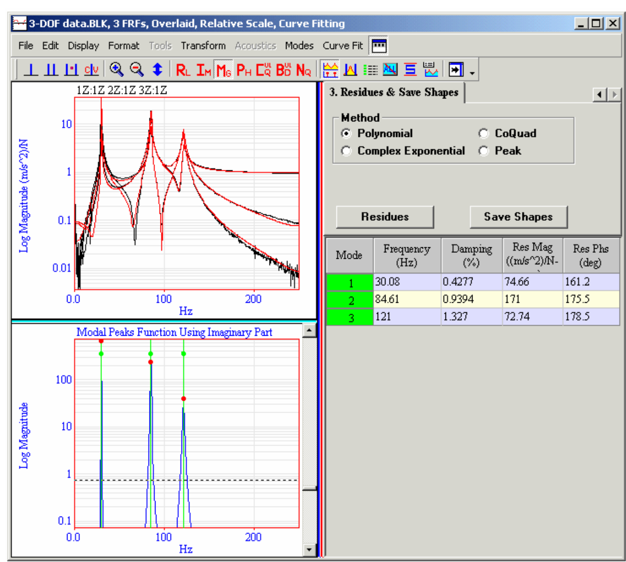
Execute: **Format | Overlay Selected Traces** to show all three of the FRFs overlaid on one another.



Default Selections for Quick Fitting.

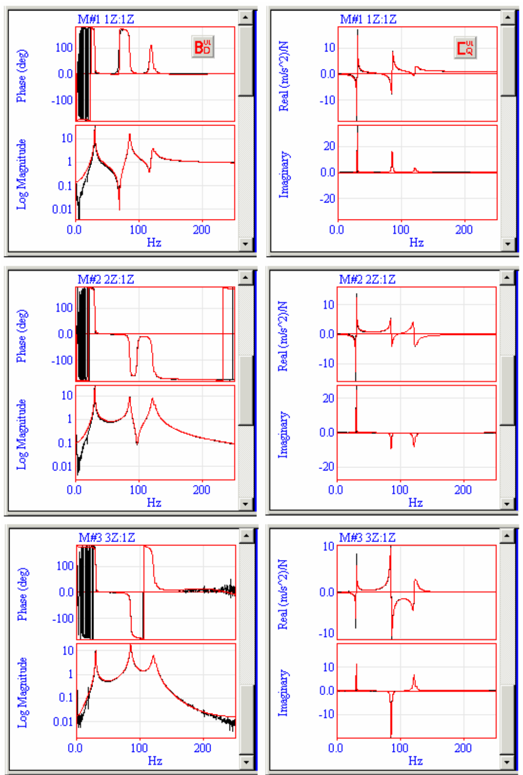
Execute: **Display | Magnitude** to display FRF magnitudes.

Execute: **Curve Fit | Quick Fit.**



Quick Fit Results.

The results should appear as shown in the figure above. In the upper Measurements graph, each (black) FRF is overlaid with a (red) **Fit Function** that was synthesized from the curve fitting results. The lower **Mode Indicator** graph displays the Modal Peaks function, which was used to count the modes. The Modal Parameters spreadsheet lists the estimated frequency, damping and residue values.



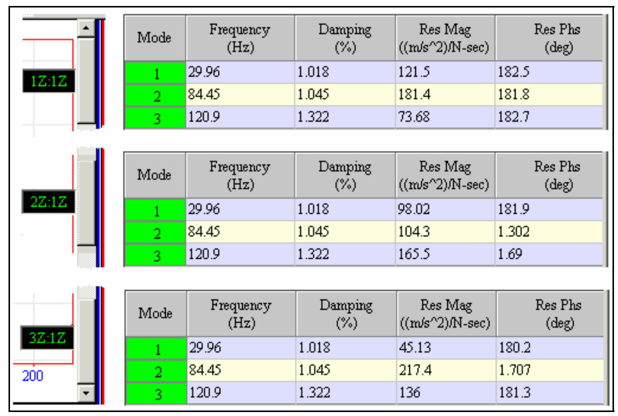
Graphically Comparing FRFs and Fit Functions.

- Execute: **Format | Rows/Columns** and use the scroll bar to the right of the measurements to step through a display of each FRF overlaid with its corresponding Fit Function.

Notice that the Fit Functions overlay the FRFs very closely. This close agreement indicates a successful curve fit.

- Execute: **Display | Real**, **Imaginary**, **Magnitude**, **Phase**, **Bode** or **CoQuad** to compare each FRF with its corresponding *Fit Function in different formats*.

As you scroll through the measurements, notice that the **Frequency** and **Damping** are the same for all measurements. These are *global* properties. The complex **Residues** (with Magnitude and Phase) are different for each measurement. Residues are *local* properties. Each is a component of the mode shape. The Residue Phases are all close to either 0° or 180°, indicating that these modes have *normal* shapes. All lightly damped structures have mode shapes that approximate normal mode shapes.



1Z:1Z

Mode	Frequency (Hz)	Damping (%)	Res Mag ((m/s^2)/N-sec)	Res Phs (deg)
1	29.96	1.018	121.5	182.5
2	84.45	1.045	181.4	181.8
3	120.9	1.322	73.68	182.7

2Z:1Z

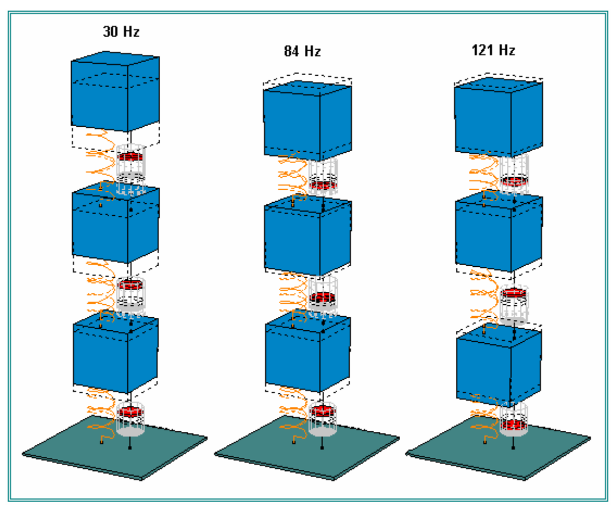
Mode	Frequency (Hz)	Damping (%)	Res Mag ((m/s^2)/N-sec)	Res Phs (deg)
1	29.96	1.018	98.02	181.9
2	84.45	1.045	104.3	1.302
3	120.9	1.322	165.5	1.69

3Z:1Z

Mode	Frequency (Hz)	Damping (%)	Res Mag ((m/s^2)/N-sec)	Res Phs (deg)
1	29.96	1.018	45.13	180.2
2	84.45	1.045	217.4	1.707
3	120.9	1.322	136	181.3

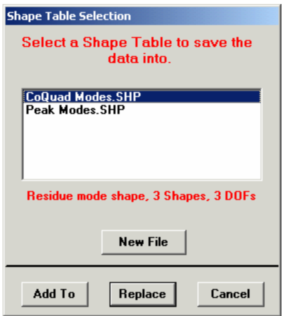
Modal Parameters Spreadsheet Matches FRF Displayed.

ANIMATING THE MODE SHAPES

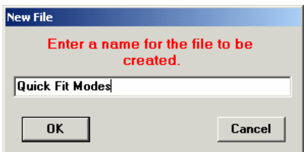


Mode Shapes of mass/spring/damper Structure.

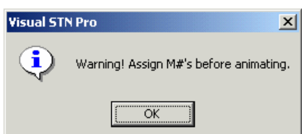
- Press **Save Shapes** on the **Residues & Save Shapes** tab. A **Shape Table Selection** dialog will open.



- Press the **New File** button. A **New File** dialog will open.



- Enter the file name, **Quick Fit Modes** and press **OK**. A dialog will open with a warning.



- Click **OK**. The **Quick Fit Modes.SHP** Shape table will open.
- Close the **3-DOF.BLK** Data Block window and reopen the **3-DOF.STR** Structure file window.
- Execute the **Draw | Animate** command and click on each **Select** button in the Shape table to display its mode shape.

A CLOSER LOOK AT QUICK FIT

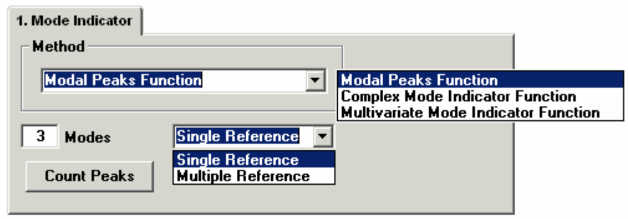
We will now examine each of the steps carried out by Quick Fit in greater detail.

- *Minimize* the **3-DOF.STR** and **Quick Fit Modes.SHP** windows by clicking on the center button in the upper right hand corner of each window.
- Reopen the **3-DOF.BLK** data block.

Execute: **Modes | Modal Parameters** to open the Curve Fitting panel.

STEP 1: Counting Resonance Peaks

- Select the **Mode Indicator** tab.



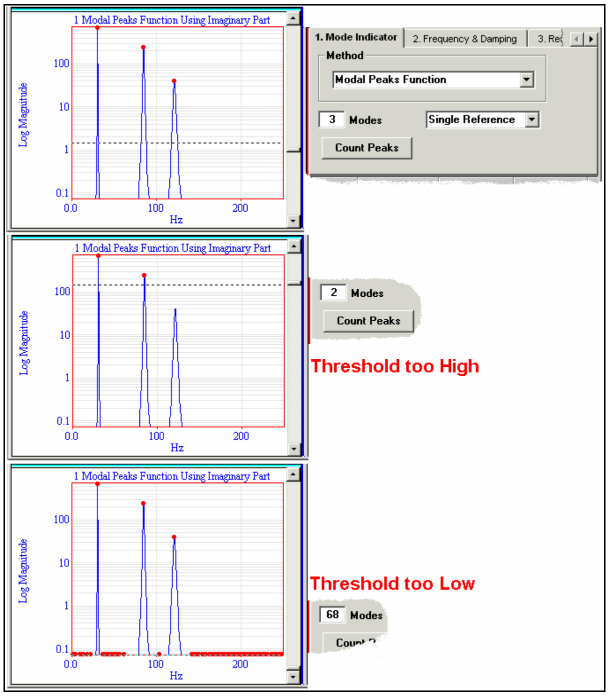
Mode Indicator Selections.

Any of three Mode Indicator Functions may be selected from the **Method** drop-down list. The default selection is the **Modal Peaks Function**. A second drop down list allows the selection of either a *Single Reference* or a *Multiple Reference* Mode Indicator. The default selection is **Single Reference**.

The Multiple Reference selection will calculate a Mode Indicator function for each reference in a *Multiple Reference* set of FRFs. The **Complex Mode Indicator Function** (**CMIF**) and **Multivariate Mode Indicator Function** (**MMIF**) are specifically designed for use with *Multiple Reference* FRF data sets, but any Indicator can be used on either *Single* or *Multiple Reference* data.

Note: For more information on Multiple Reference curve fitting see Application Notes #6, #14 and #15.

When used properly, all three of the Mode Indicator Functions should exhibit a peak at the frequency of a resonance. When the **Count Peaks** button is pressed, the Indicator function is calculated and its peaks are automatically counted and their number presented in the **Modes** box. To separate resonance peaks from noise peaks, an adjustable *Threshold Level* is also employed.



Effect of Threshold Level on Modes Counted.

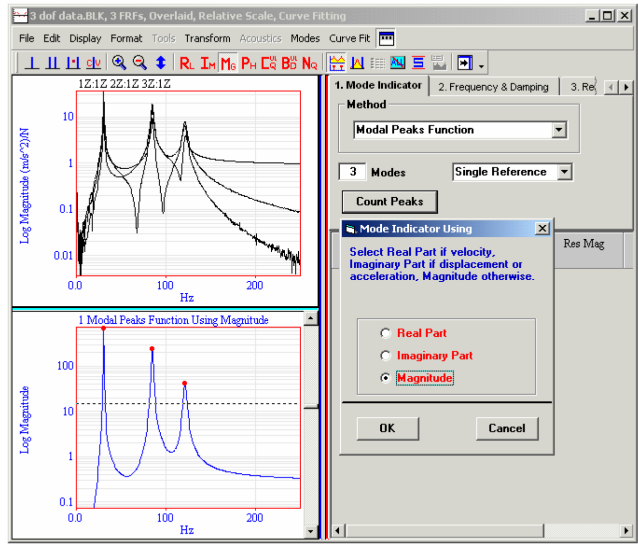
As shown in the figure above, the *Threshold Level* is drawn on the Mode Indicator graph as a dashed horizontal line. Only peaks above this line should be counted as **Modes**. The *Threshold Level* may be raised or lowered using the scroll bar to the right of the Mode Indicator graph. All peaks counted are marked with a **red dot** at each peak.

Note that if the threshold is too low, noise peaks are counted as **Modes**. On the other hand, raising the level too high will miss counting some of the peaks as modes.

Correct Part of the FRFs for the Indicator Function

Any Mode Indicator Function can be calculated using the **Magnitude**, **Real** part or **Imaginary** part of the FRFs. This is selected in a dialog box that opens when the **Count** Peaks button is pressed.

If the FRFs are either acceleration/force or displacement/force, the best choice is normally the *Imaginary* part. When the measurements are velocity/force, the *Real* part is normally the best choice. Using FRF *Magnitudes* is a "safe" choice regardless of the types of sensors employed to measure the FRFs.



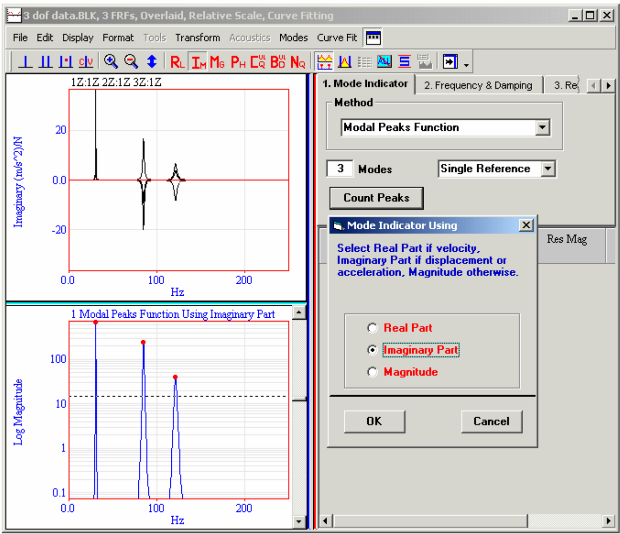
Modal Peaks Function Calculated from FRF Magnitudes.

When the **Count Peaks** button is pressed. the **Mode Indicator Using** dialog opens, offering a choice of **Real Part**, **Imaginary Part** or **Magnitude**. In the figure above, the **Magnitude** has been selected.

The **Modal Peaks Function** is calculated as the sum-of-squares of the chosen part of the FRFs using all (or selected) FRFs. Notice in the figure above that there are three resonance peaks, well separated in frequency and well above any noise peaks.

- Press the **Count Peaks** button again, but choose the **Imaginary Part** of the FRFs. The result is shown below.

Since our measurements are *acceleration/force*, each FRF *Imaginary* Part has a single narrow peak at each resonance. At the *driving point* (**M#1**), all of these peaks have the same direction. In the other *cross* measurements, a given peak may be positive or negative, depending upon the phase of the residue for that mode.



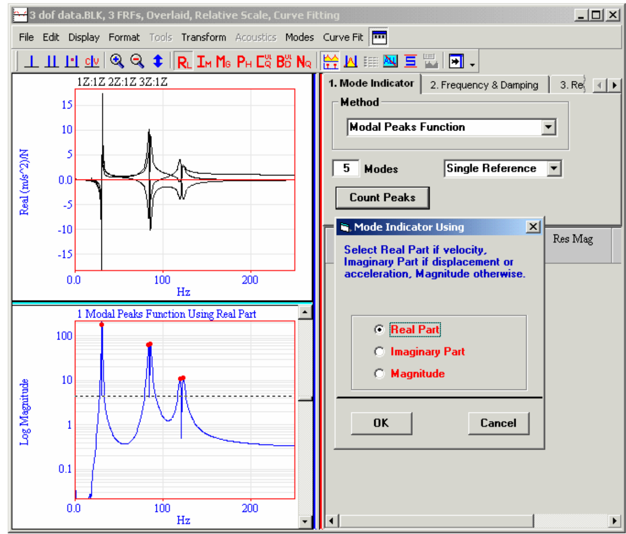
Modal Peaks Function using FRF Imaginary Parts.

Notice that the peaks in the *Imaginary* Part calculation are much narrower than those of the *Magnitude* calculation and that they are higher above the noise floor. This allows the peak counter to discriminate between closely-spaced modes and count them separately. Matching the FRF part used in the calculation to the type of sensors used for the FRF measurements provides an *optimum* **Mode Indicator** for counting peaks.

Now consider what happens when the *wrong* FRF part is chosen. In this instance, the wrong part is the *Real* Part of our *acceleration/force* measurements.

- Press the **Count Peaks** button again, but choose the **Real Part** of the FRFs.

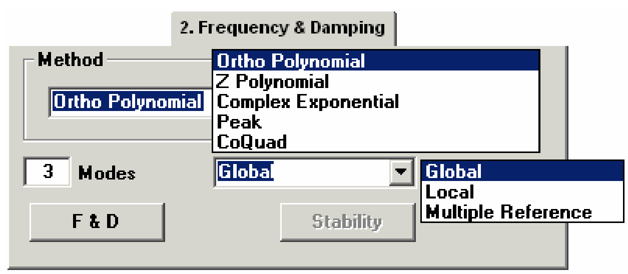
As shown above, selecting the wrong FRF part sums functions that have *two peaks of opposite sign* surrounding each resonance. This results in a **Modal Indicator** that has pairs of peaks surrounding each resonance and the *wrong number of modes is counted*. Clearly, using the **Imaginary** part or the **Magnitude** is better than using the **Real** part in this case.



Modal Peaks Function using FRF Real Parts.

STEP 2: Estimating Frequency & Damping

- Select the **Frequency & Damping** tab as shown below.



Available Frequency & Damping Selections.

In the **Method** drop-down list, you can select one of five methods to identify the frequency and damping of the modes. The **Ortho**gonal **Polynomial** method is the **default** method.

Note: The **Z Polynomial** and **Complex Exponential** methods are used with the **Stability Diagram**. These methods require **Visual Modal Pro** or any package containing the **VES 450** Advanced Modal Analysis Option. Application Note #19 discusses the use of the Stability Diagram.

The **Peak** and **CoQuad** methods estimate modal frequency using the **Peak Cursor** and **Line Cursor**, respectively. These methods *do not estimate damping values* and *fit functions* cannot be displayed without damping estimates. **Peak** and **CoQuad** are used primarily when dealing with poor quality measurements. Their use will not be discussed here.

All of the F&D fitting methods can be used to make a **Global** fit (the **default**), a **Local Fit,** or a **Multiple Reference** fit.

> **Note:** For information on Multiple Reference curve fitting see Application Notes #6, #14 and #15.

Since frequency and damping are *global* parameters of a structure, the **Global** fit is ideally the best method for estimating them. When this choice is made, all (or selected) FRFs are used in the 'least-squares" fit to obtain a single frequency and damping estimate for each mode in the **Modes** box. This was done when **Quick Fit** was previously executed.

Why Use Local Fitting?

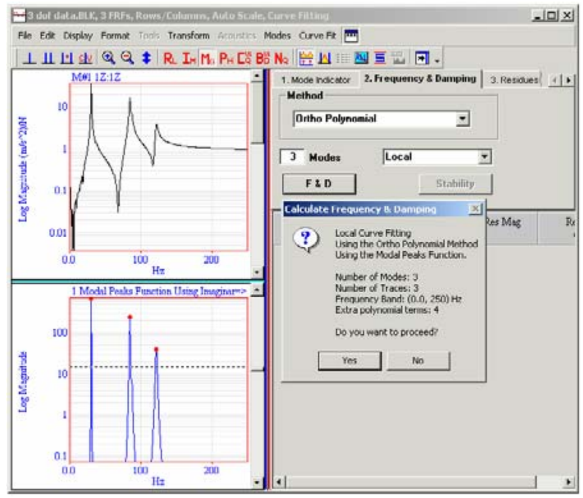
Sometimes resonant frequencies (and damping) will 'drift' from measurement to measurement. A common cause of this phenomenon is variable "mass-loading" when a relatively heavy accelerometer is moved around on a relatively light and responsive structure. Other test-specific cases can occur that cause these global parameters to change from measurement to measurement. These include "growth" of the structure with temperature, or changes in its mass distribution during a test.

When this phenomenon is encountered in a set of FRFs, using the **Local** fit option can improve the curve fitting results.

Let's perform a Local fit to the data in the **3-DOF.BLK** Data Block and examine the results.

Execute: **Curve Fit | Clear All Fit Data** to remove any prior fitting data.

- Return to the **Mode Indicator** tab and execute **Count Peaks** using the **Modal Peaks Function** and the **Imaginary Part** of the FRFs.
- On the **Frequency & Damping** tab select **Ortho Polynomial** and **Local** from the drop down lists.
- Press the **F&D** button.



Local F&D Fit Using Ortho Polynomial.

The **Calculate Frequency & Damping** dialog will open, as shown above. Verify that all entries match this figure and press the **Yes** button. The F&D fit will then be performed.

Use the scroll bar in the measurements graph to step through the display of the FRFs. Notice that the **Frequency** and **Damping** values for each mode are slightly different for each FRF, as shown below.

1Z:1Z

Mode	Frequency (Hz)	Damping (%)
1	29.98	0.9733
2	84.5	1.025
3	121	1.32

2Z:1Z

Mode	Frequency (Hz)	Damping (%)
1	29.93	1.109
2	84.47	0.9714
3	120.9	1.339

3Z:1Z

Mode	Frequency (Hz)	Damping (%)
1	29.98	0.9822
2	84.41	1.085
3	120.9	1.298

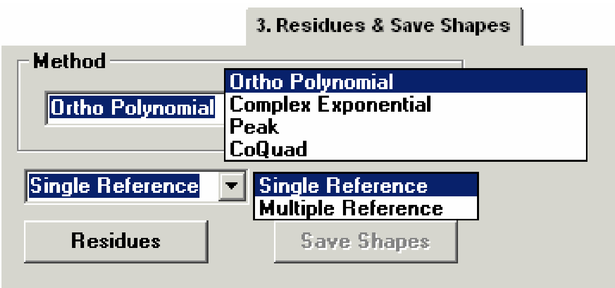
Variation of Local Fit Frequency and Damping.

To see if **Local** fitting made a significant improvement in the results, we must obtain residues, save mode shapes and compare the mode shapes with the **Global** fit results.

> **Remember:** Curve fitting is only a means to an end. Obtaining a set of accurate modal parameters is the overall objective of curve fitting.

STEP 3: Estimating Residues & Saving Shapes

- Select the **Residue & Save Shapes** tab.



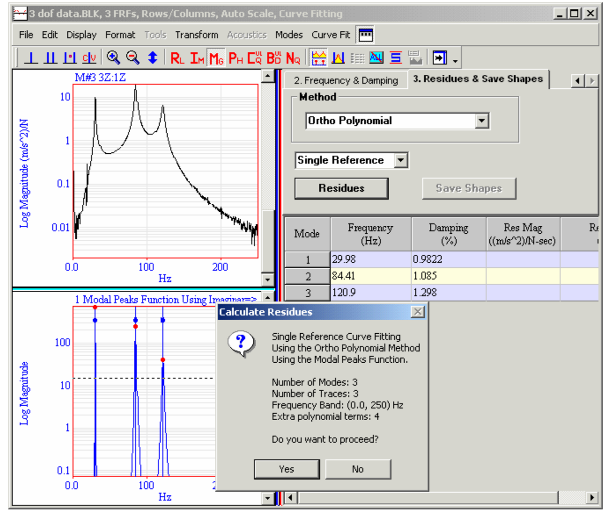
Available Residues Tab Selections.

In the **Method** drop-down list,you can select from four Residue fitting methods. The **default** method is **Ortho Polynomial**. Again, the **Peak** and **CoQuad** methods are not discussed here. They are normally only used on low quality measurements. The **Complex Exponential** will be compared with the **Ortho Polynomial** method later in this note.

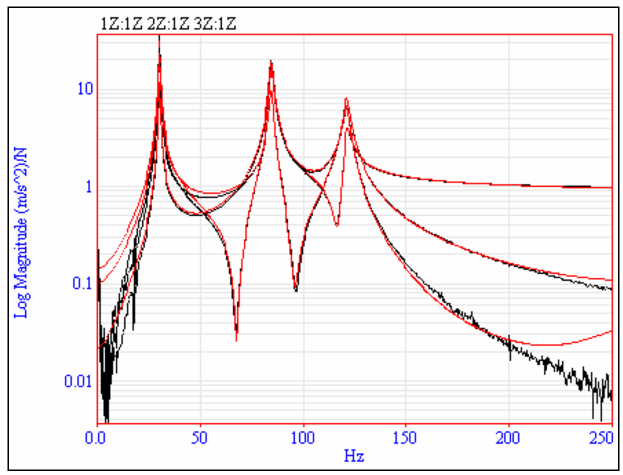
All of the **Residue** methods can be applied to either **Single Reference** or **Multiple Reference** sets of FRFs.

- Select the **Ortho Polynomial** and **Single Reference** methods on the Residues tab.
- Press the **Residues** button.

The **Calculate Residues** dialog will open, as shown in the preceding figure. Verify that all entries match this figure and press the **Yes** button; the **Residue** fit will be performed.



Ortho Polynomial to Complete Local Fit.



FRFs & Fit Functions using Local Frequency & Damping.

As shown in the figure above, the match between the (black) FRFs and the (red) fit functions and is comparable to that found from the **Quick Fit** results. This is expected since the data of this example does not contain any noticeable frequency shifts.

- Press the **Save Shapes** button and save the modal parameters into a new Shape Table named **Local Mode Fit.SHP**.
- Open the **Quick-Fit Modes.SHP** window.

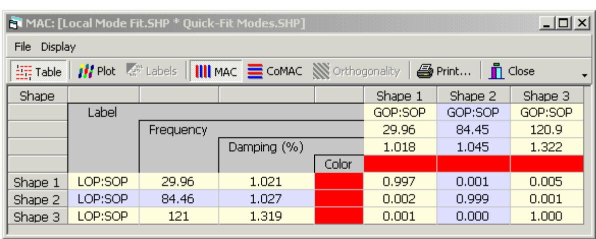
Mode Shape Comparison

As already mentioned, the purpose of curve fitting is to obtain accurate modal parameters. One way of determining whether or not the results are accurate is to compare the parameters obtained for different curve fitting methods. The **Modal Assurance Criterion (MAC)** is a quantitative method for comparing mode shapes.

The **Cross MAC** compares mode shapes from two Shape Tables and presents the results in a matrix. Each matrix element is a measure of the similarity between two shapes. A MAC value of **1** means that the shapes are the same, and a MAC value of **0** means that they are different.

Execute: **Display | Cross MAC** in the **Local Mode Fit.SHP** window. A dialog box will open.

- Select **Global Fit.SHP** and click on **OK**.



MAC: [Local Mode Fit.SHP * Quick-Fit Modes.SHP]

Shape	Label	Frequency	Damping (%)	Color	Shape 1	Shape 2	Shape 3
Label					GOP:SOP	GOP:SOP	GOP:SOP
Frequency					29.96	84.45	120.9
Damping (%)					1.018	1.045	1.322
Shape 1	LOP:SOP	29.96	1.021		0.997	0.001	0.005
Shape 2	LOP:SOP	84.46	1.027		0.002	0.999	0.001
Shape 3	LOP:SOP	121	1.319		0.001	0.000	1.000

Cross MAC between Local and Global Fit Shapes.

Rule of Thumb: MAC values above **0.9** indicate that two shapes are similar to one another.

The rows of the matrix in the figure above represent the **Local Fit** shapes while the columns represent the **Global Fit** (using Quick Fit) shapes. Notice the close agreement between these two sets of shapes. The smallest diagonal element in the MAC matrix is **0.997** and the largest off-diagonal element is **0.005**. In essence, the **Local** and **Global** fit methods produced *identical* mode shapes.

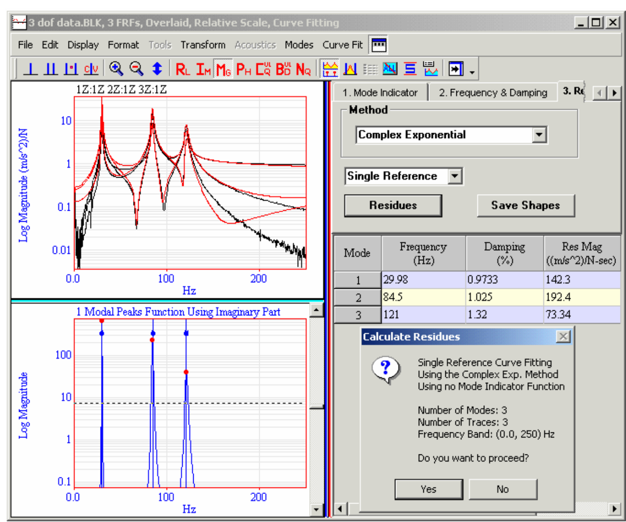
Frequency and Damping Comparison

Also, the *frequency* and *damping* values for the rows of the matrix are *averages* of the three **Local** estimates of each mode found by the **Local** fit. These averages were stored in the **Local Mode Fit.SHP** Shape Table (when the **Save** Shapes button was pressed) as the best representation of the *global* frequency and damping. Notice the very close agreement with the values found by the **Global** (or Quick Fit) results in the columns of the MAC matrix.

Comparison of Polynomial and Complex Exponential Methods

The Residues previously calculated using the **Ortho Polynomial** method will now be compared to new ones calculated with the **Complex Exponential** method.

- Close the **MAC** window.
- Minimize the **Quick-Fit Modes.SHP** and **Local Mode Fit.SHP** windows.
- On the **Residues and Save Shapes** tab, select **Complex Exponential** from the drop down list press the **Residues** button.

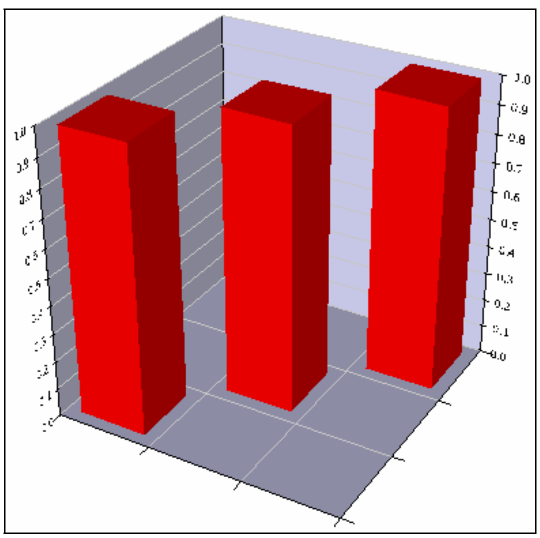


Estimating Residues using Complex Exponential Method.

- Verify the listing in the **Calculate Residues** dialog with the figure above, and press the **Yes** button.

Notice that the **Frequency** and **Damping** parameters remain unchanged. Only the **Residues** (Magnitudes and Phases) have been replaced with a new set of estimates. Also notice that the new (red) fit functions match the (black) FRFs well.

- Press the **Save Shapes** button and save the mode shapes into a new Shape Table named **Local Fit using CE Residues.SHP**.
- Use the **Cross MAC** calculation as done before to verify that **Local Fit using CE Residues.SHP**, **Local Mode Fit.SHP** and **Quick-Fit Modes.SHP** contain essentially the same mode shapes.



MAC plot of Complex Exponential and Ortho Polynomial Mode Shapes.

ORTHO-POLY IN NARROW BANDS

The **Ortho-Polynomial** method tends to work best when applied to a narrow bandwidth of FRF data containing only a few resonance peaks. On the other hand, the **Complex Exponential** method works best with wide frequency bands of data and lots of modes at a time.

When FRFs contain many modes, you can often improve the performance of the **Ortho-Poly** fits by using the **Band Cursor** to divide the measurement bandwidth into several narrower *fitting bands*.

Note: When the Band Cursor is turned ON, only data in the band is used for curve fitting.

Cursor placements should surround one or more resonance peaks, and can be guided either by the **Modal Indicator** function or by displaying the FRFs in overlaid format.

We will fit the example data using the **Ortho-Poly** method and two narrow *fitting bands*.

- Close the **MAC** window and minimize the **Local Fit using CE Residues.SHP** window.

  Execute: **Curve Fit | Clear All Fit Data** in the **3-DOF.BLK** window to remove all prior curve fitting data.

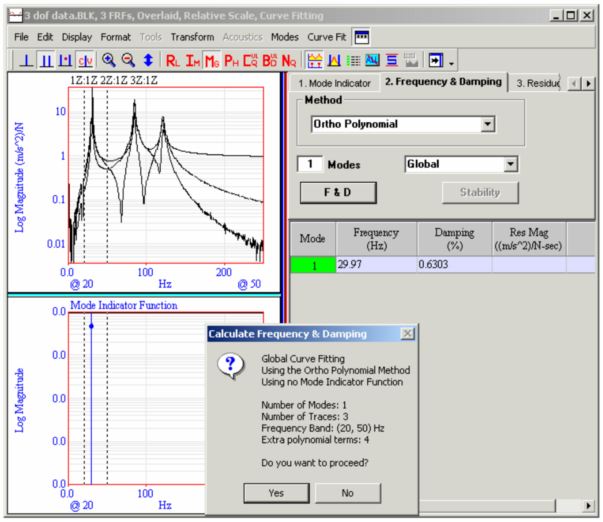
  Execute**: Display | Cursor | Band Cursor** to turn ON the band cursor.

  Execute**: Display | Cursor | Cursor Values** to display the cursor band values with the FRFs.

- Click on the **Frequency & Damping** tab and select **Ortho Polynomial** and **Global** from the drop down lists.

Adjust the **Band Cursors** to surround the lowest frequency peak in the FRFs. In the figure below, a band of 20 to 50 Hz was used. The **Band Cursor** now defines the *fit interval* used for the curve fitting.

- Enter **1** into the **Modes** box.
- Press the **F&D** button.
- Verify the desired calculation on the **Calculate Frequency & Damping** dialog and press **Yes**.



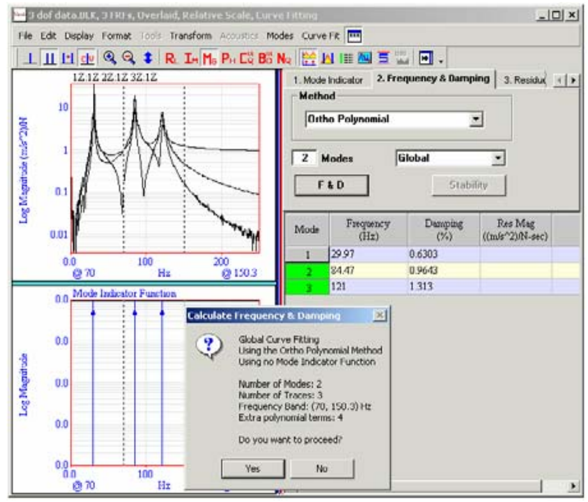
Fitting Band for Mode 1 using the Band Cursor.

The **F&D** estimates for one mode are placed in the **Modal Parameters** spreadsheet, as shown in the figure above. The modal frequency is also indicated by a vertical blue line on the **Mode Indicator** graph.

- Place the mouse pointer *inside* the Band Cursor and drag it toward the second and third peaks.
- Place the mouse pointer *outside* each edge of the Band Cursor and drag it to enclose a band of 70 to 150 Hz, as shown below.

This second *fitting band* clearly includes the 2nd and 3rd resonance peaks.

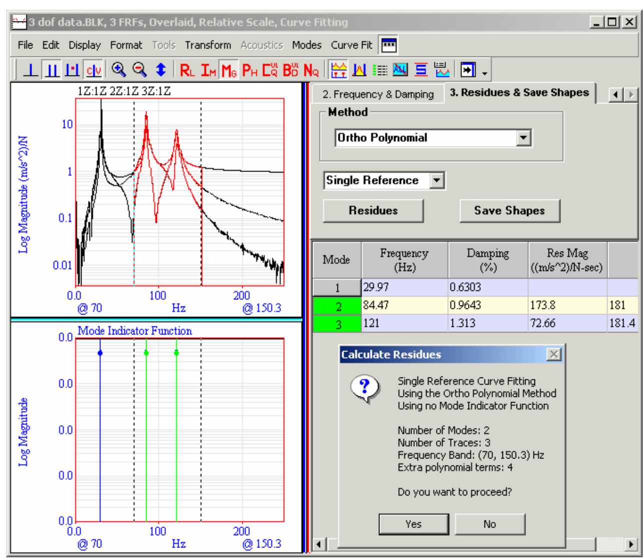
- Enter **2** into the **Modes** box.
- Press the **F&D** button again, and press **Yes** to calculate frequency and damping for the two modes.



Fitting Band for Modes 2 & 3 using the Band Cursor.

Frequency and damping for the 2nd and 3rd modes are extracted from the FRFs using data within the second *fitting band*. These parameters are added to the **Modal Parameter**s spreadsheet.

- Click on the **Residue & Save Shapes** tab and select **Ortho Polynomial** and **Single Reference** form the drop down lists, as shown below.



Residues for Modes 2 & 3 Using the Band Cursor.

- Press the **Residues** button and press **Yes** in the dialog that opens.

Residues for the *selected* modes (2 & 3) are added to the **Modal Parameters** spreadsheet and fit functions are overlaid on each FRF in the *fitting band* used.

To estimate the **Residue** for the 1st mode:

- Double-click on the **Mode** column header to *unselect* modes 2 & 3.
- Press the **Select** button for mode **1**.

Notice that when mode 1 is selected, the Band Cursor moves to the 20 to 50 Hz span of the first *fitting band*.

- Press the **Residues** button again and press **Yes** to complete the curve fit.

The **Residues** for mode 1 are added to the **Modal Parameters** spreadsheet, and the fit functions are overlaid on the FRFs in the first *fitting band*.

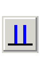
> **Warning:** If modes are *selected* when the Save Shapes button is pressed, only parameters for the *selected* modes will be saved into a Shape Table.

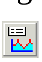
- **Double-click** on the Modes column heading in the Modal Parameters spreadsheet to *unselect* all modes.
- Press the **Save Shapes** button and save these modes as **Manual Fit.SHP**.
- Use the **Display | Cross MAC** command to compare them with the previously obtained mode shapes.

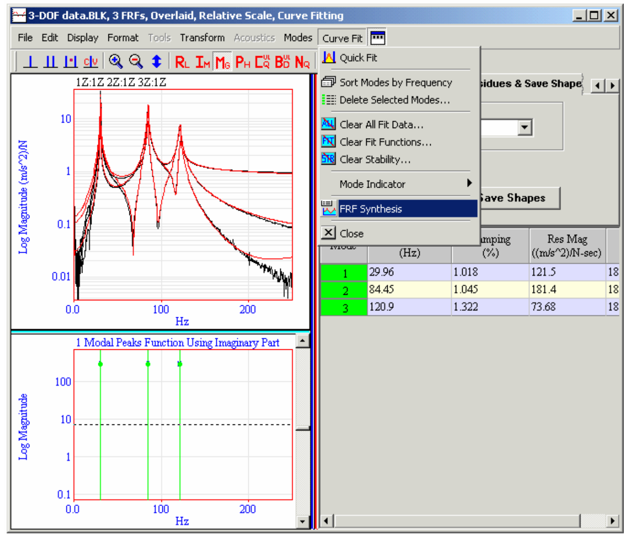
Again, the MAC values should indicate close agreement between these mode shapes and those obtained previously.

FIT FUNCTIONS FROM MODAL PARAMETERS

As a last step, we will synthesize *fit functions* using the modal parameters themselves.

 Execute: **Display | Cursor | Band Cursor** again, to turn the Band Cursors Off.

 Execute: **Curve Fit | FRF Synthesis**.



Fit Functions Synthesized from Modal Parameters.

Note that these *fit functions* now overlay the FRFs over the whole frequency band of the FRFs.

SUMMARY

By carrying out the steps of this note you have done the following:

1. Displayed ODS's in animation directly from the FRFs.
2. Used **Quick Fit** to automate the three steps required to curve fit a set of FRFs.
3. Displayed the resulting **Mode Shapes** in animation.
4. Examined the details of the three curve fitting steps carried out by Quick Fit.
5. Compared **F&D** fitting using **Global** and **Local** methods, and evaluated the resulting mode shapes using the **Modal Assurance Criterion**.
6. Compared **Residue** fitting using the **Complex Exponential** method with **Ortho Polynomial** results.
7. Compared **Ortho Polynomial** results using two *fitting bands* with the results obtained from the wide band fits.