VPG NVH Post Processing

Introduction

Since VPG simulations may make use of time domain events, they provide an ideal opportunity to also investigate the NVH response of a mechanical system during a test.

VPG simulations can be thought of test as events which may include all of the vibration responses of a structure, due to external excitations, in the same manner as a physical test. In that way, we may simulate the physical test and evaluate the structure in a manner consistent with the test.

If we think of a physical test in which we would like to study the vibrational response, we may affix accelerometers to the structure and then provide some excitation. This excitation may be a electrodynamic shaker input , an impact hammer, or operational inputs such as a vehicle moving over a road surface. These responses are then captured by the accelerometers and saved onto a recording device for post-test analysis.

From these tests we can study the structure's response to specific inputs or to a spectrum of inputs, and perform digital signal processing to identify significant responses of the structure.

These types of simulations may be performed with eta/VPG, for the purpose of studying a system level dynamic response.

eta/VPG Simulations

eta/VPG simulations make ise of a dynamic nonlinear finite element software, LS-DYNA, as a calculation engine. This software provides a set of material models, contact algorithms and damping models for use in system level event simulation.

VPG simulations can be used to simulate compete structural aspects of the test event, including the transmission of forces to the various components which make up a system. Since the simulation is dynamic/transient in nature, we can see the response of the structure with respect to time. These simulations may be performed for the purpose of stress prediction, but can simultaneously be used to measure the dynamic response.

To measure these dynamic responses we make use of "virtual accelerometers", placig them in the locations which we may consider for testing measurements. However, we have the opportunity to place these accelerometers at any location there is a node in our finite element model.

To achieve this we define a NODE SET in our model and request that this NODE SET be output to the NODOUT file at a reasonable output frequency. This frequency may match your physical test's output, for convenience.

Example Problem: Frame Modal Analysis

A truck frame model is used as our example, to determine the mode shape and associated frequencies of our structure. This model will simulate the response of the frame due to impact pulses at various locations in the structure.

Measurement locations were chose along the top of the frame, as they might be for a physical test. For visualization purposes, we have also defined a set of PLOTEL elements, so that we may easily view the results of the simulation. This is not a specific requirement, but a recommendation.

The example input file is “truckframe.dyn”, and includes all of the material data and excitations necessary to perform the simulation. The model is shown in Figure 1.

With the analysis complete the output needed to perform the NVH analysis is located in the NODOUT file. This file contains displacement, velocity and acceleration data for each node. This data is output for each time specified in the CONTROL_DATABASE_NODOUT card in the input file.

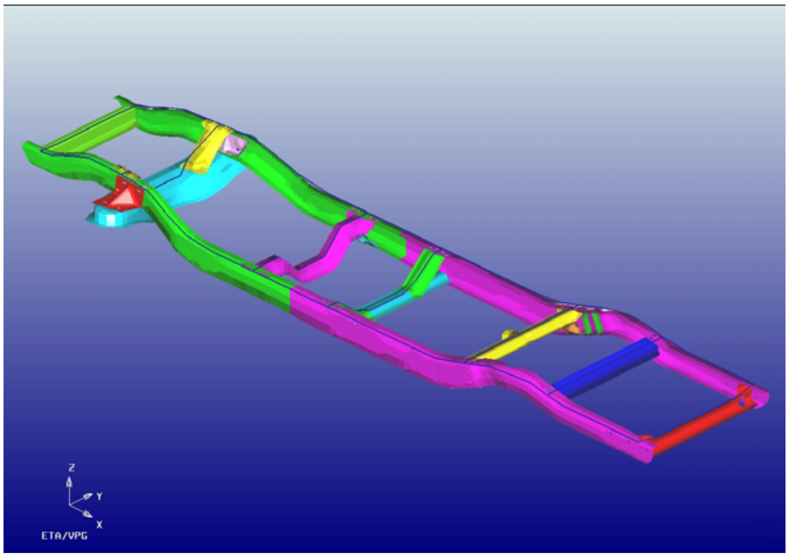

Figure 1. Truck Frame Model for NVH Analysis

To perform the NVH analysis of the impact event, the user open the VPG Post Processor, by selecting POST from the top menu in VPG. This action creates a temporary database file of the current VPG database, closes the VPG window and opens an empty post processing window.

The user then selects FILE from the Main Menu, and selects the *.dyn file type. For our example we will read the file “truckframe.dyn”. After the file is successfully read into VPG, the model will be displayed in the viewing window.

Also at this time an additional icon will be available on the top menu. This NODOUT TO MODESHAPE menu allows the user to post process the NODOUT file associated with this model and simulation.

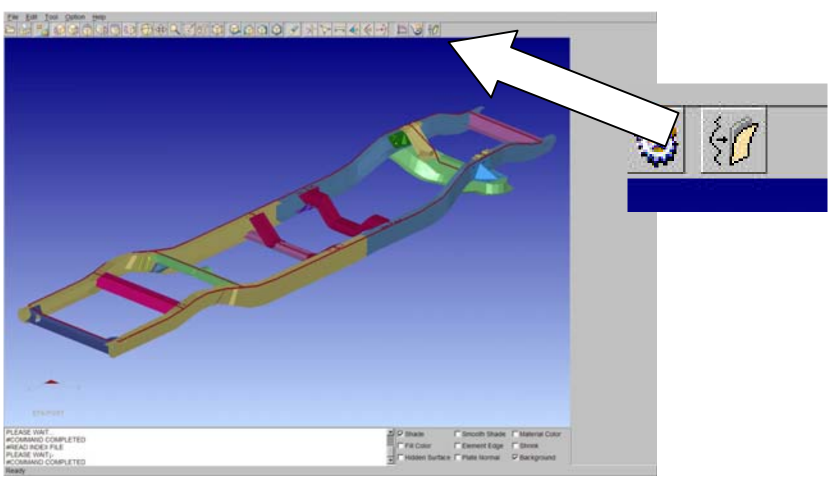

Figure 2: Post Processor Window and Detail of NODOUT to MODE SHAPE Icon

When the NODOUT TO MODESHAPE icon is selected, a menu will be opened allowing the user to import the file, specify the nodes to be processed, FFT parameters, and graphing options.

To read the NODOUT file, the user selects the LOAD CURVE button. This will open a File Selection window. The user should select the NODOUT that corresponds to their model. Please note that the model must have identical node numbering as the NODOUT file in order for the processing to be completed and the display of the results meaningful.

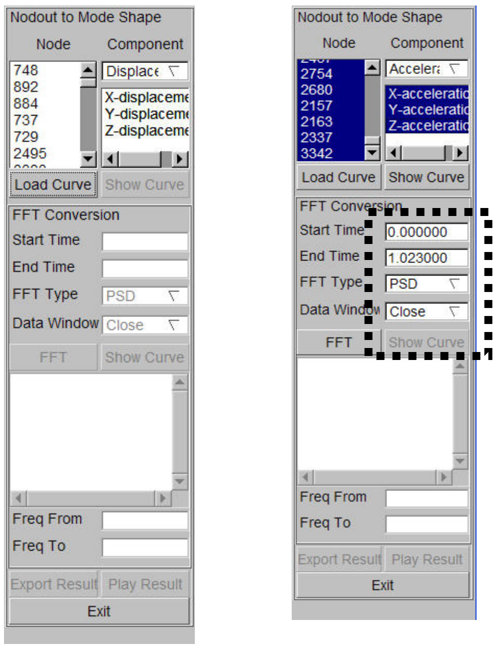

Figure 3: Node and Component Lists, FFT Options

Upon successful reading of the NODOUT file, the user will see a listing of node numbers and analysis results displayed in the top portion of the NODOUT TO MODESHAPE menu. For our example, it should appear as shown in Figure 3.

The user selects the desired nodes for processing from the list. As the nodes are selected, the node numbers and locations will be highlighted on the model. Multiple nodes may be selected by holding the SHIFT key while marking the node numbers in the list.

Selection of the quantity and component to be evaluated is performed in a similar manner. The user may select any or all of the components listed. If the NODOUT file does not contain any of these quantities, they will not be available for selection.

As the quantities are selected, VPG will provide options for processing the FFT (Fast Fourier Transform); event start/stop time, type of FFT, and windowing options. The user may opt to select only a portion of their time signal, and may select to have the FFT calculated using the PSD or amplitude of the data signals. Windowing may be used if desired by the user.*

The user may choose to display a graph showing the data selected in the NODE and COMPONENT fields. Selection of the SHOW CURVE button will open a graphing window which displays the curves. The user may print or process the curves using the toolset found in the graphing window. Any modification to the data will not be reflected in the subsequent signal processing.

The Graphing window may be closed by selecting the window close (X) on the window.

The graph of the X, Y and Z acceleration for all nodes versus time in our NODOUT file is shown In Figure 5. Note how the initial response decays over time for each of the node responses.

For our example, we will use the default parameters for the start/stop time, FFT type (PSD) and windowing (close).

To execute the FFT operation, the user selects the FFT button. The response time for this operation will be dependant on the number of nodes selected and the time duration of the event. However, in general this should require no more than a minute for our example model.

As the FFT operation is completed, a listing of mode numbers and associated frequencies are displayed. Please note that these are not eigenvalues or “natural modes” of the structure. These values represent a series of operation deflection shapes, calculated at a specific interval in the model, using the deformation and phase angle information calculated from the analysis.

Again, at this time we may display the graphical data associated with this operation. To display the FFT data ; PSD versus frequency, select the SHOW CURVE button to open a graphing window displaying the curves.

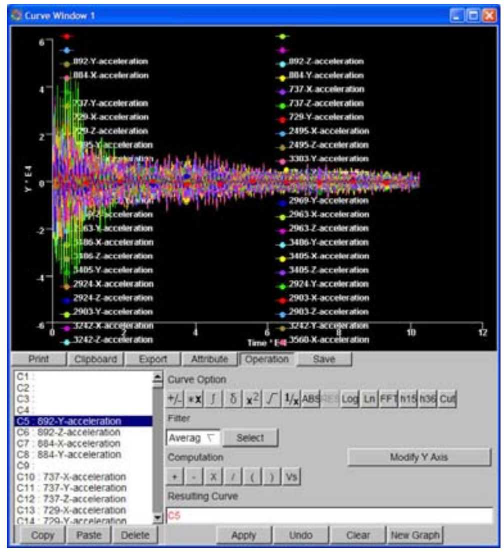

Figure 4: Acceleration vs. Time Curve

This is a valuable feature, since it allows the user to identify the frequencies which have the highest response. In our case we can see that if we look closely at the results, there is a large global response at 63.491 Hz. We know this is a global response, since many of the nodes have a significant response. Other frequencies indicate that only a single node may be active.

VPG also calculates the maximum frequency which may be created from the NODOUT data. This is based on the time increment between output steps. Our maximum frequency is 500 Hz, since our output time step is 0.001 seconds.

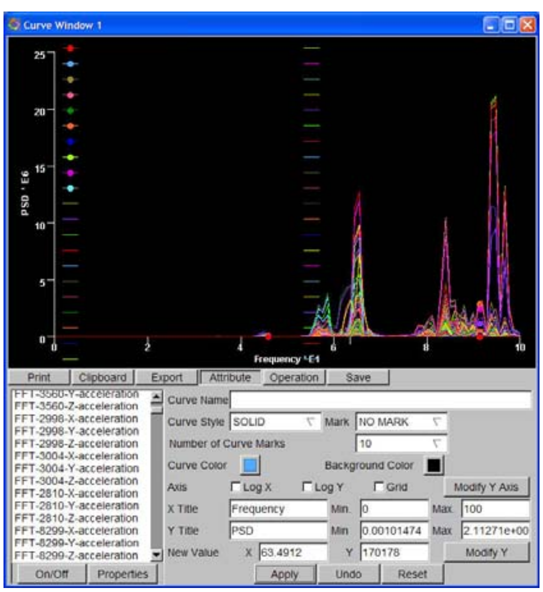

Figure 5: PSD vs. Frequency Curve

To view the mode shape associated with this frequency, the user selects the mode of interest from the mode number/frequency list. To view the results in the form of an animation, the user selects the PLAY RESULT button. The selected mode(s) will be loaded into the animation menu. The user then may select the modes to animate and control the replay of the mode shape animation.

Selecting the SUBCASE from the list will load the associated frequency information. The user then selects the desired frequency from the list.

The animation is controlled by using the play/pause/ fast forward/rewind/record buttons. The number of frames can be changed by the user to achieve the desired motion effect for the animation. These options are shown in Figure 6.

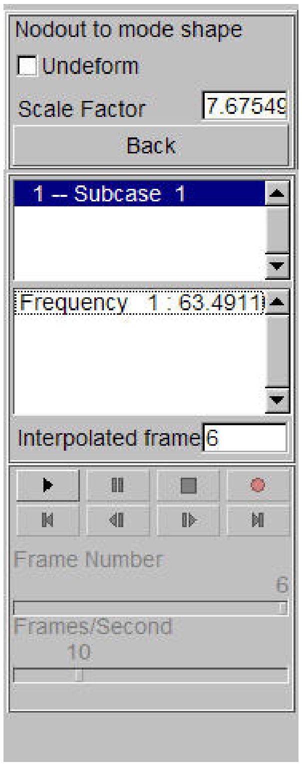

Figure 6: Subcase Selection and Animation Control

If the user would like to process additional mode, they may select the BACK button to return to the previous menu.

For visualization purposes, the user may want to animate only the nodes which have results. For this reason, the user should turn off all parts with the exception of the PLOTEL elements. The mode shape for our example at 63.491 Hz is shown in Figure 7.

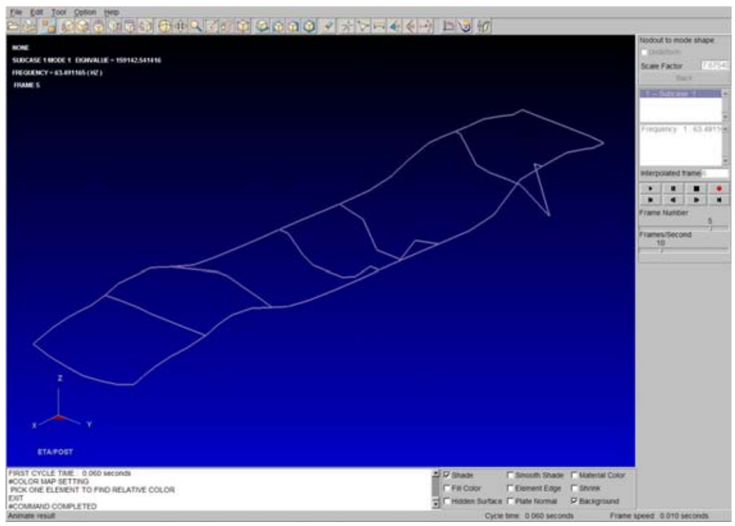

Figure 7: Mode Shape Display

* For a complete discussion of these quantities and calculation options, it is recommended that the user refer to an appropriate text on Digital Signal Processing