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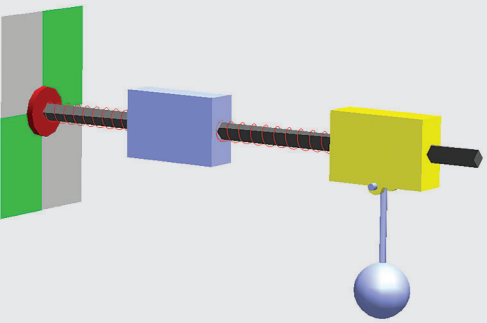
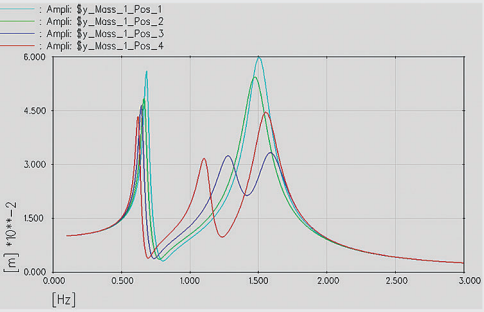
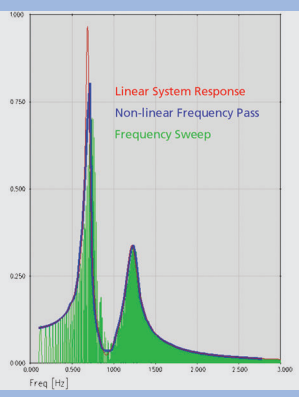
Noise, Vibration, Harshness – NVH



Two Mass Oscillator with Actuator and Non-Linear Vibration Absorber



Parameter Variation Using Linear System Response. Displacement of Blue Mass with Various Pendulum Lengths



Comparison of Methods. Displacement of Yellow Mass.

Whether for comfort analysis, system layout, durability or even analyses up into the acoustic range, the NVH module within SIMPACK offers users the ability to investigate just about any complex systems almost instantaneously. The suitability of these methods may be readily checked because SIMPACK allows easy result comparison between non-linear models, using iterative time integrations, and the linearised models which use analytical methods. The NVH module also offers various additional techniques which aid users in investigating non-linear models in the time domain.

HISTORY

Many of the NVH methods within SIMPACK were available in the mid-eighties, even before SIMPACK had been in existence. Several techniques were realised by the DLR (German Aerospace Centre), in SIMPACK's predecessor software called Medyna. Medyna is primarily a linear software analysis tool used in the wheel-rail industry. In 1993 the decision was taken by the DLR to discontinue development work on Medyna and focus on the development of SIMPACK, thus passing vast amounts of expertise and know how onto SIMPACK.

LINEAR SYSTEM ANALYSIS

Any model within SIMPACK may be linearised enabling modal analysis. An investigation of the modal energies and vector diagrams may also be readily carried out. With the NVH module, further investigations in the frequency domain, of the linearised model, may be undertaken.
Applying an excitation to a model, in the form of a force, torque or displacement, a user may employ "Frequency Response" to obtain the transfer function of any output signal in relation to the excitation signal. Phase difference between the signals is also given. "Linear System Response" differs from "Frequency Response" in that the actual value of the output signal, with respect to frequency, is calculated. Also, several simulataneous input excitations may be applied to the system. The spectral density of a system, primarily used for comfort analysis in the frequency domain, may be obtained using "Spectral Analysis". "Covariance Analysis" delivers the covariance matrix of a system, which gives an indication of how the input and output signals are coupled.

PARAMETER VARIATION AND COMPARISON

Perhaps one of the greatest advantages of NVH is the ability to carry out analyses on a large number of model variations within literally seconds of CPU time. For example, the resultant effects on an entire system caused by varying the length of a pendulum, used as a vibration absorber, may be quickly understood. Not only can a user carry out extremely fast investigations of a linearised system but also compare the difference between the linearised and non-linear model, thus determining the suitability of the applied method.

TIME DOMAIN

Using the non-linear model, a frequency range may be investigated by applying a "Frequency Sweep" time excitation to the system. Because the excitation signal is continually changing the system is never in a truly settled state. Transient effects may be reduced by using a longer simulated time period, with the same frequency range, but this will also increase CPU times. In order to eliminate all transient effects the "Non-linear Frequency Pass" (NLFP), has been implemented into SIMPACK.

NON-LINEAR FREQUENCY PASS

Using NLFP, a system is excited using sinusoidal or rotational, used for simulating unbalanced masses or roller rigs, input signals. Once the system has settled down into a steady state oscillation, the amplitude and phase of all output signals are recorded and the excitation frequency is then

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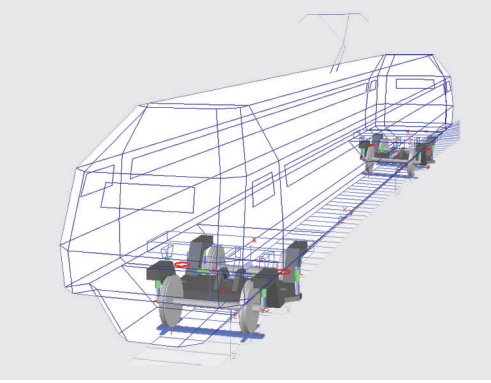
advanced to the next frequency step, and the procedure is repeated. Thus an entire range of frequencies may be easily investigated without the undesired transient effects.
Complete vehicles, employing either test rigs or track/road excitations, may be investigated using a number of NVH techniques. Because a stochastic signal may be easily converted into a track or road excitation, SIMPACK enables straight forward comparison between linearised and non-linear (using time integration and FFT post processing), analyses. A very useful tool for ensuring method suitability.

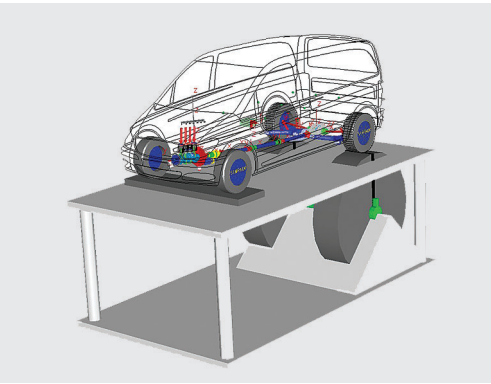
PRE- & POST-PROCESSING

The NVH module also offers a pre-processing tool which helps determine the polynomial coefficients from measured data for simulating frequency dependent force elements. A new post-processing filter enables quick order analysis, often necessary for vibration investigations of engines and drive trains.

The SIMPACK NVH module offers users the power to examine complex systems almost instantaneously. Because a model may be investigated either within the frequency domain or time domain, using the same excitations, a SIMPACK user can always be confident in the chosen methods suitability.



Analyses Using Either the Linearised or Non-Linear Model



Complete Vehicle Testing with Roller Rig