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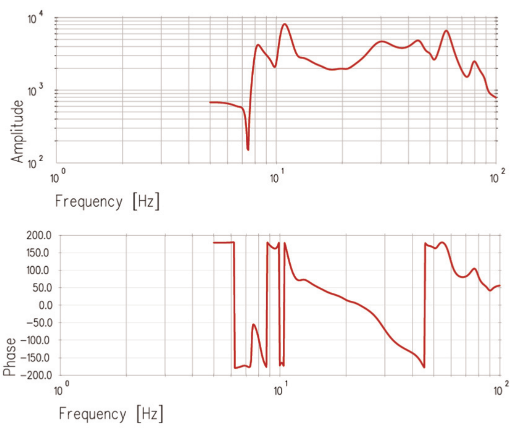
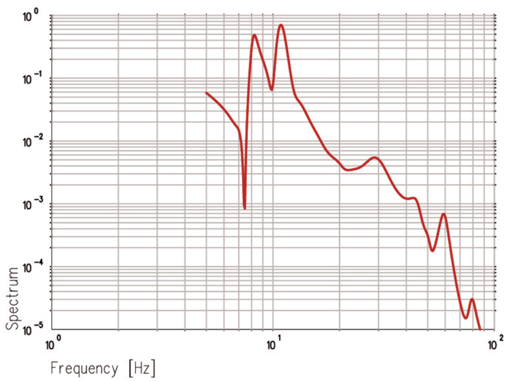
New Plug-In for Version 8.5: SIMPACK NVH

Noise, vibration and harshness problems are often very cumbersome to solve numerically due to the high frequency vibrations. This leads to models which contain a significant amount of detail. 'Parameter Variation' is often required to find a solution for NVH problems, however, due to the long calculations required, it may not be possible to use a standard time integration, even using the SIMPACK solver. SIMPACK has therefore been able to solve NVH problems in the frequency domain since version 6 and the new SIMPACK release will contain new model libraries and extended time domain solver features. Overall this will lead to excellent performance times and calculation accuracy for high frequency calculations.



Result of a Frequency Response Analysis



Spectrum: Response to Stochastic Excitation

An example of an exhaust system, see figure on page 11, has been used in this article to demonstrate the functionality of SIMPACK NVH. Linear calculation methods have been applied to obtain an overview about the system behaviour. The linear characteristics of springs and dampers were then replaced by frequency dependent, and later by fully non-linear characteristics. The system is excited by signals which are applied to the rubber bearings on the car body and also by the engine vibration.

Linear System Analysis

Linear calculation methods have been an integral part of SIMPACK for a number of years and with version 8.5, SIMPACK NVH will include the entire Linear System Analysis, i.e. Frequency Response Analysis, Linear System Response and Power Spectral Density Analysis. Linear System Response can be used to create Bode plots with multiple input signals that are linked to each other by user-defined functions. Stochastic response functions can be created using Spectral Analysis.
SIMPACK users can take full advantage of the Linear System Analysis which offers excellent analytical solvability by efficiently performing the linearised calculations. The general non-linear equations of motion are linearised automatically by SIMPACK to allow the user to get an overview of the system's behaviour in the frequency domain.
Additionally, the Linear System Analysis is fully integrated in the SIMPACK module 'Parameter Variation', i.e. the user can obtain an overview of the system behaviour with very little effort. SIMPACK's 'Parameter Variation' functionality allows up to three different sets of parameters to be varied during one calculation run.

Time Domain Analysis

If non-linear connection elements or friction elements play an important role for NVH problems, there is often no alternative to running a time integration. SIMPACK NVH minimises the impact of high frequencies in time domain calculations. Because amplitudes that generally occur during a vibration analysis are usually small, the non-linearity of the kinematical equations often does not have a significant impact on the results. This opens up the potential to save calculation time and SIMPACK NVH utilises this fact by offering a time integration approach which is based on linearised kinematics. The force elements, however, can still be modelled as non-linear elements, i.e. friction can still be part of the system. These mixed equations of linearised

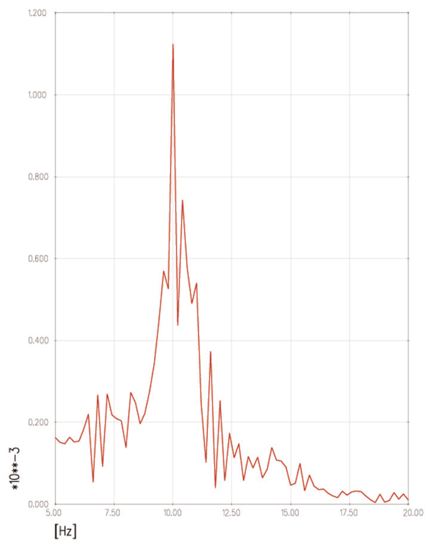
kinematics and non-linear forces considerably increase the numerical performance. The time required to perform a time domain analysis on an exhaust system example, for instance, has been decreased by a factor of five using this method.
Efficient time domain solutions for systems with high frequencies are also available through the use of SIMPACK's Symbolic Code. Solution times can be still further reduced as SIMPACK's symbolic solver allows the optimisation of the equations for each specific model.

Modelling Elements

A new time excitation element has been created to control time domain calculations, which imitates the frequency domain approach. An excitation signal is applied between certain frequency limits until an arbitrary response signal (such as position, velocity, acceleration or force) has reached a steady state solution, i.e. the signal's final amplitude is within a certain tolerance. The frequency of the excitation is then increased and the process restarted. This results in a 'quasi-non-linear' frequency response analysis, where the amplitude response and the phase angle are plotted against frequency. However the individual results are obtained by the time integrator, allowing completely non-linear or partially linearised models to be used.
If the frequency dependency of the exhaust mounts of our example is to be investigated, SIMPACK NVH offers a pre-processor which automatically creates a transfer function (using numerator and denominator polynomials) based on the input file. This polynomial can then be used in both the time and frequency domains.

SIMPACK NVH for Current SIMPACK Users

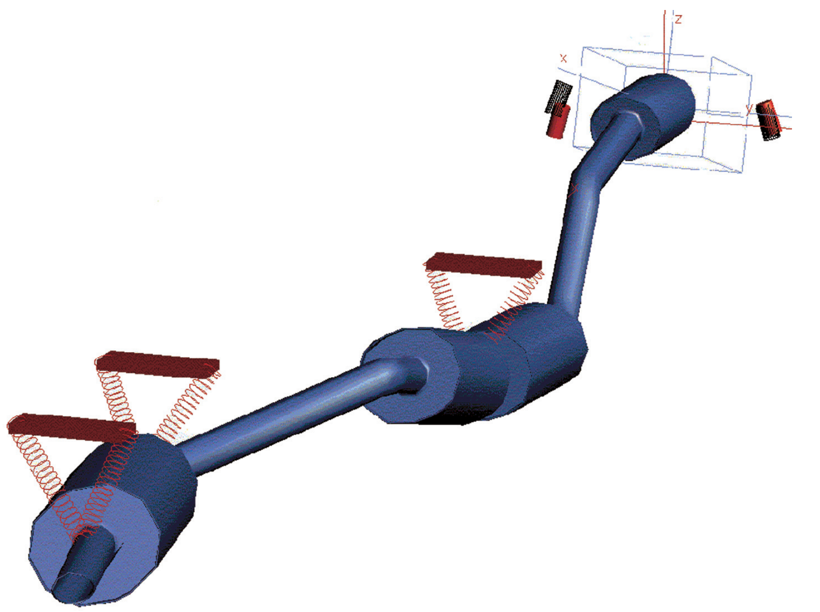
Existing users of SIMPACK can continue to use the parts of SIMPACK NVH which have been included in the standard SIMPACK package before, for instance Linear Systems Analysis. An upgrade version of SIMPACK NVH for existing SIMPACK users is available with the new SIMPACK version 8.5.



Time Domain Result, FFT-Filtered

Mode	Computing Time
fully non-linear	49.81 sec
fully non-linear using symbolic code	8.49 sec
partially linearised	4.53 sec

Table Computing Time



Exhaust System Model with Flexible Bodies