Natural frequency analysis of Modelica powertrain models

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The natural frequency analysis of complex powertrain models created in Modelica presents a number of problems. This paper presents the basic principles and some of the problems associated with carrying out this kind of analysis. As a result of this work, a new feature in the Powertrain Dynamics Library has been developed to automate these methods and provide the end-user with a simple set of functions to perform natural frequency analysis. Simple examples are used to illustrate the problems and solutions and a complex powertrain model is then analysed using the library.

Using Dymola it is possible to linearize models automatically but the results of this present a number of issues when linearizing complex models. Two issues are described in detail in the paper: the first is the handling of relative states; and the second relates to components that use the standard Modelica stick/slip friction model.

In the first case, the use of relative states rather than positional states makes the interpretation of the modal response more difficult. It is generally easier to understand how to interpret the magnitude and phase diagrams when the states represented are the ends of the shaft rather than a plot based on relative states. A method is described to convert the relative states to absolute states.

The behaviour of the standard Modelica stick/slip friction models is also not linearized in the expected manner and modifications to the analysis have to be made around these components.

Simple examples are used to describe and illustrate these problems and the solutions developed. An example of a complex powertrain model is then analysed using automatic functions that implement these methods in the Powertrain Dynamics library and it’s natural frequencies and modal response discussed. The modal response for the shuffle frequency is in Figure 1 and the bode diagram for the complete powertrain model is also generated.

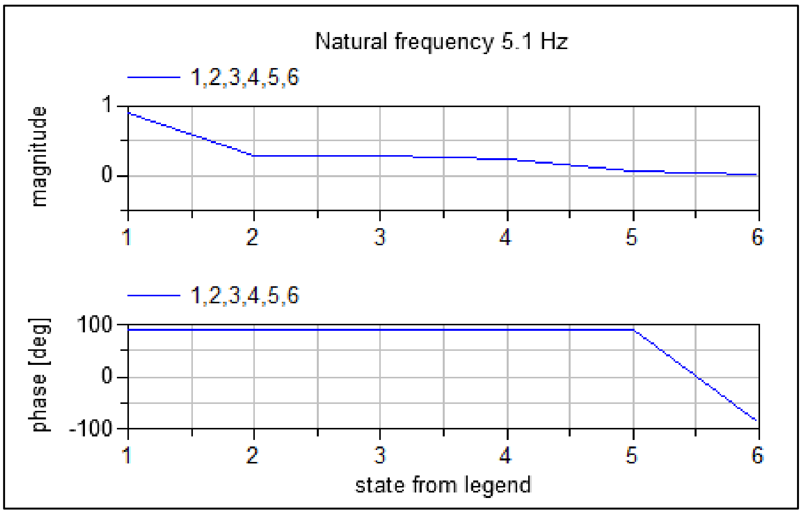

Figure 1. Modal response of the Simple vehicle model at 5.1Hz. The magnitude and phase of the different states are plotted.