BRIDGING THE GAPS IN DYNAMIC ANALYSIS

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A mechanical system typically exhibits distinctively different dynamic characteristics as frequency varies. While the extreme (low and high) frequencies are considered adequately covered by a combined use of the FEA and SEA methods, there is not yet a widely accepted method for the mid-frequency problems. In the mid-frequency region, the response spectra are typically highly irregular and very sensitive to the boundary conditions, the geometrical details, material properties, and other physical variables. Because the dominant excitation bands usually fall in the mid-frequency range in many noise and vibration problems, the mid-frequency analysis is desperately needed and of critical importance to the design of dynamic systems.

A general method, referred to as Fourier Space Element Method (FSEA), has been recently developed for modeling the dynamic characteristics of complex systems over the entire frequency range. In an FSEA model, a mechanical system is considered as the collection of a number of interconnected structural components such as beams and plates. The formulations of the FSEA method are based on the powerful variational or energies principles developed in finite element methods, and its modeling philosophy has well reflected the essence of the conventional substructure techniques and the SEA method. More explicitly, the FSEA solution is truthfully derived from the original dynamic equations by taking into account the uncertainties and the probabilistic nature of the model parameters in the mid- and high-frequency ranges. It has stroked *a delicate and optimal balance between truthfully modeling of the physical details and statistically predicting of the averages*.

In practice, the creation of an FSEA model does not require the determination of any secondary input data such as the coupling loss factors as in the SEA or the modal properties for the involved components as in most substructure techniques. It also has many other important and unique advantages that are critical to the design and optimization of large complex mechanical systems, which include, but are not limited to:

- An accurate and faithful representation of the interactions of components under the actual system condition.
- The explicit dependence and inclusion of design variables in the final system equations makes the method extremely suitable for parametric and sensitivity study, symbolic processing, design optimization, and uncertainty and statistical analysis.

- A closed form of solution on each component allows an easy and accurate determination of other (secondary) variables (such as, bending moments, shear forces and power flows at a junction) of design interest.
- The meshless model makes it much easier to deal with moving loads, time-dependent boundary conditions, time-varying systems, nonlinear large deformation problems, etc.
- The physics-based system model provides a platform which allows an easy and seamless integration/coupling with different solution methods, models, and other engineering functions and capabilities.