How to Shape Noise Spectra for Continuous System Simulation

Andreas Klöckner[1] Andreas Knoblach[1] Andreas Heckmann[1]

[1]DLR German Aerospace Center, Institute of System Dynamics and Control, 82234 Weßling, Germany, andreas.{kloeckner,knoblach,heckmann}@dlr.de

Modeling stochastic signals is of interest in a wide range of applications, such as sensor modeling, aerodynamic turbulence, and rail irregularities. A Modelica `Noise` library has thus recently been released in order to enable the engineer to conveniently and consistently define noise signals (Klöckner et al., 2014).

The `Noise` library also introduces a new class of random number generators. They eliminate the need for time-events, but can be used to generate a random signal directly from the `time` variable. This has been shown to positively affect the simulation performance (van der Linden et al., 2015). Additionally, it allows to define noise signals in dimensions other than the time. Rail irregularities e.g. are typically defined with respect to the location on the track.

Unfortunately, it is not at all obvious how to parametrize the frequency properties of such noise signals. We thus present a systematic method to shape the frequency content of noise signals. The contributions of this paper are as follows:

1. Using the example of rail irregularities, we summarize how noise is typically specified.
2. We then shortly define the probability distribution of the noise signals generated in this paper.
3. Starting from a given power spectral density (PSD) we rigorously derive a way to shape this frequency content onto a noise signal. This method will turn out to be perfectly simple to use and to be applicable to almost any kind of noise spectrum.
4. We finally implement the approach and verify that it yields the same results as conventional methods.

References

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