Example nonlinear analysis of a moving coil; speaker

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The information contained here uses Simscape components from the Foundation Library and from the Acoustical Library for Simscape to model the performance of a moving coil loudspeaker. The components go beyond simple linear behavior to include several nonlnearities.

As of the date of this report, the Acoustical Library fro Simscape includes components that model the following nonlinearities

- `BL_of_x` - models the fact that the electrical to mechanical Force Factor BL is a function of the speaker displacement X.
- `K_of_x` - models the fact that the mechanical stiffness K of the speaker cone is a function of the speaker displacement X.
- `L_of_x` - models the fact that the electrical inductance L of the speaker coil is a function of the speaker displacement X.
- `D_of_v` - models the fact that the mechanical damping D of the speaker cone is a function of the speaker velocity v.

The example presented here includes measured data for the first three nonlinearties in a particular speaker driver unit.

The files included in this example are

- `SpeakerSubsystemLibrary_1_0_0.slx` - A Simscape subsystem library containing two subsystem models. One is a simple linear speaker model. The second is a nonlinear model that includes hte four nonlinear components mentinoed above.
- `Examples.slx` - A Simscape model file that includes two speaker models operating in parallel. One is the linear model from the library above. The other is the nonlinear model from the same library. Each speaker model includes a sealed enclosure on the back side and a radiation impedance on the front side of the cone. There are also blocks that calculate the far field radiated pressure from each speaker.
- `vars.mat` - A mast file that contains variables used to provide values to the speaker components. The particular speaker is one the author is familiar with. It is a 3 1/2 in. speaker with a rated maximum power output of 25 W.

The reader is encouraged to experiment with these models. With small drive voltage signals (1 V or less) the output of the linear and nonlinear models is similar enough that you need to do frequency analysis of the output signals to see the differences. For very large drive voltage (say 15 V peak) the differences are large enough to be clearly visible in the time waveforms.