Nonlinear Speaker Modeling

Starting with release 1.1, the Moving Coil Speaker library directory contains a component that includes the ability to model several nonlinearities in a speaker driver. This component follows the methods of Wolfgang Klippel [1, 2, 3] to allow the magnetic force factor and mounting spring stiffness to be functions of x, the cone displacement; and the mechanical damping to be a function of v,the cone velocity. Each nonlinearity is modeled as a fourth order polynomial. Specifically

$$B\ell\left(x\right) = \sum_{n=0}^{4} B\ell_n x^n$$

$$K\left(x\right) = \sum_{n=0}^{4} K_n x^n$$

$$R_m\left(v\right) = \sum_{n=0}^{4} R_n v^n$$

The Nonlinear Moving Coil Speaker component allows each nonlinearity to be optionally included via a drop-down list option in the component data entry window. This is shown in the figure below. The polynomial coefficients can be measured on any speaker using methods that area also described by Klippel. [2, 3]

References

[1] Klippel, Wolfgang, "Loudspeaker Nonlinearities – Causes, Parameters, Symptoms," https://www.klippel.de/fileadmin/klippel/Files/Know_How/Literature/Papers/Loudspeaker%20Nonlinearities_Causes%2CParameters%2CSymptoms_06.pdf link (viewed Apr. 15, 2023).

[2] Klippel, Wolfgang, "Measurement of Large-Signal Parameters of Electrodynamic Transducer," https://www.klippel.de/fileadmin/klippel/Files/Know_How/Literature/Papers/Measurement_of_Large-Signal_Parameters_99.pdf link (viewed Apr. 15, 2023).

[3] Klippel, Wolfgang, "Modeling the Large Signal Behavior of Micro-speakers," https://www.klippel.de/fileadmin/klippel/Files/Know_How/Literature/Papers/KLIPPEL%20Modeling%20the%20Large%20Signal%20Behavior%20of%20Micro-Speakers.pdf link

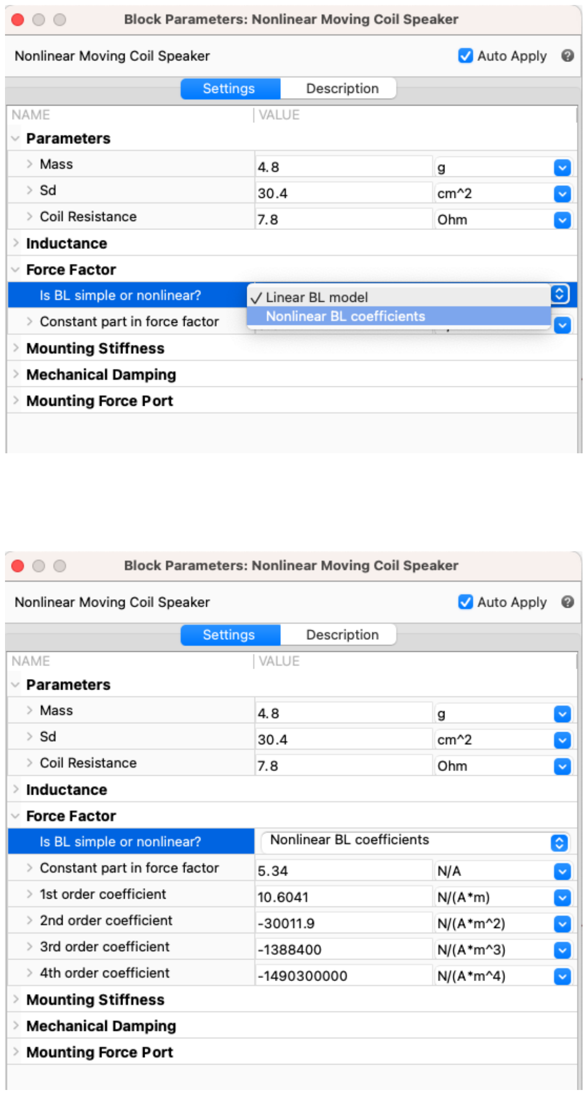
Block Parameters: Nonlinear Moving Coil Speaker
Nonlinear Moving Coil Speaker
Auto Apply
Settings
Description
NAME
VALUE
Parameters
Mass
4.8
g
Sd
30.4
cm^2
Coil Resistance
7.8
Ohm
Inductance
Force Factor
Is BL simple or nonlinear?
✓ Linear BL model
Nonlinear BL coefficients
Constant part in force factor
Mounting Stiffness
Mechanical Damping
Mounting Force Port
Block Parameters: Nonlinear Moving Coil Speaker
Nonlinear Moving Coil Speaker
Auto Apply
Settings
Description
NAME
VALUE
Parameters
Mass
4.8
g
Sd
30.4
cm^2
Coil Resistance
7.8
Ohm
Inductance
Force Factor
Is BL simple or nonlinear?
Nonlinear BL coefficients
Constant part in force factor
5.34
N/A
1st order coefficient
10.6041
N/(A*m)
2nd order coefficient
-30011.9
N/(A*m^2)
3rd order coefficient
-1388400
N/(A*m^3)
4th order coefficient
-1490300000
N/(A*m^4)
Mounting Stiffness
Mechanical Damping
Mounting Force Port

Figure 1: