Modeling and Simulation of a Linear Piezoelectric Stepper Motor in MapleSim

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Devices based on piezoelectric materials have traditionally been modeled in PDE simulation software. These simulations are expensive to create and run. In this paper it is shown that lumped-parameter models of such devices can provide good fidelity with low computational cost.

In this research, Modelica components implementing piezoelectric material properties, electrostatic forces, and time-varying frictions were developed and integrated into a device-level model of a linear piezoelectric stepper motor. The model is parametric and extensible: the parameters can be changed to suit application-specific requirements, and nonlinear effects can be easily included. It was modeled in MapleSim, which is a Modelica-based system-level modeling and simulation platform provided by Maplesoft [1].

MapleSim simulation results matched those in [2][2] when similar values were implemented. Most importantly, the relative execution speed of the model permits multiparameter optimizations not possible in full PDE simulations. This is demonstrated via the investigation of the effects of the motor clamp voltage on velocity using a compiled MapleSim procedure in Maple. Figure 1 shows an example of the model output.
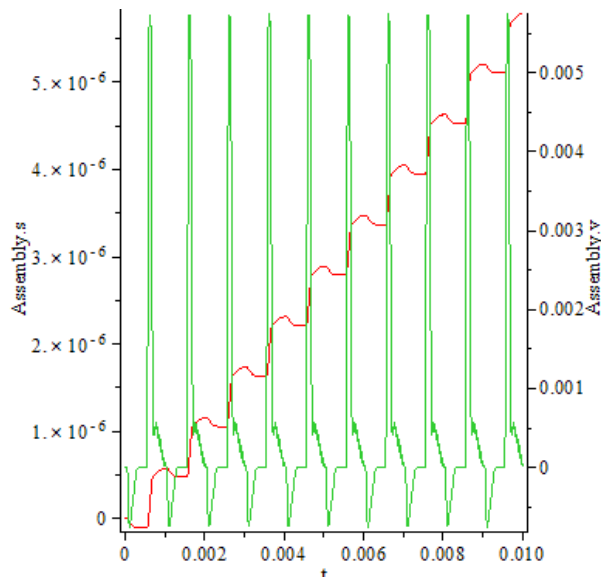

Figure 1: Plots of the position (red) and velocity (green) versus time of the linear motor.

References

[1]   www.maplesim.com

[2]   Judy J W, Polla D L, and Robbins W P. A Linear Piezoelectric Stepper Motor With Submicrometer Step Size and Centimeter Travel Range. IEEE Trans. UFFC, Vol. 37, No. 5, 1990.