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Creating a Response Surface Model of an Actuator for Multi-Discipline Design in SystemVision

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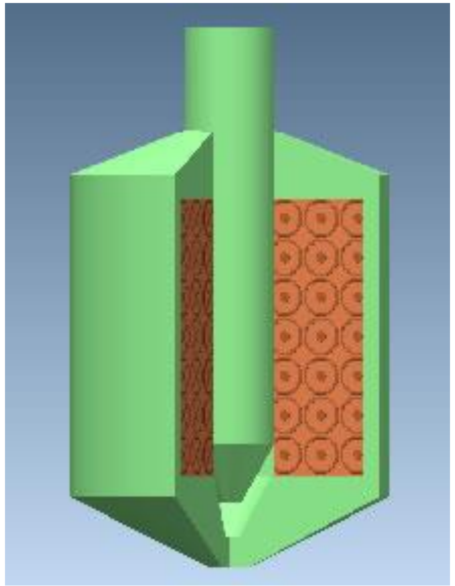
Accurately simulating the dynamic interaction between a drive circuit, an electric actuator and a load can be a challenging problem due to the multi-discipline design required.

One possible approach is to use response surface modeling (RSM). In this case, a functionally equivalent model of the actuator can be created by performing a large number of magnetostatic analyses at different currents and positions. This model can then be used in system simulators.

The System Model Generator, an add-on to Simcenter MAGNET, automates the process of creating the VHDL-AMS code that implements the actuator's RSM. VHDL-AMS is an IEEE standard (1076.1) supported by many circuit and system simulators.

For the purpose of this example, the SystemVision system simulator from Mentor Graphics® is used.



CIRCUIT DIAGRAM OF THE ACTUATOR AND DRIVE IN SYSTEMVISION

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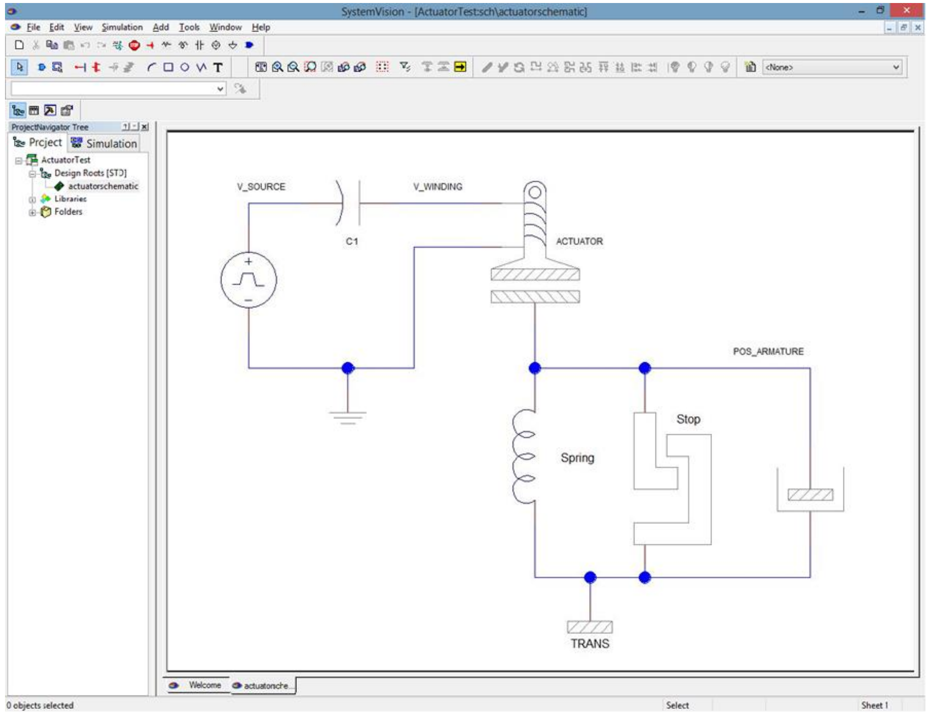

The coil is driven by a capacitor charged to 12 V (see the circuit diagram). A spring holds the plunger against the upper stop. At time t=0, a switch closes to connect the charged capacitor to the coil. On the mechanical side the spring, viscous damper, and upper and lower stops are modeled using appropriate mechanical components which, in fact, are themselves described using VHDL-AMS.

MESHING AND FLUX LINKAGE OF THE ACTUATOR

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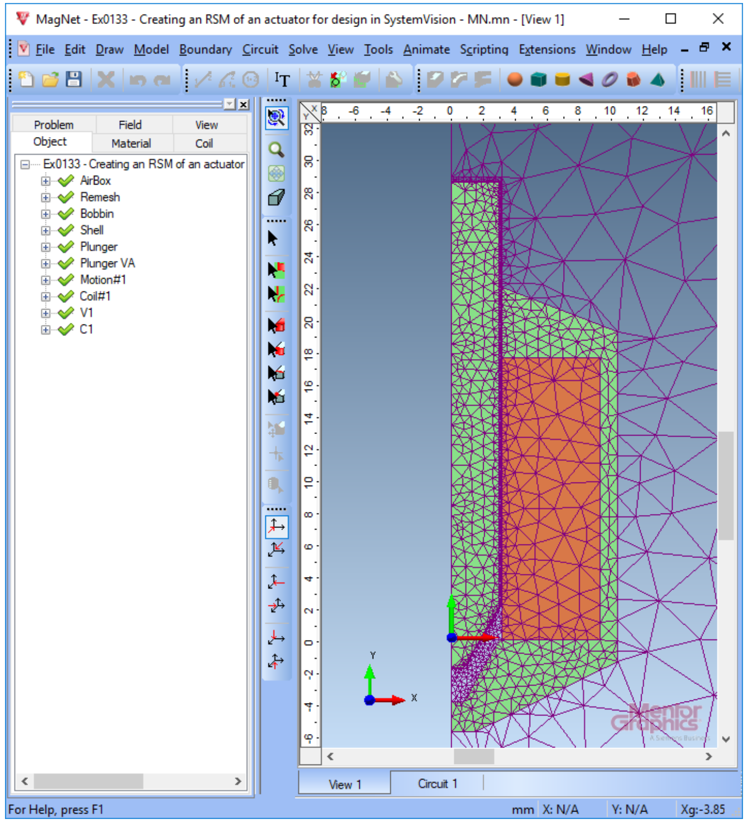
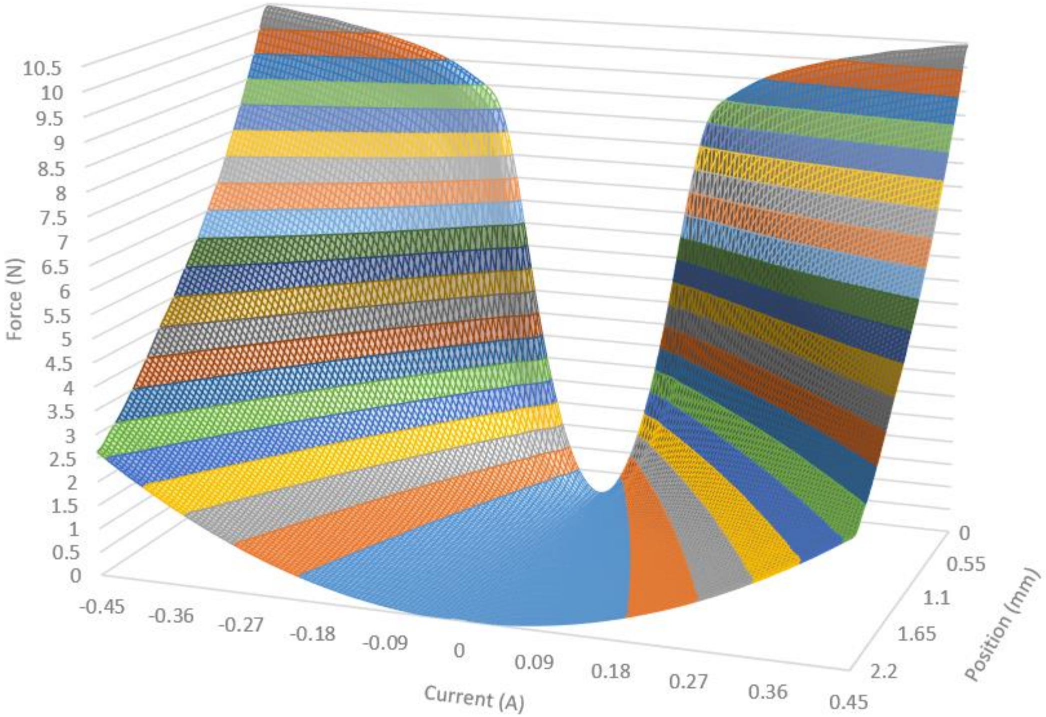


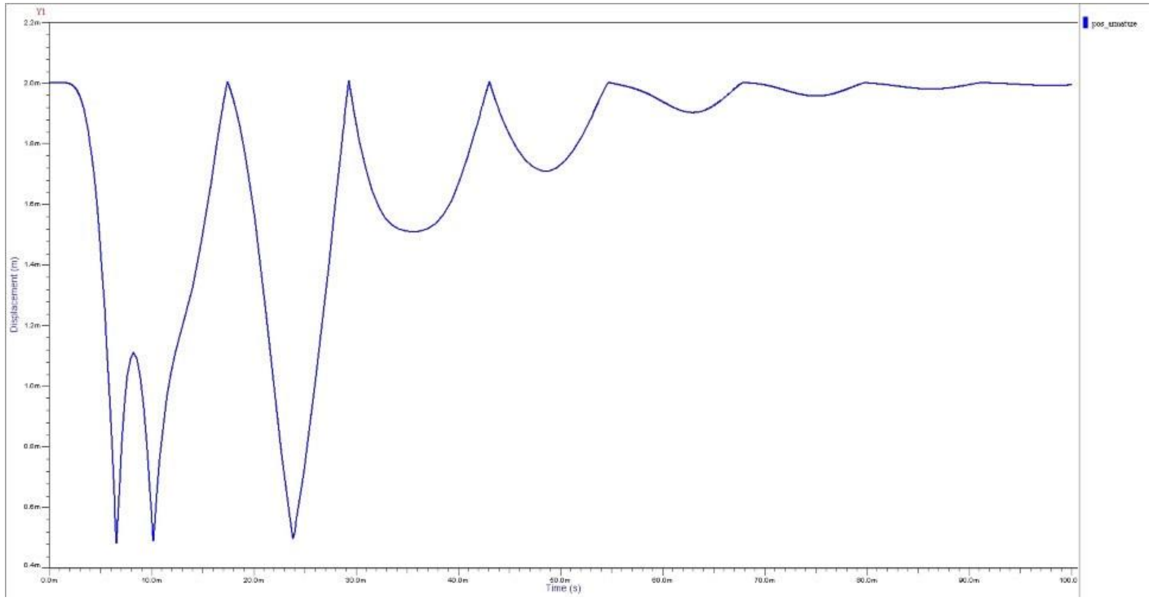
The actuator is meshed and simulated in Simcenter MAGNET 2D/3D. The force and flux linkage are calculated at different positions and currents. The solution setup to create the response surface model in VHDL-AMS format is automated with the use of the System Model Generator

RESPONSE SURFACE MODEL OF AN ACTUATOR



The System Model Generator creates a RSM of the actuator where the force is a function of coil current and plunger position.

PLUNGER POSITION VS. TIME



The complex behavior arises from the transfer of energy between the potential energy of the capacitor, the energy stored in the magnetic field, the potential energy in the spring, and the kinetic energy of the plunger.

USING MAGNET TO SIMULATE AN IDEAL BOUNCE

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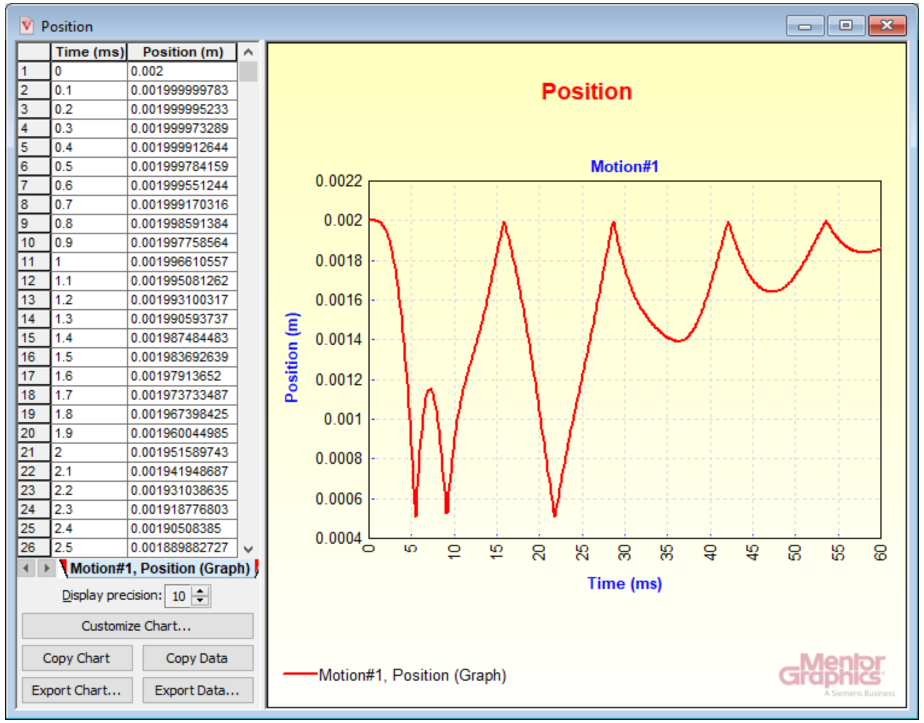
The system (actuator, spring, capacitor, etc.) can also be modeled and simulated entirely in Simcenter MAGNET using the Transient with Motion solver. The position vs. time graph is a bit different because Simcenter MAGNET simulates an ideal bounce (instant velocity reversal), whereas a very large spring constant was used in the VHDL-AMS implementation of the spring in SystemVision. This error at each bounce is amplified over time.



Number of time steps: 600
Transient solution time: 6 minutes 12 seconds
Number of static solutions in RSM: 460
Static solution time (total): 5 minutes 10 seconds
SystemVision simulation time: 1.234 seconds