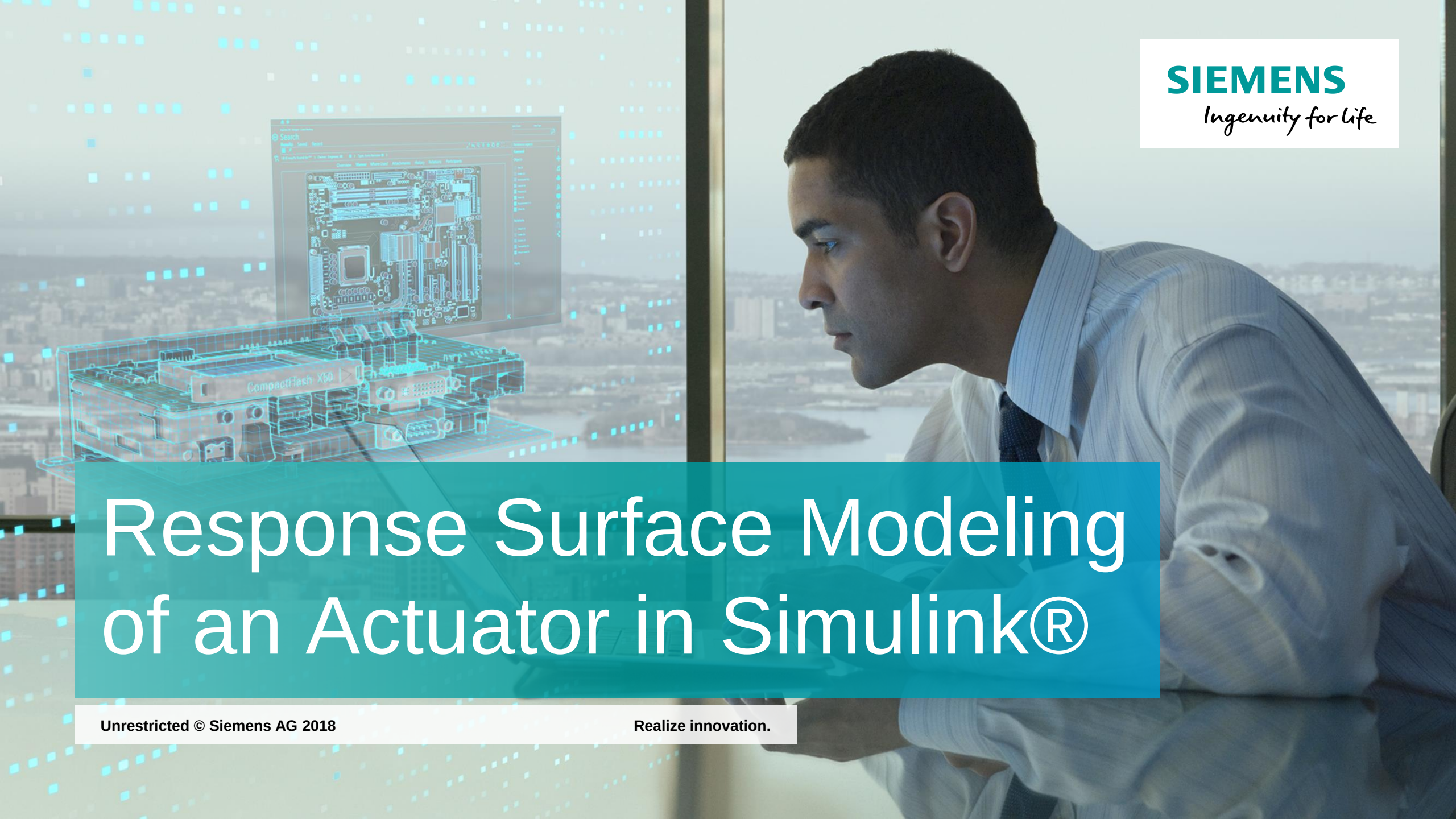

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Response Surface Modeling of an Actuator in Simulink®

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Response Surface Modeling of an Actuator in Simulink®

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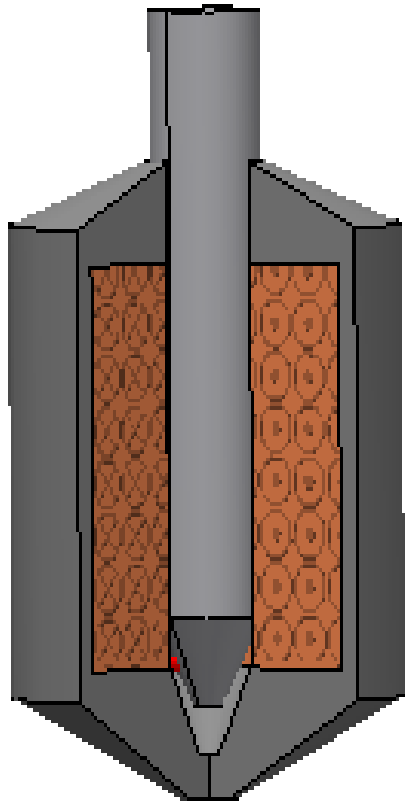
Modeling an electromagnetic actuator in a systems context is sometimes required to accurately simulate the dynamic interaction between drive circuit, actuator, and load. Response Surface Modeling (RSM) creates a functionally equivalent model of the actuator by performing a large number of static analyses at different currents and positions.

Presented here is an example of an RSM, used in conjunction with the Simulink® system simulator from The MathWorks, Inc. The procedure is automated with the System Model Generator, which drives Simcenter MAGNET to perform static analyses and generates a file containing the RSM data.

In this example, the coil is driven by a capacitor charged to 12 V. A spring holds the plunger against the upper stop. At time t=0, a switch closes to connect the charged capacitor to the coil.



CUTAWAY VIEW OF ACTUATOR MODEL

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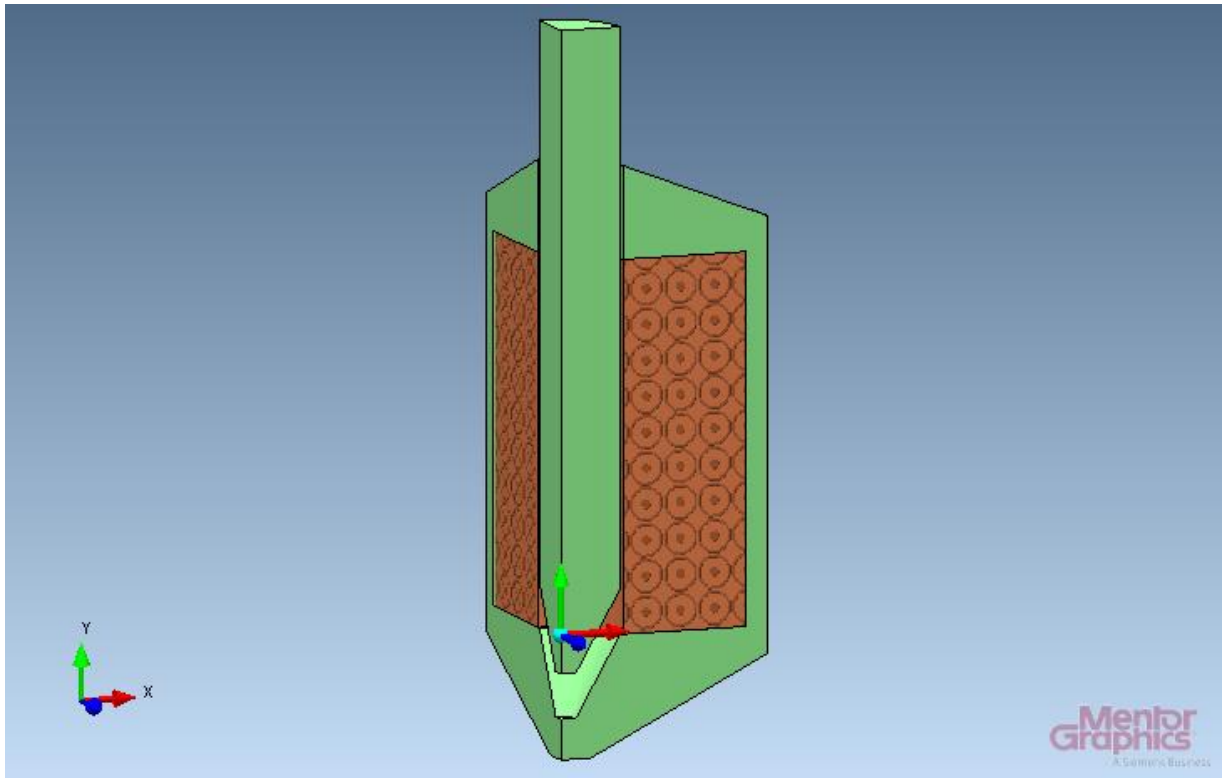

The actuator model is shown in a 90-degree view. Simcenter MAGNET is used to calculate force and flux linkage at different positions and currents. The solution setup to create the Response Surface Model (RSM) is automated with the use of the System Model Generator.

RSM OF THE PLUNGER FORCE

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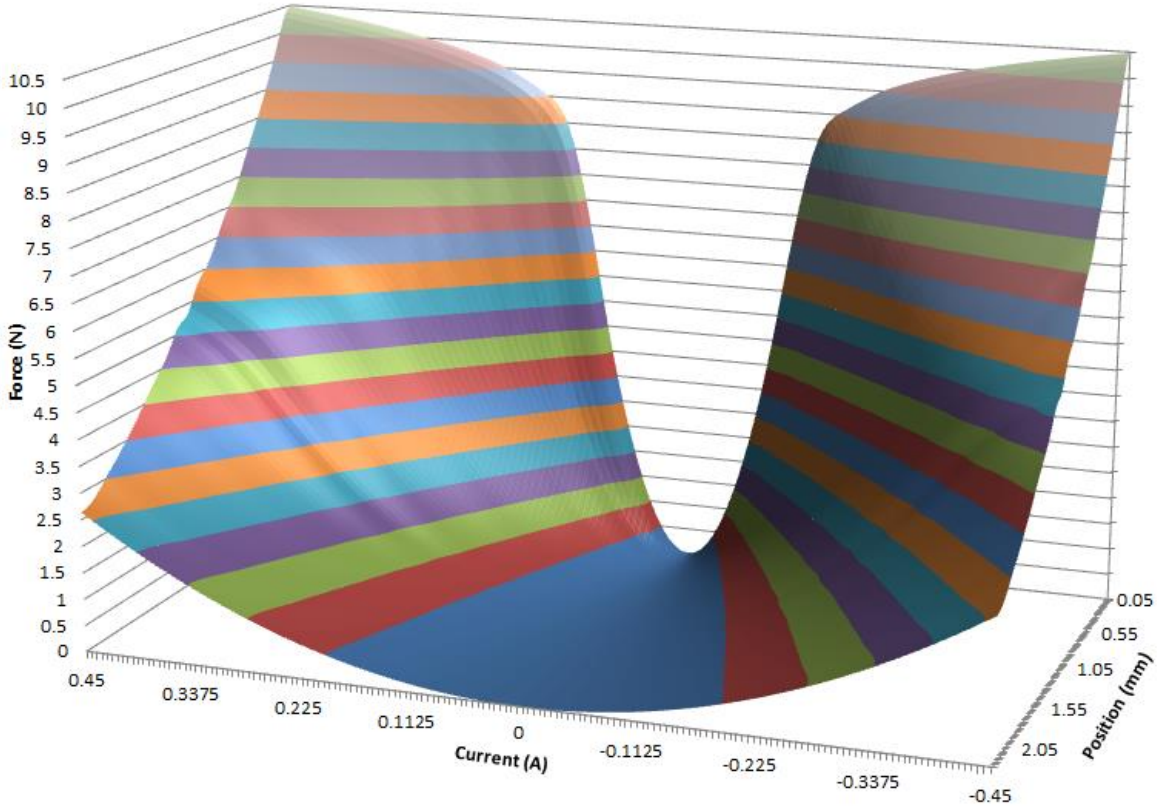

The RSM of the force as a function of coil current and plunger position is shown here. The response surface models for both flux and force were created using the System Model Generator and required a total of 460 solutions: 20 coil currents to 23 plunger positions.

ACTUATOR & DRIVE CIRCUIT IN SIMULINK

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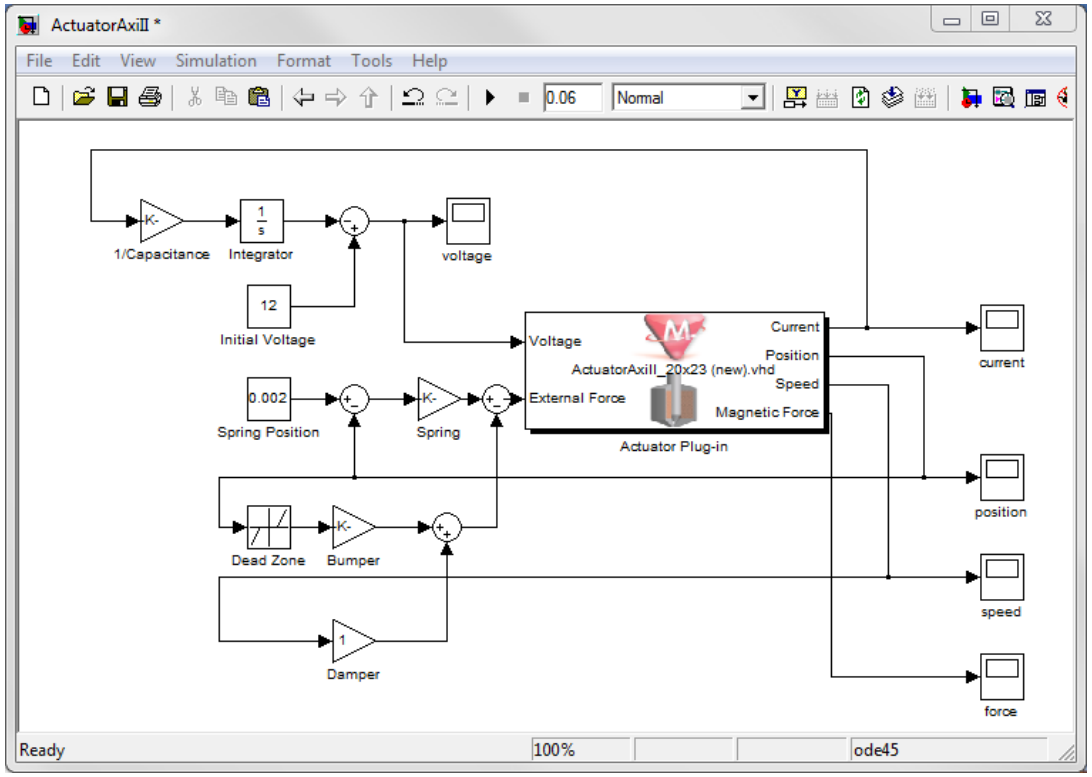
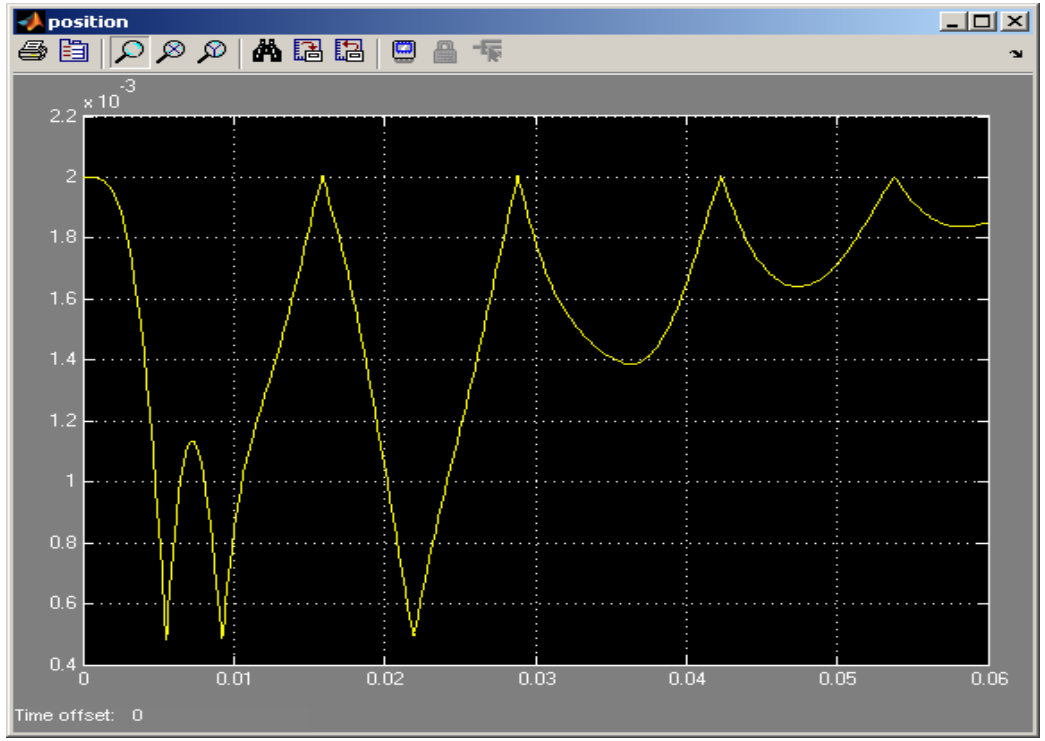
The RSM block has inputs for coil voltage and external plunger force; outputs for coil current, plunger position and velocity and electromagnetic force.

On the electrical side an integrator models the charged capacitor which discharges through the actuator's coil. On the mechanical side the spring, viscous damper, and upper and lower stops are modeled using appropriate Simulink blocks.



POSITION OF THE PLUNGER



This graph, plotted in Simulink, shows the position of the plunger as a function of time. The complicated 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.

COMPARING RESULTS WITH SIMCENTER MAGNET

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This system can be modeled directly in Simcenter MAGNET's Transient with Motion solver, as shown here. Simcenter MAGNET was able to simulate ideal bounces (instant velocity reversal) while Simulink had to use a very large spring constant. Nevertheless, the position waveform is almost identical.

The transient solution time is comparable to the time required to generate the RSM. The RSM allows changes in the drive circuit to be made and the result to be simulated almost instantly in Simulink.