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Actuator with Diode

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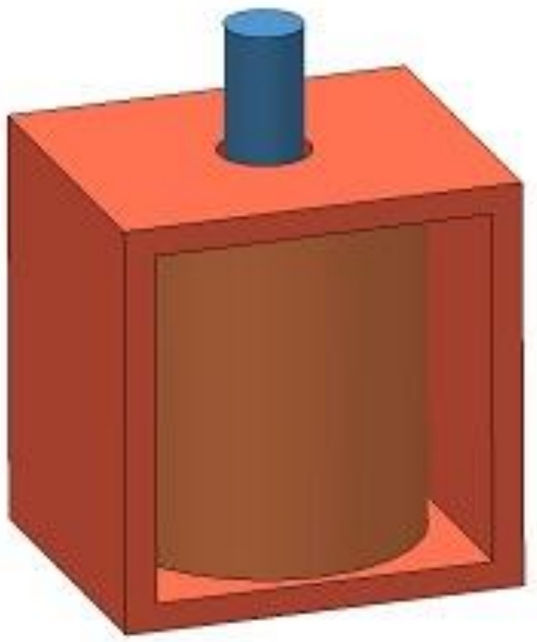
This actuator example demonstrates the power of the fully integrated Transient 3D with motion solver, which simultaneously solves the circuit equations, the field equations on the finite element mesh, and the equations of motion. All three sets of equations include some sort of non-linearity. For the circuit the non-linear element is the diode. The finite element solver must deal with non-linear magnetic materials, and the motion solver handles the instantaneous reversal of velocity that occurs when the plunger bounces off a bumper.



MESH OF THE ACTUATOR

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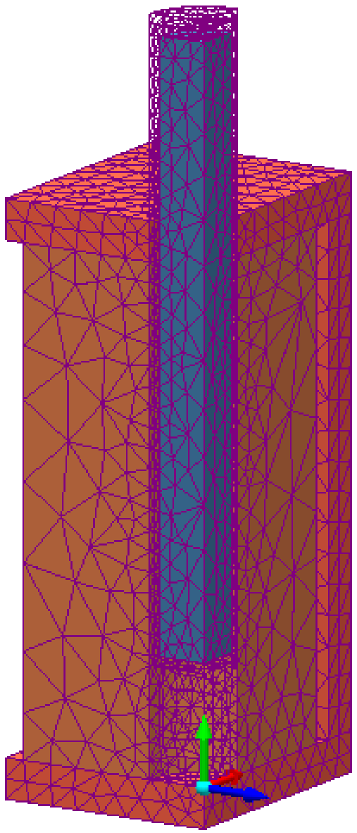
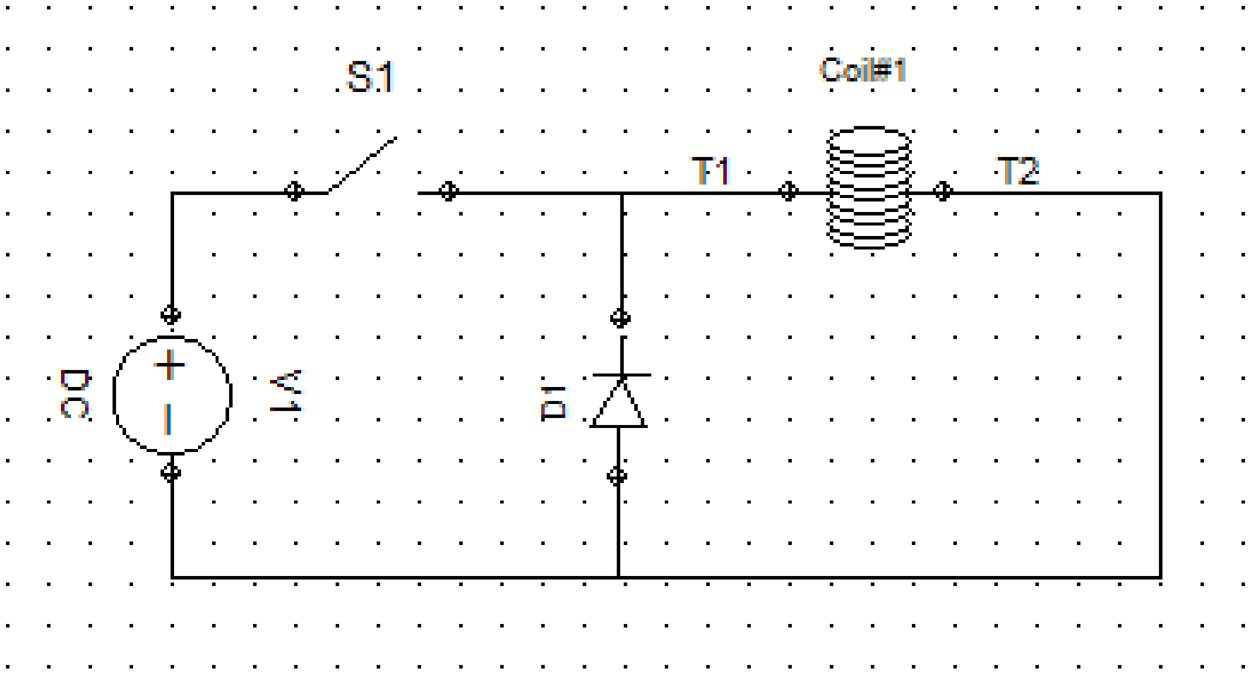
The mesh of the actuator, shown here, takes advantage of symmetry to reduce the problem to one-quarter of its full size. When the plunger moves, the region of air immediately adjacent to it is re-meshed. Since this is a small, well-defined volume, the re-meshing is quick, and the solution time is still dominated by the conjugate gradient and Newton iterations used to solve the sparse matrix equation. Thus re-meshing is preferable to other methods that increase the number of degrees of freedom and hence the size of the matrix, and the number of iterations required to solve it.





The actuator is connected to a simple circuit that applies a voltage pulse to the coil. With the switch closed, the voltage is applied across the coil terminals and causes the coil current to increase. After the switch opens, the diode becomes forward-biased and provides a conduction path for any current in the coil.

VOLTAGE ACROSS THE ACTUATOR COIL

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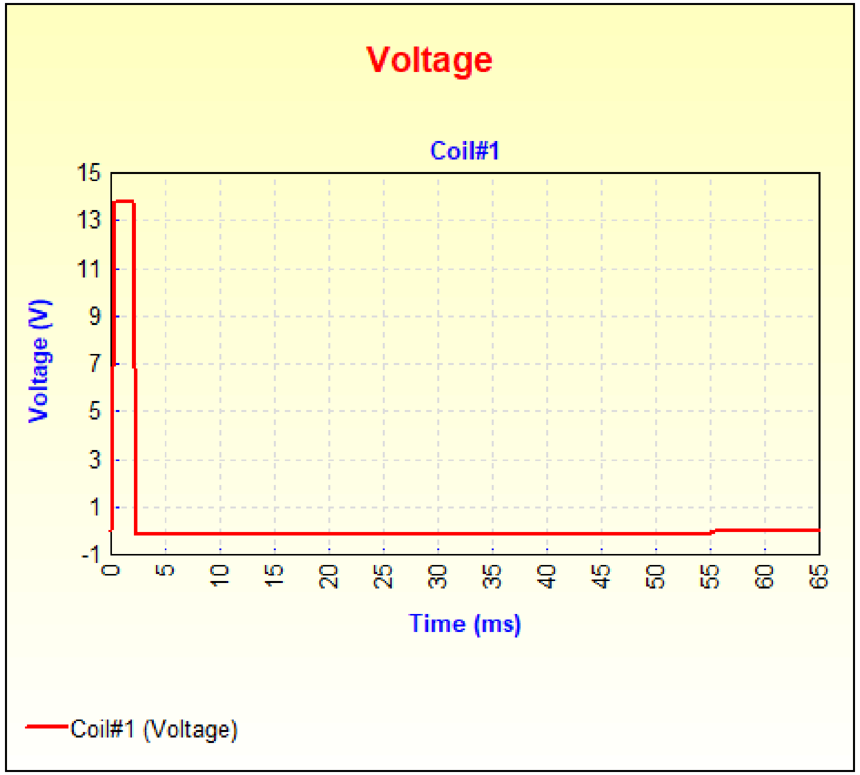
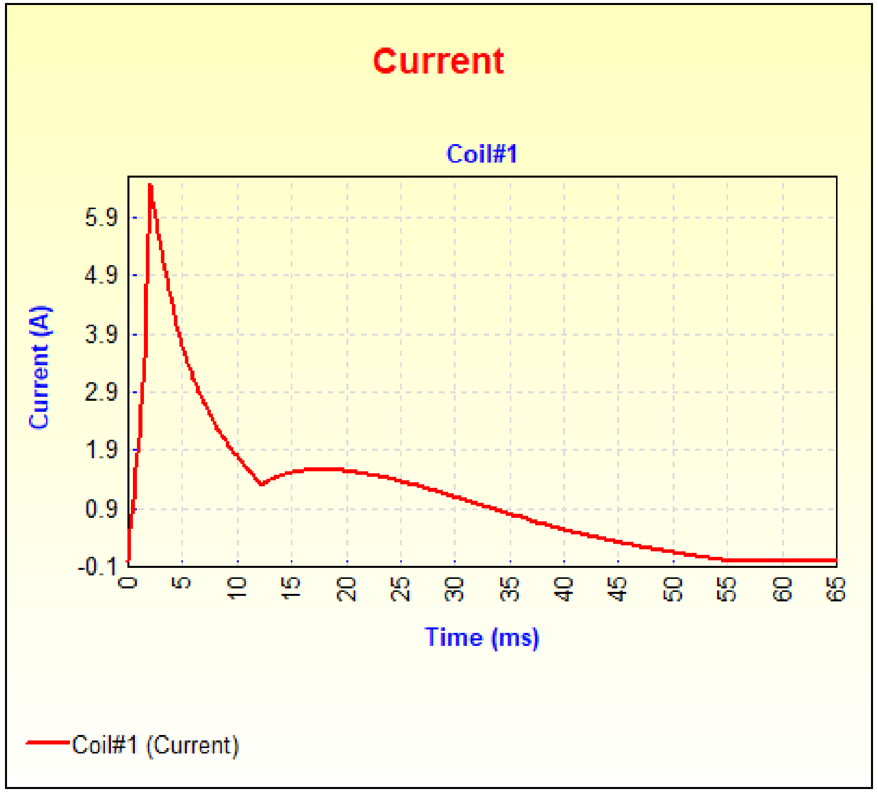
This graph shows the voltage across the terminals of the actuator coil. The 55 V pulse (13.75 V in this graph since this is only a quarter model) lasts only 2 ms, after which the switch opens and the current in the coil is re-routed through the diode. From this point onward the coil sees only the diode forward voltage drop, until the current drops below the threshold at 55 ms.



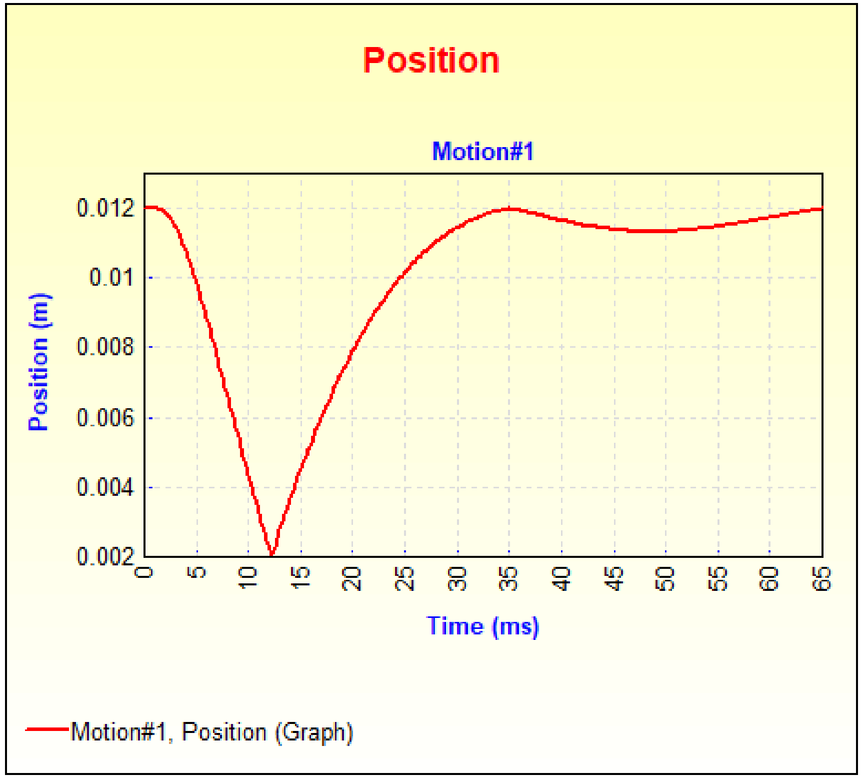
CURRENT IN THE ACTUATOR COIL



The current in the coil of the actuator is shown here. The effect of motion on the magnetic circuit is clearly seen when the plunger bounces off the lower bumper at 12 ms.

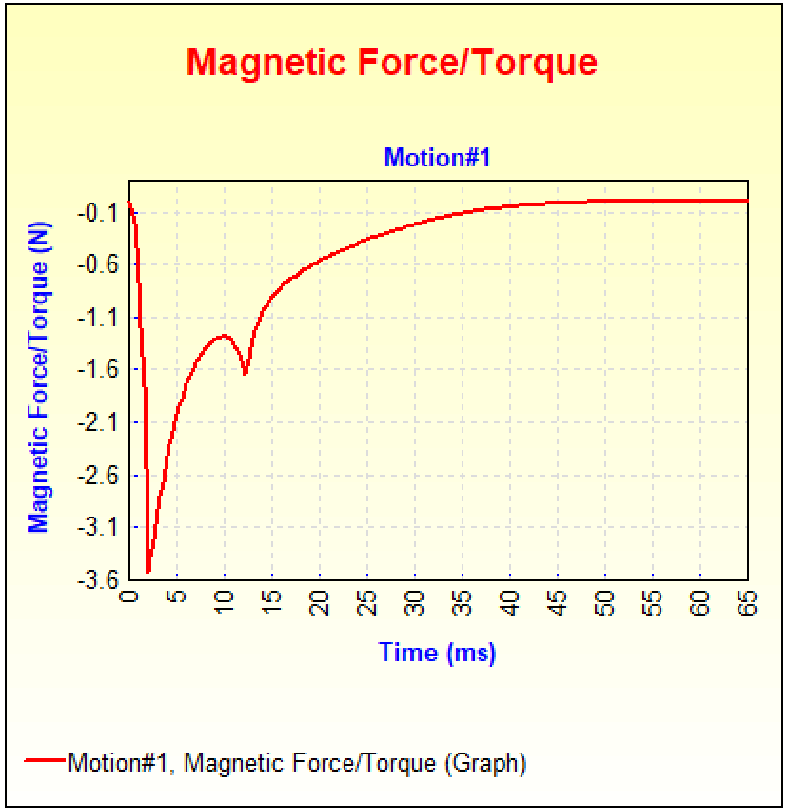
PLUNGER POSITION

The plunger undergoes rapid acceleration once the current nears its peak, and is moving quite rapidly when it hits the lower bumper. After rebounding, it is pulled back by the spring as the current decays, so it bounces against the upper stop. It would keep bouncing indefinitely if it weren't for the viscous friction which damps out the oscillations.



MAGNETIC FORCE ON THE PLUNGER

The magnetic force on the plunger is calculated by Simcenter MAGNET using the Maxwell stress method, which gives an accurate prediction of the force. The force reaches its first (negative) peak when the current peaks, but has a second peak when the plunger reaches the lower bumper, due to the small air gap at that point.



ACTUATOR WITH DIODE B

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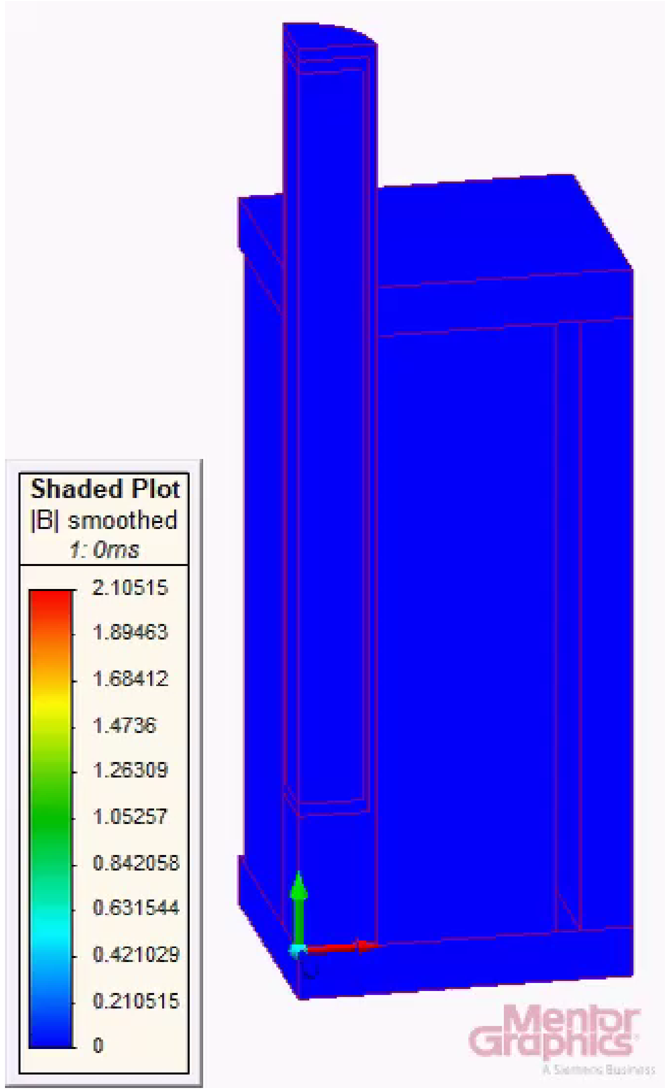

PLUNGER POSITION