Sage Model Notes

MotorTransducer.stl

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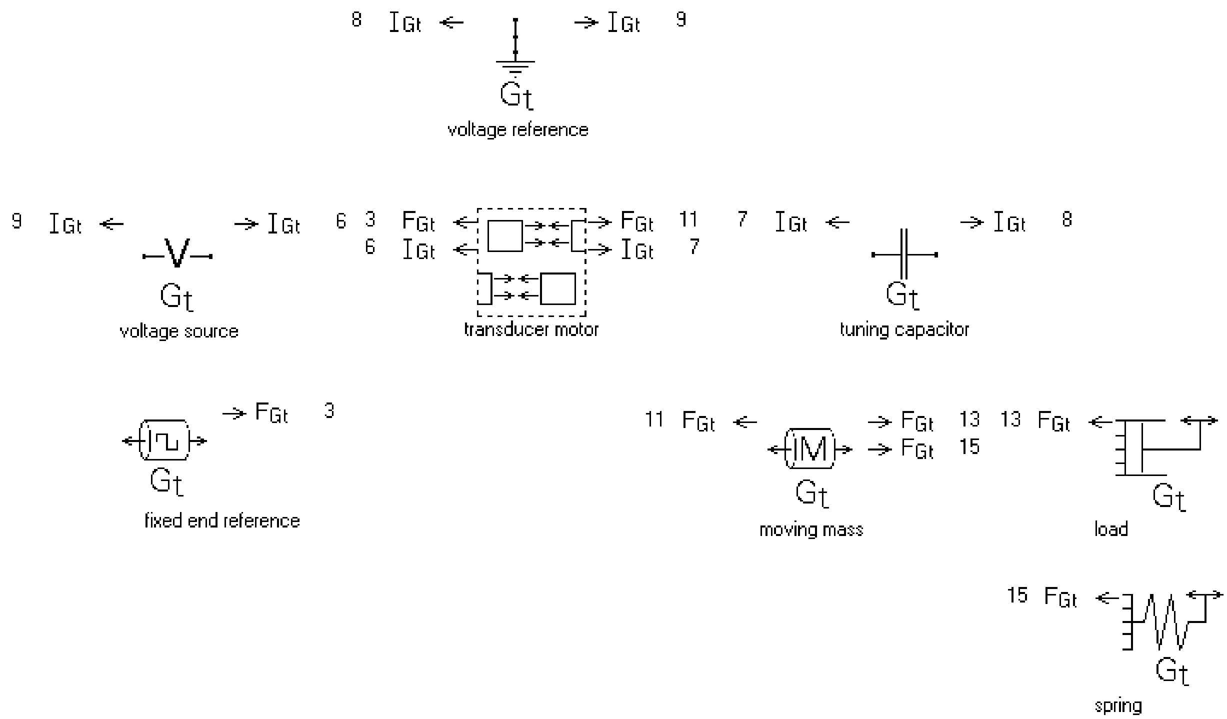
A model of a generic linear motor based on a non-physical transducer component that provides mechanical force in proportion to electrical current. The Sage model looks like this:



A *voltage source* (second row) drives electrical current through the components in the t*ransducer motor* submodel in series with a *tuning capacitor*. A constrained piston *fixed end reference* anchors the negative end of the transducer. The other end of the transducer drives the *moving mass* connected to a damper *load* and a *spring*. The driving voltage and phase are independent inputs and the electrical current through the circuit and motion of the *moving mass* are outputs.

One purpose of the *spring* is to establish the mean position of the *moving mass*. The *transducer* force depends only on the electrical current and the *load* force only on the mechanical velocity, neither of which care about the mean position. The presence of the *spring* prevents the *moving mass* mean position from drifting off to absurd values.

The purpose of the *tuning capacitor* is to adjust the voltage and current so they are in phase in the voltage source so as to transfer the most electrical power for a given voltage amplitude. In electrical engineering parlance the tuning *capacitor* adjusts the voltage source *power factor* to one. The optimizer chooses the tuning capacitance in this model by optimizing *tuning capacitor* C input in order to satisfy this constraint in the *voltage source*:

FDeltaV.Arg.1 = FI.Arg.1

The transducer motor submodel contains these components:

The transducer converts electrical current I to mechanical force F or vice-versa according to the linear relationship

$$F = C_f I$$

Where Cf is based on the inputs

Cf0	force coefficient at X = 0 (N/A)	1.000E+02
Xm	reference extension (m)	1.000E-02
Rp	force coef / Cf0 at X = Xm (NonDim)	1.000E+00
Rn	force coef / Cf0 at X =-Xm (NonDim)	1.000E+00

Wired in series with the *transducer* are *internal resistance* and *internal inductance* components that capture some of the electrical properties of a real transducer (e.g. moving magnet motor). In particular the *internal resistance* dissipates electrical power that is not available as mechanical power output from the *transducer*.

To model a linear alternator you could replace the *moving mass*, *load* and *spring* by a constrained piston or just remove the *load* and apply a forcing function to the *moving mass*, either with the built-in FF input or through a force connection to another moving component of your model. Then replace the *voltage source* with a load resistor. The model would then convert mechanical power input from the driving piston to electrical power in dissipated in the load resistor.

Energy Balance

Energy conservation is built into electrical and mechanical components separately and into the transducer component via the relationship between mechanical force F, relative velocity dx/dt, voltage drop ΔV and current I

$$F \frac{dx}{dt} = \Delta V \; I$$

This table summarizes the overall time-average energy balance:

	Power W
Input power from voltage source (Fwe)	-6.433E+01
Internal resistance I^2R loss (FWe)	4.138E+00
Load power dissipation (W)	6.019E+01

The motor efficiency is available a user-defined variable in the root model:

Efficiency WmechOut / WelecIn	9.357E-01

Where WmechOut and WelecIn are user-defined variables in the *transducer* and *voltage source* components.