Simscape 3

Model and simulate multidomain physical systems

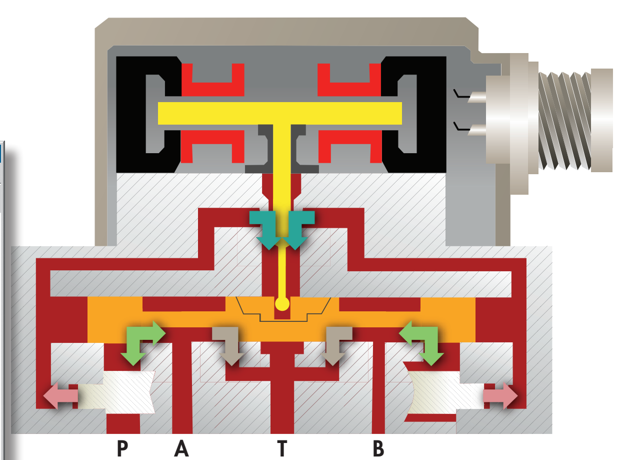
Simscape™ extends Simulink® with tools for modeling systems spanning mechanical, electrical, hydraulic, and other physical domains as physical networks. It provides fundamental building blocks from these domains to let you create models of custom components. The MATLAB® based Simscape language enables text-based authoring of physical modeling components, domains, and libraries.

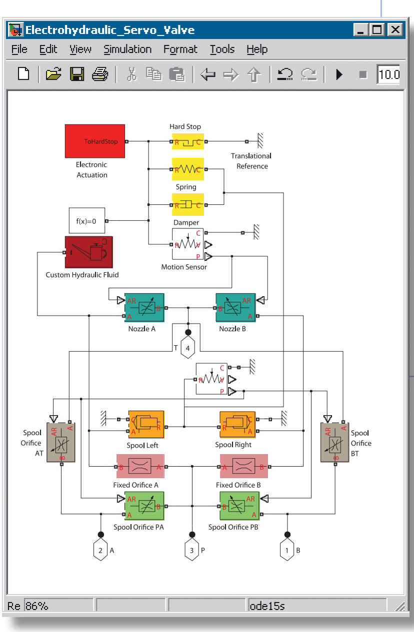
Simscape models can be converted to C code (with Real-Time Workshop®). The C code can be used as a standalone executable, incorporated into other simulation environments, and executed in real time on hardware-in-the-loop (HIL) systems.

Simscape can be used to model custom electrohydraulic valves, electromechanical actuators, inverting op-amps, heat transfer in a DC motor, and a variety of other systems. You can combine Simscape with other MathWorks physical modeling products to model complex interactions in multidomain physical systems.

KEY FEATURES

- Single modeling environment for modeling and simulating physical systems, such as mechanical, electrical, hydraulic, and thermal systems
- Library of fundamental physical modeling building blocks and mathematical elements, for modeling custom components
- MATLAB based Simscape language, enabling text-based authoring of physical modeling components, domains, and libraries
- Ability to specify units of parameters and variables, with all unit conversions handled automatically
- Connection blocks for bridging physical domains
- Full simulation and limited editing capabilities for models built with Simscape add-on products without requiring a license for these products
- Ability to convert Simscape models to C code (with Real-Time Workshop)





Cross-section illustration of an electrohydraulic servo-valve that uses a flapper-nozzle amplifier, highlighted in yellow (above). The colored blocks in the associated Simscape model (left) correspond to the colored arrows (above), which represent typical hydraulic flow paths.

Modeling Multidomain Physical Systems

With Simscape, you build a model of a system just as you would assemble a physical system. Simscape employs a physical network approach, also referred to as acausal modeling, to model building: Components (blocks) corresponding to physical elements, such as pumps, motors, and op-amps, are joined by lines corresponding to the physical connections that transmit power. This approach lets you describe the physical structure of a system rather than the underlying mathematics. From your model, which closely resembles a schematic, Simscape automatically constructs the differential algebraic equations (DAEs) that characterize the system's behavior. These equations are integrated with the rest of the Simulink model, and the DAEs are solved directly. The variables for the components in the different physical domains are solved simultaneously, avoiding problems with algebraic loops.

Creating Custom Components

Simscape lets you create models of custom components by using the basic elements contained in its foundation libraries.

Modeling Mechanical Components

Simscape provides mechanical building blocks for representing one-dimensional translational and rotational motion. In addition to basic elements like mass, spring, and damper, nonlinear effects such as backlash and friction are also included. Interface blocks provided with SimMechanics™ and SimDriveline™ enable you to connect Simscape models to models built using those tools.

Modeling Electrical Components

Simscape provides electrical building blocks for representing electrical components and circuits. In addition to basic elements like resistors, capacitors, and inductors, more complex elements such as op-amps and transformers are also included. More elaborate electronic and electromechanical components are available in SimElectronics™.

Modeling Hydraulic Components

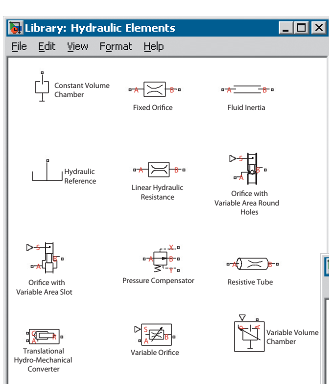
Simscape provides hydraulic building blocks that model fundamental hydraulic effects and can be combined to create more complex hydraulic components. These blocks define the pressure/flow relationship for basic physical effects, such as fluid compressibility, fluid inertia, mechanical friction, energy transduction, and flow through basic fixed and variable orifices. You can define a fluid by entering its fluid properties. More elaborate hydraulic components are available in SimHydraulics®.

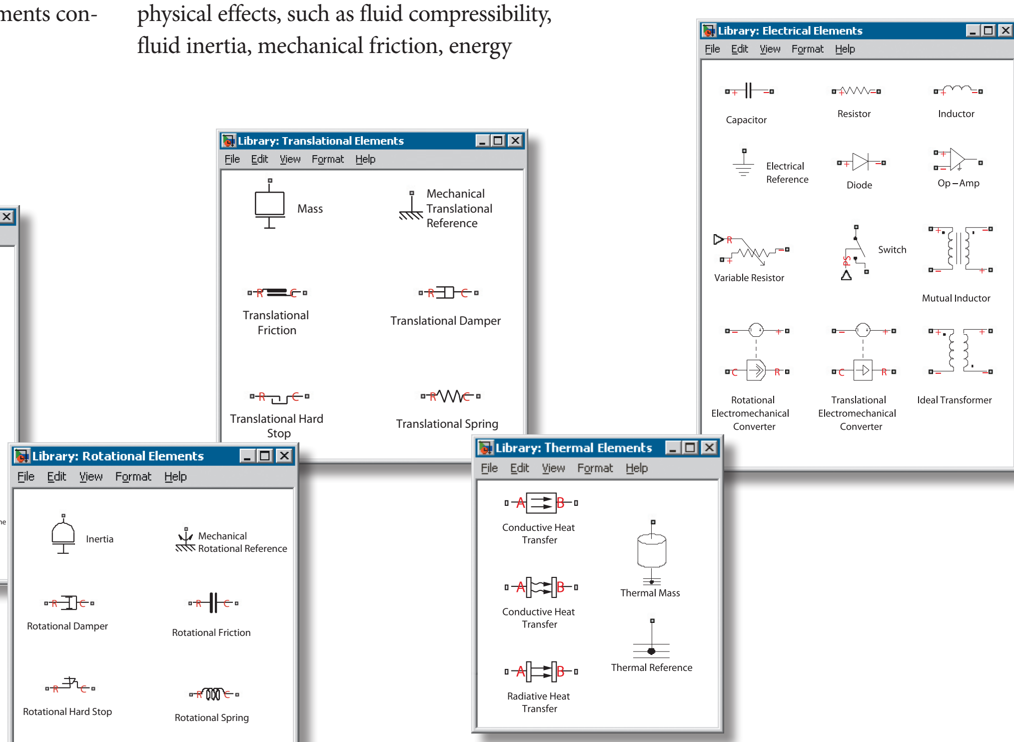
Modeling Thermal Effects

Simscape provides thermal building blocks for modeling and simulating thermal effects in your system. You can model conductive, convective, and radiative heat transfer as well as the thermal mass of elements. Using thermal source blocks, you can specify the temperature or heat transfer; using thermal sensor blocks, you can measure the amount of heat transfer or temperature change.

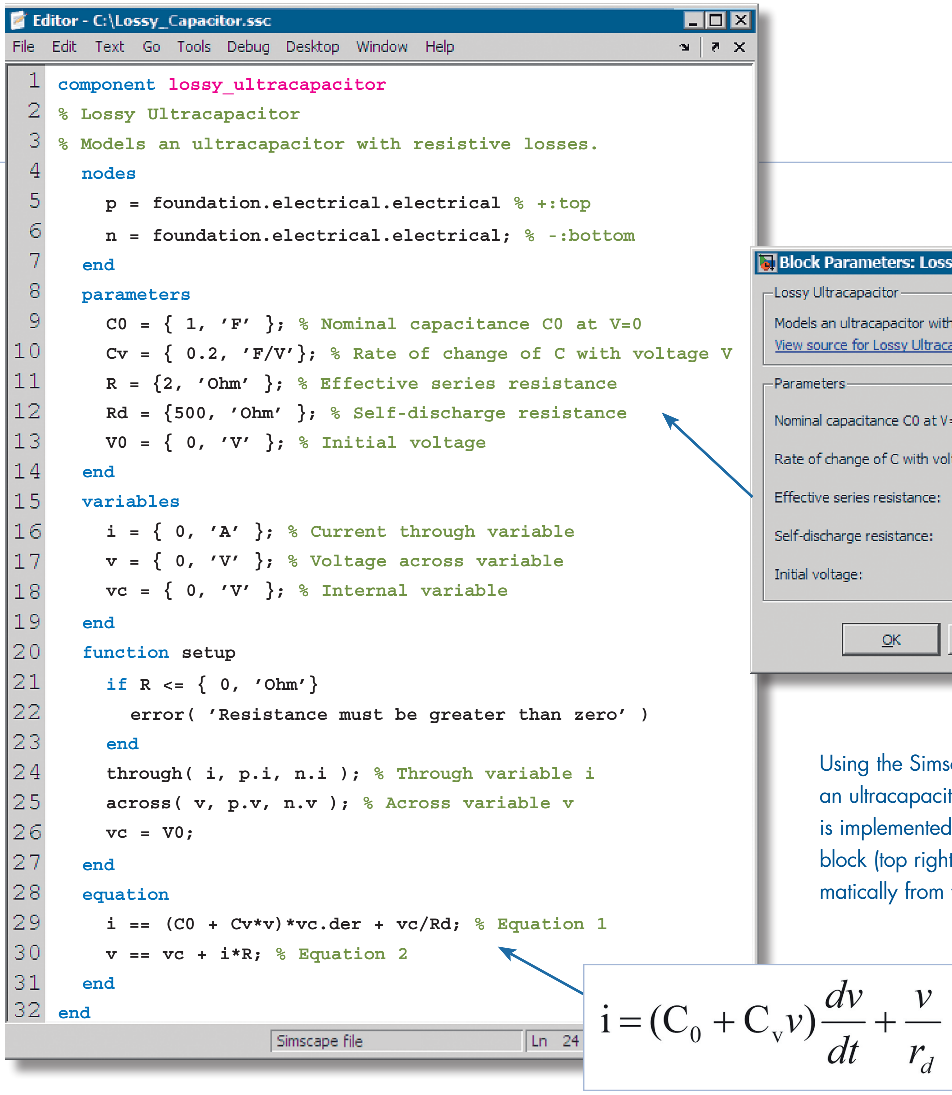
Working with Physical Signals

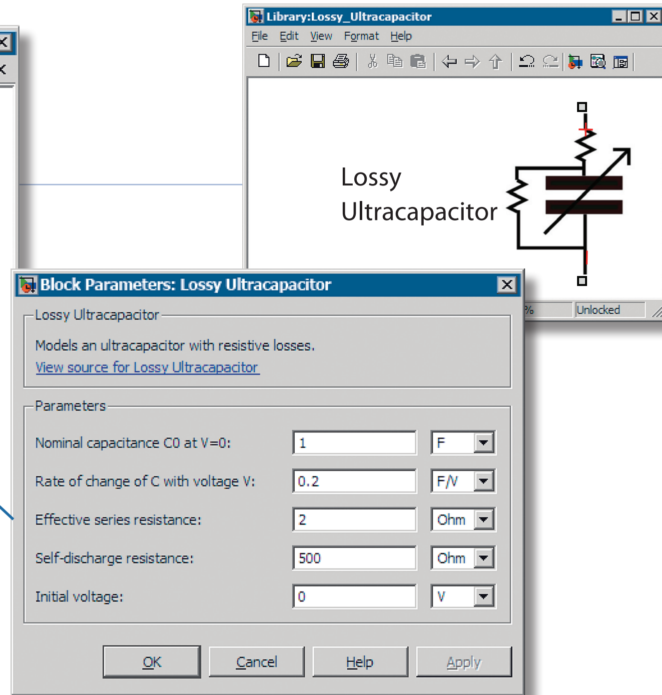
With Simscape your models can include physical signals that have units associated with them. You specify the units and parameter values in the block dialog boxes, and Simscape performs the necessary unit-conversion operations when solving a physical network. The Physical Signals block library





Simscape libraries of electrical, mechanical, hydraulic, and thermal building blocks for creating customized component models.





Using the Simscape language to create a custom model of an ultracapacitor with losses. The equation shown (bottom) is implemented in the Simscape language (left). The Simulink block (top right) and dialog box (center) are created automatically from the Simscape file.

lets you perform math operations on physical signals and graphically enter equations inside the physical network. Physical signal ports are used in Simscape block diagrams to better integrate physical signals into your physical system, which increases computational speed.

Using the elements contained in these foundation libraries, you can create more complex components that span different physical domains. As with Simulink, you can then group this assembly of blocks into a subsystem and parameterize it to reuse and share these components.

You can use the sensor blocks in Simscape to measure values for different physical quantities such as mechanical (force/torque, velocity), hydraulic (pressure, flow rate), or electrical (voltage, current) variables, and then pass these signals into standard Simulink blocks. Source blocks enable Simulink signals to assign values to any of these variables. Sensor and source blocks let you connect a control algorithm developed in Simulink to a Simscape network.

Using the Simscape Language

The Simscape language enables you to add new physical domains and to create your own physical modeling components and libraries. It is based on the MATLAB programming language, well-known by engineers. Using this object-oriented modeling language, you can define custom components, complete with parameterization, physical connections, and equations represented as acausal implicit DAEs. You can also use MATLAB to analyze the parameter values, perform preliminary computations, and initialize system variables. The Simulink block and dialog box for the component are automatically created from the Simscape file.

The components you create can reuse the physical domain definitions provided with Simscape to ensure that your components are compatible with the standard Simscape components. You can also add your own physical domains. You can automatically build and manage Simulink libraries of your Simscape components and domains, enabling you to share these models across your organization. You can also generate C code from Simulink models that contain your custom components.

Sharing Models Using Simscape Editing Modes

The Simscape Editing Modes let you perform physical modeling and simulation using Simscape and its add-on products: SimDriveline, SimElectronics, SimHydraulics, and SimMechanics. You can open, simulate, tune parameters for, and save models that contain blocks from add-on products with only a Simscape license, as long as the add-on products are installed on your machine. You can share your models across your organization without purchasing additional licenses.

Converting Simscape Models to C Code

With Simscape you can convert your models into C code, enabling you to use the accelerator modes of Simulink to reduce simulation time. You can also convert Simscape models into C code using Real-Time Workshop, which lets you:

- Run your model in real time, enabling you to perform HIL testing
- Integrate your model into other simulation environments
- Compile your Simscape model for standalone simulations, which accelerate analyses like parameter studies and Monte Carlo simulations

Multidomain Physical Modeling in MATLAB and Simulink

Simscape provides expanded capabilities for modeling physical systems. You can create your physical plant model using physical connections and connect it directly to your control model built using signal flows in Simulink. Simscape models can also be connected directly to other MathWorks application- and domain-specific physical modeling tools, enabling you to model complex interactions in multidomain physical systems. You can use MATLAB to parameterize your model, automate simulation tests, analyze output data, and optimize system performance. As a result, you can test your entire system (multidomain physical plant and controller) within the MATLAB and Simulink environment.

Required Products

MATLAB®
Simulink®

Related Products

SimDriveline™
Model and simulate mechanical driveline systems

SimElectronics™
Model and simulate electronic and electromechanical systems

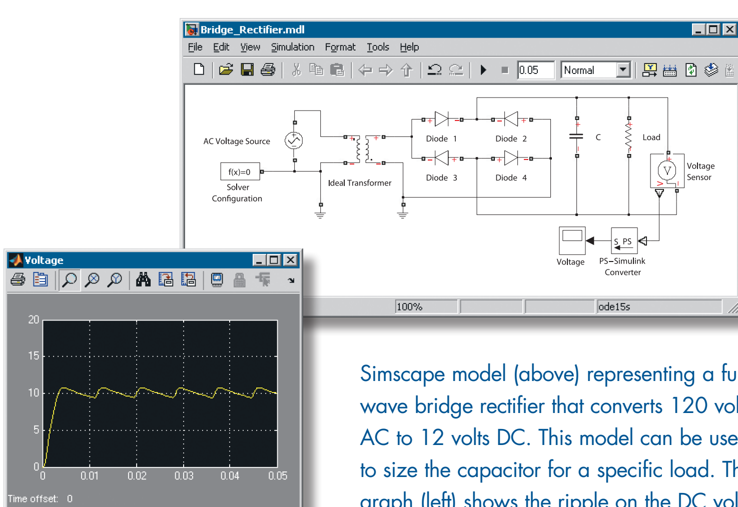
SimHydraulics®
Model and simulate hydraulic systems

SimMechanics™
Model and simulate mechanical systems

SimPowerSystems™
Model and simulate electrical power systems

Platform and System Requirements

For platform and system requirements, visit *www.mathworks.com/products/simscape* ■



Simscape model (above) representing a full-wave bridge rectifier that converts 120 volts AC to 12 volts DC. This model can be used to size the capacitor for a specific load. The graph (left) shows the ripple on the DC voltage.

Learn More

www.mathworks.com/products/simscape

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