SimElectronics® Release Notes

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*SimElectronics® Release Notes*

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**Version: 2.8**

**New Features**

**Compatibility Considerations**

## Fault block for modeling open-circuit and short-circuit electrical faults

Fault modeling helps you understand system behavior when a fault occurs during simulation, as well as test out fault detection and isolation algorithms. You can then stop the simulation, or just warn and continue, to see subsequent behavior.

The new `Fault` block in the Passive Devices library represents an electrical fault as an instantaneous change in resistance. Use it to replicate both open-circuit and short-circuit fault behaviors, and thus to represent faults on other library components. The block can trigger fault events:

- At a specific time
- When a predefined voltage range or current range is exceeded
- When an external trigger signal goes high or low

## Operating limits, tolerances, and fault parameterization for Resistor block

Operating limits modeling lets you detect when components exceed their rated values during simulation. Fault modeling helps you understand system behavior when a fault occurs during simulation, as well as test out fault detection and isolation algorithms. You can then stop the simulation, or just warn and continue, to see subsequent behavior.

The `Resistor` block now has additional fault, tolerance, and operating limits modeling options. The block lets you model the following effects:

- Nominal resistance tolerances
- Operating limits in terms of power and maximum working voltage
- Fault modeling at a specific time, or when a current limit is exceeded for longer than a specific time interval
- Thermal noise current
- Thermal effects, such as temperature-dependent resistance and operating limits, when you expose the thermal port on the block

## Compatibility Considerations

The ability of the Resistor block to model thermal effects renders the `Thermal Resistor` block obsolete. At this time, the Thermal Resistor block remains unchanged in the Passive Devices library to preserve compatibility of existing models. However, this

block may be removed in a future release. MathWorks recommends that, going forward, you use the Resistor block to model thermal effects, by exposing its thermal port.

## FEM-Parameterized PMSM block

The new `FEM-Parameterized PMSM` block in the Rotational Actuators library implements a model of a permanent magnet synchronous motor (PMSM) defined in terms of magnetic flux linkage. You parameterize the block by providing tabulated data of motor magnetic flux as a function of current and rotor angle.

## Servomotor block with tabulated efficiency option

`Servomotor` block now lets you specify efficiency using table lookup, as a function of torque and speed.

The block allows both simplified and tabulated definition of electrical losses. The default, simplified, behavior is the same as in previous releases.

Alternatively, you can provide tabulated loss values as a function of motor speed and load torque. When using this option, provide data for all of the operating quadrants that your simulation will run in. If you provide partial data (for example, just for the quadrant 1 forward motoring region), then the other quadrants are assumed to repeat the same pattern of losses. This will normally be correct for the reverse motoring region, but may be an approximation for the braking/generating quadrants. The block does no extrapolation of loss values for speed and torque magnitudes that exceed the range of the table.

# R2015a

**Version: 2.7**

**New Features**

**Bug Fixes**

## `elec_getPowerLossSummary` function to calculate and view semiconductor switching device losses

Checking dissipated power is useful for verifying that circuit components are operating within their working envelopes. All components that constitute blocks in the Semiconductor Devices library now have an internal variable called `power_dissipated`, which represents the instantaneous power dissipated by the component. When you log simulation data, the time-value series for this variable represents the power dissipated by the component over time. You can view and plot this data using the Simscape™ Results Explorer.

The elec_getPowerLossSummary function lets you calculate average losses for a block over a period of time. Some blocks are composite components and therefore have more than one `power_dissipated` variable, depending on their member components. For example, the N-Channel IGBT block has separate `power_dissipated` logging nodes for the MOSFET, PNP bipolar transistor, collector resistor, and emitter resistor member components. In this case, the `elec_getPowerLossSummary` function sums all these losses and provides the power loss value for the whole block.

To use the `elec_getPowerLossSummary` function, you have to enable simulation data logging and run the simulation. For more information, see Data Logging.

The function takes a Simscape logging node as the first input argument. The second and third input arguments are optional and represent the start and end of a time interval for averaging the power losses. If you omit these two input arguments, the function averages the power losses over the whole simulation time.

The function returns a MATLAB® table. The first column lists all blocks, within the specified logging node, that have at least one `power_dissipated` variable, and the second column lists the corresponding losses in watts.

For an example of using this function to determine the efficiency of a single-stage solar converter, see Solar Power Converter.

## Nonlinear magnetization inductance with hysteresis option for Nonlinear Inductor and Nonlinear Transformer blocks

A new parameterization option for magnetization inductance, `Magnetic Flux Density Versus Magnetic Field Strength Characteristic with Hysteresis`, is available for the following blocks:

- Nonlinear Inductor
- Nonlinear Transformer

This option lets you define magnetic flux density as a function of both the magnetization of the core and the history of the magnetic field strength, based on the Jiles-Atherton model of hysteresis. See the block reference pages for details.

## Schmitt Trigger block

The Schmitt Trigger block in the Logic sublibrary of the Integrated Circuits library implements a behavioral model of Schmitt trigger. The block output logic level is HIGH when the input rises above the **High level input voltage** value and does not go LOW until the input falls below the lower-valued **Low level input voltage** value. This implements a hysteresis characteristic between input and output of the block.

## Current Limiter block

The Current Limiter block in the Semiconductor Devices library provides a behavioral model of a current limiter. Use it to represent current limiting as found in some power supplies and motor drives, and also to represent components that are used to limit inrush current.

## Droop parameterization for DC-DC Converter block

The DC-DC Converter block now has a new parameter, **Droop parameterization**, which lets you choose between two options:

- `By voltage droop with output current` — Specify the absolute value of droop by using the **Output voltage droop with output current** parameter. This is the default option and the method available in previous releases.
- `By percent voltage droop at rated load` — Specify droop as a percentage at rated load by using the **Percent voltage droop at rated load** parameter. This is the new method. You specify a value, in percent, by which voltage drops compared to the nominal output volage when supplying the rated load. The default is 2 percent.

The DC-DC Converter block now also has a new physical signal input port F and a new tab, **Faults**, in the block dialog box, to let you simulate the DC supply failure and converter failure. See the block reference page for details.

## Thermal port available for H-Bridge block

The H-Bridge block can now have an optional thermal port. By default, the thermal port is not displayed. To expose the thermal port, right-click the H-Bridge block in your model, and then from the context menu select **Simscape** > **Block choices** > **Show thermal port**. This action displays the thermal port H on the block icon, and adds the **Temperature Dependence** and **Thermal port** tabs to the block dialog box.

When the thermal port is visible:

- The heat generated by the bridge on-resistance and freewheeling diodes is added to the thermal port. The thermal port has an associated thermal mass and initial temperature that are set from the **Thermal port** tab.
- The bridge on-resistance and freewheeling diode resistance become functions of temperature. The values for these resistances and the second measurement temperature are defined from the **Temperature Dependence** tab. Resistance is assumed to vary linearly between the two measurement temperatures. Extrapolation is used for temperatures outside of this range except for when simulating in averaged mode with discontinuous load current characteristics.

## New examples

Examples introduced in this version are:

- Inductor With Hysteresis
- Analog Anti-Aliasing Filter
- Phase-Locked Loop

# R2014b

**Version: 2.6**

**New Features**

## Averaged mode for stepper motor and driver blocks

A new parameter, **Simulation mode**, lets you select between `Stepper` and `Averaged` modes, and is available for the following blocks:

- Stepper Motor
- Stepper Motor Driver
- Unipolar Stepper Motor
- Unipolar Stepper Motor Driver

If you select Averaged simulation mode for a motor-driver pair (that is, for a Stepper Motor block and for the Stepper Motor Driver block that controls it, or for a Unipolar Stepper Motor block and its Unipolar Stepper Motor Driver block), then the individual steps are not simulated. This can be a good way to speed up simulation.

Averaged mode includes a slip estimator to predict whether the stepper motor would have slipped if running in Stepping simulation mode. Upon detecting slip, the simulation either continues (with or without a warning) or stops with an error, depending on your setting for the **Action on slipping** parameter. If you simulate or predict slip, it is generally a good practice to do some validation runs comparing Stepping and Averaged modes before using the averaged model representation for simulation studies. See the block reference pages for details.

## Torque or force calculation option for FEM actuator blocks

FEM-Parameterized Rotary Actuator and FEM-Parameterized Linear Actuator blocks let you either enter the torque or force data, as in previous releases, or calculate the torque or force matrix from flux linkage information.

If the finite element package does not provide torque (force) and provides only flux data, then you can let the block automatically calculate the torque (force) matrix from the flux information. To select this option, set the **Calculate torque matrix?** or **Calculate force matrix?** parameter (as appropriate) to `Yes`. The torque (force) matrix calculation occurs at model initialization based on current block flux linkage information. See the block reference pages for details.

## Nonzero threshold width in Switch blocks

A new parameter, **Threshold width**, is available for the following blocks:

- SPST Switch
- SPDT Switch
- DPST Switch
- DPDT Switch

If the **Threshold width** parameter is set to zero (which is the default), the switch is closed if the voltage presented at the vT control port exceeds the value of the **Threshold** parameter.

If the **Threshold width** parameter is greater than zero, then switch conductance $G$ varies smoothly between off-state and on-state values. Defining a small positive **Threshold width** can help solver convergence in some models, particularly if the control port signal $vT$ varies continuously as a function of other network variables. However, defining a nonzero threshold width precludes the solver from making use of switched linear optimizations. Therefore, if the rest of your network is switched linear, MathWorks recommends that you set **Threshold width** to zero.

## Event-based variant of the N-Channel IGBT block

In previous releases, the N-Channel IGBT block provided two ways of modeling an IGBT:

- As an equivalent circuit based on a PNP bipolar transistor and N-channel MOSFET
- By a lookup table approximation to the I-V (current-voltage) curve

These two methods are still available under the **Full I-V and capacitance characteristics** block variant. In documentation, this variant is also referred to as the detailed model. A new block variant, **Simplified I-V characteristics and event-based timing**, provides a simplified, event-based model, which lets you represent the IGBT more simply by using just the on-state I-V data corresponding to the gate voltage used in your circuit. Switching between states is achieved by linearly ramping the collector-emitter voltage, which results in much faster simulation speed. Use the event-based variant when the focus of the analysis is to understand overall circuit behavior rather than to verify the precise IGBT timing or losses characteristics. For details, see Event-Based IGBT Variant.

To select the desired variant, right-click the N-Channel IGBT block in your model. From the context menu, select **Simscape** > **Block choices**, and then one of the following options:

- **Full I-V and capacitance characteristics | No thermal port** — Detailed model that does not simulate the effects of generated heat and device temperature. This is the default.
- **Full I-V and capacitance characteristics | Show thermal port** — Detailed model with exposed thermal port.
- **Simplified I-V characteristics and event-based timing | No thermal port** — Simplified event-based model, which also does not simulate the effects of generated heat and device temperature.
- **Simplified I-V characteristics and event-based timing | Show thermal port** — Simplified event-based model with exposed thermal port.

See the N-Channel IGBT block reference page for more information.

## Tabulated capacitance options for MOSFET and IGBT blocks

N-Channel IGBT, N-Channel MOSFET, and P-Channel MOSFET blocks now have additional options on the **Junction Capacitance** tab that let you parameterize the charge model using table lookup.

In previous releases, these blocks provided two options for modeling capacitance: either by specifying the junction capacitance values directly, or by letting the block derive them from the input and reverse transfer capacitance values. Now each of these methods allows you to enter either fixed capacitance values or tabulated values as a function of the collector-emitter (drain-source) voltages. See the block reference pages for details.

## Z pulse width change in Incremental Shaft Encoder block

In previous releases, there was no correlation between the Z pulse width and the length of the A and B pulses. Therefore, although the block created a rising edge for the synchronization Z pulse at the correct time, you could not use this block to synchronize on the falling edge.

The Z pulse on time is now equal to the A and B pulse on times for a given rotational speed, giving you the ability to decode on the rising edge and on the falling edge. For existing models where just the rising edge of the pulse trains is used for decoding or where the Z pulse is not used, there is no change in behavior.

## New examples

Examples introduced in this version are:

- Behavioral IGBT Using Event-Based Equations
- Stepper Motor Averaged Mode

# R2014a

**Version: 2.5**

**New Features**

**Compatibility Considerations**

## Unipolar Stepper Motor Driver block and half-stepping option for stepper motor drivers

The new Unipolar Stepper Motor Driver block in the Drivers library represents a driver specifically configured for use with the Unipolar Stepper Motor block. It connects the two winding center-tap connections A0 and B0 to the positive supply with a voltage equal to the value you provide for the **Output voltage amplitude** parameter. The A+, A-, B+ and B- ports are then grounded in the appropriate sequence to create the stepping motion. The block initiates a step each time the voltage at the PWM port rises above the **Enable threshold voltage**.

The Stepper Motor Driver block now has an option to produce the output waveforms required for half-stepping. By default, the driver operates in full-stepping mode, but if you set the **Stepping mode** parameter to `Half stepping`, the driver generates an intermediate state between the full steps, in which just one of the A or the B half-windings is powered. As a result, the step size is half of the stepper motor's full step size. The new Unipolar Stepper Motor Driver block also has this option.

## Detent torque for stepper motors

Both the Stepper Motor and the Unipolar Stepper Motor blocks now let you account for the torque variation observed when the motor is unpowered and the shaft is rotated. Detent torque is generated by the interaction of the permanent magnet flux and the variation in reluctance as the teeth come in and out of alignment. The new **Detent torque** parameter represents the amplitude of the sinusoidal torque variation, and the corresponding term is added to the block equations. By default, the parameter value is 0, in which case detent torque is neglected in block computations. Legacy models are not affected.

## Output capacitance for MOSFET and IGBT blocks

A new block parameter lets you specify a value for output capacitance:

- For N-Channel IGBT, the **Output capacitance, Coes** parameter represents the output capacitance applied across the collector-emitter ports.
- For N-Channel MOSFET and P-Channel MOSFET, the **Output capacitance, Coss** parameter represents the output capacitance applied across the drain-source ports.

Modeling the output capacitance is generally important in signal processing applications, as it has measurable effect on circuit behavior. For motor control applications the

effect is not as significant, because the other capacitances play a much bigger part in setting turn-on and turn-off dynamics. However, if your datasheet provides a value for output capacitance, you can enter it to increase the block fidelity. The default value is 0, therefore legacy models are not affected.

## Lookup table definition of I-V relationship in IGBT and Thyristor blocks

In previous releases, the Thyristor and N-Channel IGBT blocks have been represented by an equivalent circuit constructed from other semiconductor blocks, such as bipolar transistors and MOSFETs. Now both blocks have an additional representation option, by a lookup table approximation of the on-state current-voltage curve. The main advantages of using this option are increased simulation speed and ease of parameterization. See the block reference pages for details.

## Thyristor block that now models devices with higher leakage currents

In the Thyristor block represented by an equivalent circuit, the underlying model has been enhanced with a pair of back-to-back diodes to allow a wider range of leakage current variation. To help you parameterize your thyristor to match the manufacturer datasheet, two test harnesses have been added to the SimElectronics® examples, Thyristor Static Behavior Validation and Thyristor Dynamic Behavior Validation. See the block reference page for more information.

## Compatibility Considerations

To take advantage of the additional diodes, the mapping of the block parameters to the equation parameters has been changed. Existing models may need fine-tuning of parameter values to match the exact behavior with previous versions of the block, particularly for parameters associated with dynamics.

## New examples

Examples introduced in this version are:

- FEM-Parameterized Switched Reluctance Motor
- Automotive Electrical System
- Photovoltaic Generator Performance
- Microcontroller with GPIO, ADC and DAC Connections

- Tabulate IGBT Switching Losses

# R2013b

**Version: 2.4**

**New Features**

## Voltage-Controlled Oscillator block

The new Voltage-Controlled Oscillator block in the Integrated Circuits library models abstracted behavior of a voltage-controlled oscillator (VCO). VCOs are basic building blocks for RF transmitter and receiver devices, microprocessor clocks, and A-to-D converters. The block models a behavioral representation of a VCO for simulation efficiency.

You have two options for specifying frequency dependence on the input voltage:

- Linear — By specifying a coefficient for the rate of change of frequency with input voltage.
- Tabulated — By using a lookup table and specifying a vector of input voltages and a corresponding vector of VCO frequencies relative to the nominal frequency.

You also can model the time delay between a change in the input control voltage and the oscillator frequency.

## Servomotor block that now permits parameterized torque-speed curve and optional iron losses

In previous versions, the Servomotor block allowed you to specify the torque-speed envelope only as a set of speed data points and corresponding maximum torque values. Now, you can also define the torque-speed envelope by specifying a maximum torque and a maximum power instead of providing the tabulated torque-speed data.

The block now also accounts for iron losses due to eddy currents. The **Torque-independent electrical losses** parameter is renamed to **Fixed losses independent of torque and speed**, and the new **Iron losses** parameter lets you specify the iron losses at the speed and torque at which efficiency is defined.

## Solar Cell block that now models solar cell arrays

In previous versions, the Solar Cell block allowed you to model a single photovoltaic cell. Now, you can model any number of solar cells connected in series using a single Solar Cell block by setting the parameter **Number of series cells** to a value larger than one. Internally the block still simulates only the equations for a single solar cell, but scales up the output voltage according to the number of cells. This results in a more efficient simulation than if equations for each cell were simulated individually.

If you want to model N cells in parallel, you can do so for single cells by scaling the parameter values accordingly. That is, multiply short-circuit current, diode saturation current, and solar-generated currents by N, and divide series resistance by N. To connect solar cell blocks in parallel, where each block contains multiple cells in series, make multiple copies of the block and connect accordingly.

## New examples

Examples introduced in this version are:

- Solar Cell Power Curve
- Solar Power Converter

# R2013a

**Version: 2.3**

**New Features**

**Compatibility Considerations**

## Resistor with optional thermal noise

The new Resistor block in the Passive Devices library models a linear resistor that can optionally generate thermal noise current. The Gaussian noise is generated using the new Random Number source block in the Simscape Foundation library. The **Repeatability** parameter gives you the following options for noise control: not repeatable, repeatable with a random seed, and repeatable with explicitly specified seed.

## Compatibility Considerations

Legacy models, created in R2009b or earlier and not saved using a more recent version, may need updating if they contain the SPICE Resistor block. If this is the case, upon opening the model you will get a warning saying that the Resistor block does not have a parameter named SCALE. To fix this issue, replace the resistor either with the new Resistor block from the Passive Devices library, or with a new copy of the SPICE Resistor block from the Additional Components/Spice-Compatible Components library.

## Voltage and current sources with DC, AC, and noise components

Two new blocks have been added to the Sources library:

- Voltage Source block — Configurable as either AC or DC voltage source with optional noise
- Current Source block — Configurable as either AC or DC current source with optional noise

By default, both AC and DC components are set to 0 in each block. Define the AC/DC voltage or current by specifying nonzero values for the appropriate parameters after placing the block in your model.

If you enable the noise component, the Gaussian noise voltage or current, respectively, is generated using the new Random Number source block in the Simscape Foundation library. The **Repeatability** parameter gives you the following options for noise control: not repeatable, repeatable with a random seed, and repeatable with explicitly specified seed.

## Nonlinear charge model for N-Channel MOSFET, P-Channel MOSFET, and N-Channel IGBT blocks

The two MOSFET blocks now model gate junction capacitance as a fixed gate-source capacitance and either a fixed or a nonlinear gate-drain capacitance. The IGBT block now models gate junction capacitance as a fixed gate-emitter capacitance and either a fixed or a nonlinear gate-collector capacitance.

If you select the nonlinear option for the charge-voltage linearity, then the gate-drain charge relationship, or the gate-collector charge relationship, respectively, is defined by a piecewise-linear function. For more information, see the respective block reference pages.

## New examples

Examples introduced in this version are:

- Op-Amp with Noise
- Sigma Delta ADC with Noise
- IGBT Dynamic Characteristics

# R2012b

**Version: 2.2**

**New Features**

**Compatibility Considerations**

## Single-pole and double-pole switch blocks

The Passive Devices library now contains a sublibrary, named Switches, with four new blocks:

- The DPDT Switch block models a double-pole double-throw switch.
- The DPST Switch block models a double-pole single-throw switch.
- The SPDT Switch block models a single-pole double-throw switch.
- The SPST Switch block models a single-pole single-throw switch.

For each switch type, you have an option of modeling turn-on and turn-off delays, that is, a delay between the point at which the voltage at the control port passes the threshold and the point at which the switch opens or closes.

## Five new sensor blocks: PTC Thermistor, Pressure Transducer, Resolver, Gyro, and Accelerometer

Five new blocks have been added to the Sensors library:

- The Accelerometer block provides an abstract model of a MEMS accelerometer. The acceleration at the mechanical translational port is mapped to either a voltage level or the duty cycle of a PWM voltage across the electrical + and - ports. The output voltage is limited according to the values that you provide for maximum and minimum output voltage. Optionally, you can model sensor dynamics by adding a first-order lag between the angular rate at the mechanical port and the corresponding voltage applied to the electrical + and - ports.
- The Gyro block provides an abstract model of a MEMS gyroscope. The gyro provides an output voltage that is proportional to the angular rotation rate presented at the mechanical rotational port. The output voltage is limited according to the values that you provide for maximum and minimum output voltage. Optionally, you can model sensor dynamics by adding a first-order lag between the angular rate at the mechanical port and the corresponding voltage applied to the electrical + and - ports.
- The PTC Thermistor block models a switching type positive temperature coefficient (PTC) thermistor. This type of thermistor has a decreasing resistance with increasing temperature, up to the Curie temperature. Above the Curie temperature, the resistance increases very rapidly with increasing temperature. To represent a non-switching linear PTC thermistor, use the Thermal Resistor block.
- The Pressure Transducer block models a generic pressure transducer that turns a pressure measurement into a voltage. The output voltage is linearly proportional to

the pressure. If the pressure is less than zero, the block outputs zero volts. An input pressure equal to the **Pressure range** parameter value results in an output voltage equal to the **Full-scale deflection** parameter value. For higher pressures, the output voltage remains at this **Full-scale deflection** value. You have three choices of operation mode, which let you select between vacuum, atmospheric pressure, or sealed-gauge reference pressure as the reference point for the pressure measurement. You also have an option of approximating the sensor dynamics by a first-order lag.

- The Resolver block models a generic resolver, which consists of a rotary transformer that couples an AC voltage applied to the primary winding to two secondary windings. These secondary windings are physically oriented at 90 degrees to each other. As the rotor angle changes, the relative coupling between the primary and the two secondary windings varies. In the Resolver block model, the first secondary winding is oriented such that peak coupling occurs when the rotor is at zero degrees, and therefore the second secondary winding has minimum coupling when the rotor is at zero degrees.

## Nonlinear Transformer and Nonlinear Inductor blocks

Two new blocks in the Passive Devices library let you take into account nonlinearities in inductors and transformers due to magnetic saturation:

- The Nonlinear Inductor block represents an inductor with a core that is nonideal, due to its magnetic properties or dimensions. You have multiple options of block parameterization, including single inductance, single saturation point, magnetic flux versus current characteristic, and magnetic field density versus magnetic field strength characteristic.

- The Nonlinear Transformer block is based on the Nonlinear Inductor block and has similar parameterization options, which let you model varying levels of nonlinearity. You can parameterize the transformer winding either by combined primary and secondary values, or by separate values for primary and secondary leakage resistance and inductance.

## DC-DC Converter block and Incandescent Lamp block

The new DC-DC Converter block in the Sources library represents a behavioral model of a power converter. The power converter regulates voltage on the load side and the required amount of power is drawn from the supply side to balance input power, output power, and losses. Optionally, the converter can support regenerative power flow from load to supply.

The new Incandescent Lamp block in the Passive Devices library models an incandescent lamp. The key characteristic of this block is that the resistance increases as the filament warms up. The rate of heat loss from the filament is proportional to the filament's temperature difference to ambient. Optionally, you can simulate the fault dynamics by specifying a simulation time at which the lamp fails.

## Unipolar Stepper Motor block and Stepper Motor block that now account for iron losses

The new Unipolar Stepper Motor block in the Rotational Actuators library represents a stepper motor that has center taps on the two phase windings. All four half-windings are identical. The block lets you simulate thermal effects, and also accounts for iron losses, both in its electrical and thermal equations.

The existing Stepper Motor block has been enhanced to account for iron losses, as well. It now has an additional thermal port HR, corresponding to the rotor and associated iron losses. Additional parameters on the **Electrical** and **Thermal Port** tabs let you specify magnetizing resistance, rotor thermal mass and initial temperature, and the percentage of the magnetizing resistance associated with the magnetic path through the rotor.

### Compatibility Considerations

If your existing model uses a Stepper Motor block with thermal ports exposed, the block now has an additional thermal port HR (corresponding to the rotor and associated iron losses). Leaving this new port unconnected results in a simulation-time error. If iron losses associated with the rotor are not important, you can connect the HR port to an Adiabatic Cup block.

### New examples

Examples introduced in this version are:

- Automotive Alternator
- Nonlinear Inductor Characteristics
- Nonlinear Transformer Characteristics
- Parameterizing a TVS Diode
- Ultracapacitor With Converter
- Hybrid Vehicle Electrical Network

# R2012a

**Version: 2.1**

**New Features**

## Thermal Ports Available for Actuator Blocks and for Solar Cell Block

All the blocks in the Rotational Actuators and Translational Actuators libraries, as well as the Solar Cell block in the Sources library, can now have optional thermal ports. By default, the thermal ports are not displayed. To expose the thermal port, right-click on the relevant block in your model, and from the context menu select **Simscape block choices** > **Show thermal port**. This action displays the thermal port H on the block icon, and adds the **Thermal port** tab to the block dialog box.

This functionality is not always available for blocks in existing models, depending on when the model was last saved. If you right-click on a block in a model saved in a previous version, and the context menu item **Simscape block choices** does not appear, make a new copy of the block from the SimElectronics library.

## Fully Differential Op-Amp Block

The new Fully Differential Op-Amp block in the Integrated Circuits library models an operational amplifier with fully differential output, that is, not referenced to ground. The output common-mode voltage is controlled by the common-mode port `cm`. Internal resistors set the nominal output common-mode voltage to be midway between the values you provide for the positive and negative supply voltages. Applications include data acquisition where inputs are differential, for example, sigma-delta converters.

The block provides a behavioral model of a fully differential operational amplifier. It does not represent nonlinear effects, such as variation in gain with output voltage amplitude, and the nonlinear nature of the output voltage-current relationship for large load currents.

## Transmission Line Block

The new Transmission Line block in the Passive Devices library lets you model a transmission line either by using delays, or by a lumped parameter model. Use the delay-based models for better simulation performance at system level. The lossless delay-based model represents an ideal transmission line.

## Power Sensor Block

The new Power Sensor block in the Sensors library calculates the power taken by the load connected across the + and - terminals under the assumption that only the load is connected to the + terminal.

The sensor can return either instantaneous power, or power averaged over a fixed time period. The latter option is useful when working with periodic current and voltage waveforms, such as those associated with PWM control.

For an example of using this block, see the Flyback Converter demo.

## Induction Motor Block Usability Enhancement

The usability of the Induction Motor block has been improved. In previous versions, when setting **Model parameterization** to By motor ratings, you had to provide a value for either the motor starting current or maximum torque. This group of parameters has been removed, and instead the **Rated RMS line current** parameter value is used to determine the total motor inductance. In existing models, if you used consistent values for **RMS starting (or locked rotor) line current** and **Rated RMS line current**, simulation results are the same as in previous versions.

## Controlled PWM Voltage Block Enhancement

The Controlled PWM Voltage block has two new parameters, **Pulse delay time** and **Pulse width offset**. Use these parameters to add a small turn-on delay and a small turn-off advance. This can be helpful when fine-tuning switching times, to minimize switching losses.

## Exponential Diode Block Now Models Charge Dynamics

The Diode block now lets you model charge dynamics. The Exponential diode model contains an additional set of parameters that let you either specify values for the transit time and carrier lifetime directly, or calculate them using the peak reverse current and reverse recovery time. This functionality is especially useful for applications such as commutation diodes.

## New Demos

Demos introduced in this version are:

- Controllable Phase Shifter
- Low-Pass Filter Using Operational Transconductance Amplifiers
- Fourth-Order Sallen-Key Lowpass Filter

- Flyback Converter

# R2011b

**Version: 2.0**

**New Features**

**Compatibility Considerations**

## Thermal Ports Available for Semiconductor Blocks

All the blocks in the Semiconductors library, as well as the Photodiode and Light-Emitting Diode blocks in the Sensors library, can now have optional thermal ports. By default, the thermal ports are not displayed. To expose the thermal port, right-click on the relevant block in your model, and from the context menu select **Simscape block choices** > **Show thermal port**. This action displays the thermal port H on the block icon, and adds the **Thermal port** tab to the block dialog box.

## Compatibility Considerations

In the N-Channel IGBT block, several new parameters on the **Advanced** tab have been added, to better match the typical device datasheets. The **Forward Early voltage, VAF** parameter, with the default value of 200 V, specifies the Forward Early voltage for the PNP transistor. Previously the effect was not modeled. This means that existing models will show small differences in the current-voltage relationship associated with the PNP bipolar transistor, compared to the previous version. Additionally, the new **Collector resistance, RC** and **Emitter resistance, RE** parameters have nonzero default values, to improve the numeric efficiency of computations. If you want to preserve the simulation results for the existing models, set **Forward Early voltage, VAF** to `1e10`, **Collector resistance, RC** to `0`, and **Emitter resistance, RE** to `0`.

## New Operational Transconductance Amplifier Block

The Operational Transconductance Amplifier block, added to the Integrated Circuits library, provides a behavioral representation of an operational transconductance amplifier. A transconductance amplifier converts an input voltage into an output current. Applications include variable frequency oscillators, variable gain amplifiers, and current-controlled filters. These applications are based on the fact that the transconductance gain is a function of current flowing into the control current pin.

The block does not model the detailed transistor implementation. This results in faster simulation, but the model is only valid when operating in the linear region, that is, where the device input resistance, output resistance, and transconductance gain all depend linearly on the control current, and are independent of input signal amplitude.

## New Push-Pull Output Block

The Push-Pull Output block, added to the Integrated Circuits library, provides a behavioral representation of a CMOS complementary output stage. To improve

simulation speed, the block does not model all the internal individual MOSFET devices that make up the gate You can use this block to create a representative output current-voltage relationship when defining an integrated circuit model behavior with Physical Signal blocks from the Simscape Foundation library. For an example, see the Modeling an Integrated Circuit demo.

## H-Bridge Block Enhancements

The following enhancements have been implemented for the H-Bridge block:

- In Averaged mode, a new **Load current characteristics** parameter is available with two options, `Smoothed` and `Unsmoothed or discontinuous`. The first option assumes that the current is practically continuous due to load inductance, and corresponds to the old block behavior. For cases where the current is not smooth, or goes to zero between PWM cycles, use the `Unsmoothed or discontinuous` option, and provide values for the new **Total load series resistance**, **Total load series inductance**, and **PWM frequency** parameters. During simulation, the block uses these values to calculate a more accurate value for H-bridge output voltage that achieves the same average current as would be present if simulating in PWM mode.

- The **Freewheeling mode** parameter is now available not only in PWM mode, but also in Averaged mode in cases where you select `Unsmoothed or discontinuous` for the **Load current characteristics** parameter.

- An additional **Freewheeling mode** option, `Via two semiconductor switches and one freewheeling diode`, controls the load by maintaining one high-side bridge arm permanently on and using the PWM signal to toggle between enabling the corresponding low-side bridge arm and the opposite high-side bridge arm. This means that the block uses a freewheeling diode in parallel with a bridge arm, plus another series bridge arm, to complete the dissipation circuit when the bridge turns off.

- The block dialog box has been reorganized using tabs, to improve usability.

## DC Motor Block Supports No-Load Current Data for Rotor Damping

The DC Motor block has an additional option that lets you use no-load current data to calculate a value for rotor damping. This is helpful when the manufacturer datasheet does not provide an explicit rotor damping value.

The **Rotor damping parameterization** drop-down has been added to the **Electrical Torque** tab of the block dialog box, with the following values:

- By damping value — Specify a value for rotor damping directly, by using the **Rotor damping** parameter on the **Mechanical** tab. This is the default.
- By no-load current — The block calculates rotor damping based on the values that you specify for the **No-load current** and **DC supply voltage when measuring no-load current** parameters. If you select this option, the **Rotor damping** parameter is not available on the **Mechanical** tab.

## Compatibility Considerations

Previously, if the **Model parameterization** parameter was set to By stall torque & no-load speed or By rated power, rated speed & no-load speed, the block did not take rotor damping into account. The new block equations always include rotor damping, because it is now tied to no-load current. Therefore, rated speed and no-load speed results for existing models using these options will be slightly different than in previous versions if the model has a nonzero damping value.

If you wish to retain the original behavior, set the rotor damping to zero, and add an external Rotational Damper block (from Simscape Foundation library) across the motor R and C ports.

## New Demos

Demos introduced in this version are:

- IGBT Thermal Characteristics
- Low-Cost Voltage Regulator
- Synchronous Buck Converter With Thermal Dynamics
- Thermal Characteristics of a Synchronous Buck Converter

# R2011a

**Version: 1.6**

**New Features**

**Compatibility Considerations**

## Thermal Dependency Added to Semiconductor Blocks

Dialog boxes of most of the blocks in the Semiconductors library, and some related blocks, now have a new tab, **Temperature Dependence**, which lets you specify additional parameters to model the temperature dependence during simulation. For details, see reference pages of the following blocks:

- Diode
- Light-Emitting Diode
- N-Channel IGBT
- N-Channel JFET
- N-Channel MOSFET
- NPN Bipolar Transistor
- Optocoupler
- Photodiode
- P-Channel JFET
- P-Channel MOSFET
- PNP Bipolar Transistor

### Compatibility Considerations

In NPN and PNP Bipolar Transistor blocks, a new parameter, **Collector-emitter voltage at which h-parameters are defined**, has been added. It serves to increase the accuracy with which equation parameters are calculated from h-parameters, to better capture current gain dependence on temperature. As a result, when you use `Specify from a datasheet` for the **Parameterization** parameter, there is a small change in the resulting transistor gain BF (calculated from the **Forward current transfer ratio h_fe** parameter value), compared to the previous version of the block.

### New Demos

Demos introduced in this version are:

- Torque Motor
- Schottky Barrier Diode Characteristics
- IGBT Characteristics

- Master-Slave J-K Flip-Flop

Change to an existing demo:

- The Finite Element Parameterized Solenoid demo now includes comparison with the Simscape solenoid demo `ssc_solenoid.mdl`, to illustrate the effects of flux saturation.

# R2010b

**Version: 1.5**

**New Features**

## New Thyristor Block

The new Thyristor block, located in the Semiconductor Devices library, represents a thyristor modeled using an NPN and a PNP transistor. The collector of each device is connected to the base of the other device so as to give the P-N-P-N junction structure of a thyristor.

## New Multiplier Block

The new Multiplier block, located in the Integrated Circuits library, represents an integrated circuit multiplier for physical signals. It allows you to multiply and divide signals without switching to Simulink signals and back.

## Additional Exponential Diode Parameterization Options

When using the Diode block, with the **Diode model** parameter set to `Exponential`, you now have two additional options under **Parameterization**:

- `Use an I-V data point and IS` — Specify measured data at a single point on the diode I-V curve in combination with the saturation current.
- `Use an I-V data point and N` — Specify measured data at a single point on the diode I-V curve in combination with the emission coefficient.

See the block reference page for details.

## Channel Modulation Parameter Added for MOSFET Blocks

The N-Channel MOSFET and P-Channel MOSFET blocks now have an additional parameter, **Channel modulation, L**. The default value is 0 1/V. See the respective block reference pages for details.

## Changes to the Bipolar Transistor Blocks

The following changes have been implemented in the NPN Bipolar Transistor and PNP Bipolar Transistor blocks:

- The **Junction Capacitance** tab has been renamed to **Capacitance**, and the two existing parameters on it have been renamed:

- **Base-emitter capacitance** to **Base-emitter junction capacitance**
- **Base-collector capacitance** to **Base-collector junction capacitance**

- Two new parameters have been added to the **Capacitance** tab:

  - **Total forward transit time**, representing the mean time for the minority carriers to cross the base region from the emitter to the collector

  - **Total reverse transit time**, representing the mean time for the minority carriers to cross the base region from the collector to the emitter

- Default values for ohmic resistances have been changed to RB = 1 $\Omega$, RC = 0.01 $\Omega$, and RE = 1e-4 $\Omega$, to be consistent with the SPICE-compatible library.

## New Demos

Demos introduced in this version are:

- Thyristor Static Behavior Validation
- Thyristor Dynamic Behavior Validation
- IC Multiplier Circuits
- Synchronous Buck Converter

# R2010a

Version: 1.4

New Features

Compatibility Considerations

## New Linear and Rotary Motors Defined in Terms of Flux

Two new blocks represent models of a motor or actuator defined in terms of magnetic flux:

- FEM-Parameterized Linear Actuator block, located in the Translational Actuators library
- FEM-Parameterized Rotary Actuator block, located in the Rotational Actuators library

## New Potentiometer Block

The new Potentiometer block, located in the Passive Devices library, represents a potentiometer, where the wiper position is controlled by the input physical signal.

## Initial Conditions Tab Added for Logic Blocks

The dialog boxes of blocks in the Logic library now have an additional tab, Initial Conditions, which lets you specify the output initial state (low or high). See the respective block reference pages for details.

## Changes in Block Parameterization

The ability to parameterize SimElectronics blocks by importing circuit data from a SPICE netlist is no longer supported. As a result, using the `netlist2sl` function is no longer recommended. See Parameterizing Blocks from Datasheets in the *SimElectronics User's Guide* for alternative ways of block parameterization. Additional related changes introduced in this version are:

- "Changes to the SPICE-Compatible Blocks" on page 12-2
- "Changes to the Solar Cell Block" on page 12-3

### Changes to the SPICE-Compatible Blocks

The SPICE-compatible blocks have been moved to the Additional Components library. They are organized in sublibraries according to function, for example, the SPICE-Compatible Sources library is now the Sources sublibrary of the Additional Components/ SPICE-Compatible Components library. The Resistor block, renamed SPICE Resistor, and the Current-Controlled Switch and Voltage-Controlled Switch blocks have been

moved to the Passive Devices sublibrary of the Additional Components/SPICE-Compatible Components library.

Some of the blocks have been renamed so that their names start with the "SPICE" prefix. The following table lists the old and new block names.

| Old Name | New Name |
| --- | --- |
| Diode (SPICE) | SPICE Diode |
| NJFET | SPICE NJFET |
| NMOS | SPICE NMOS |
| NPN | SPICE NPN |
| PJFET | SPICE PJFET |
| PMOS | SPICE PMOS |
| PNP | SPICE PNP |
| Resistor | SPICE Resistor |

There are no compatibility considerations as a result of renaming the SPICE-compatible blocks and moving them to the Additional Components library. Your existing models will be updated automatically when you open and save them in the new version.

### Changes to the Solar Cell Block

In previous versions, the Solar Cell block had the option of using the SPICE Environment Parameters block to set temperature. This is removed in R2010a to eliminate dependency on the SPICE sublibrary. Also, the Solar Cell model now uses the regular Diode block (exponential diode) rather than the SPICE Diode block.

## Compatibility Considerations

There is an insignificant change in results, of the order of 1e-12, in the Solar Cell block because of the diode replacement.

## New Demos

Demos introduced in this version are:

- Finite Element Parameterized Solenoid

- Circuit Level Switched Capacitor ADC
- Switching Audio Power Amplifier
- Bridge Configuration Switching Audio Power Amplifier
- Differential Pair Amplifier
- Low-Noise Bipolar Transistor Voltage Amplifier
- Triangle Wave Generator
- LC Transistor Oscillator
- Voltage-Controlled Oscillator with PI Control
- Voltage Regulator
- Band-Pass Filter Using Three Mutually-Coupled Inductors
- Class-E RF Amplifier
- Diode Ring Demodulator
- LC Transmission Line and Test Bridge

## Functions and Function Elements Being Removed

| Function or Function Element Name | What Happens When you use the Function or Element? | Use This Instead | Compatibility Considerations |
|---|---|---|---|
| `netlist2sl` | Issues a warning that it is not supported and may be removed in future releases | See Parameterizing Blocks from Datasheets in the *SimElectronics User's Guide* for alternative ways of block parameterization | See "Changes in Block Parameterization" on page 12-2 |

# R2009b

**Version: 1.3**

**New Features**

**Compatibility Considerations**

## Actuators & Drivers Library Blocks

New features and changes introduced in this version are:

- "New Generic Rotary Actuator Block" on page 13-2
- "New Generic Linear Actuator Block" on page 13-2
- "Improved Servomotor Block" on page 13-2

### New Generic Rotary Actuator Block

The Generic Rotary Actuator block models the torque-speed characteristics of a generalized rotary actuator.

### New Generic Linear Actuator Block

The Generic Linear Actuator block models the force-speed characteristics of a generalized linear actuator.

### Improved Servomotor Block

The Servomotor block now allows for the specification of additional parameters from within the Block Parameters dialog box.

## Compatibility Considerations

During simulation, the updated Servomotor block is backwards-compatible with models defined in earlier versions of the software. However, the model generates a warning in this version because the block dialog box supports additional unit options for torque and speed data. To remove the warnings, open the block dialog box and select appropriate units for the torque and speed data.

## New Abstracted Timer Block

The new Timer block, located in the Integrated Circuits library, is an abstracted behavioral model of a timer integrated circuit, such as the NE555.

## New Demos

Demos introduced in this version are:

- Brushless DC Motor
- ARINC 429 Communications Link
- PNP Bipolar Transistor Characteristics

# R2009a

**Version: 1.2**

**New Features**

## Actuators & Drivers Library

New features and changes introduced in this version are:

- "New Piezo Motor Blocks" on page 14-2
- "Enhanced H-Bridge Block" on page 14-2

### New Piezo Motor Blocks

The Actuators & Drivers library now contains blocks for modeling piezoelectric travelling wave motors. The library contains these new blocks:

- The Piezo Rotary Motor models the torque-speed characteristics of a rotary piezoelectric motor.
- The Piezo Linear Motor models the force-speed characteristics of a linear piezoelectric motor.

### Enhanced H-Bridge Block

The H-Bridge block now provides the option to dissipate current via two freewheeling diodes when the signal at the PWM port is low. To use this new option, select `Via two freewheeling diodes` for the `Freewheeling mode` parameter.

## Passive Devices Library

New features and changes introduced in this version are:

- "New Switch Blocks" on page 14-2
- "New Resistor Block" on page 14-2
- "New Crystal Block" on page 14-3
- "Enhanced Variable Inductor and Variable Capacitor Blocks" on page 14-3

### New Switch Blocks

The Passive Devices library now contains Current-Controlled Switch and Voltage-Controlled Switch blocks to model electrical switches with hysteresis.

### New Resistor Block

The Passive Devices library now contains a Resistor block to model a resistor as a function of temperature and process data.

### New Crystal Block

The Passive Devices library now contains a Crystal block to model the electrical characteristics of a crystal resonator.

### Enhanced Variable Inductor and Variable Capacitor Blocks

The Variable Inductor and Variable Capacitor blocks have the following enhancements:

- The Variable Inductor block now provides two options for the relationship between the voltage across the device and the current through the inductor. The new **Equation** parameter lets you select the voltage-current equation that you want.
- The Variable Capacitor block now provides two options for the relationship between the current through the device and the voltage across the capacitor. The new **Equation** parameter lets you select the current-voltage equation that you want.

## Sources Library

New features and changes introduced in this version are:

- "Enhanced Solar Cell Block" on page 14-3
- "New Two-Input Dependent Source Blocks" on page 14-3

### Enhanced Solar Cell Block

The Solar Cell block has the following enhancements:

- The block now provides the option to use an 8-parameter model that includes an additional diode and a parallel resistor.
- The block now models temperature dependence.

### New Two-Input Dependent Source Blocks

The SPICE-Compatible Sources library (in the Sources library) contains blocks for modeling dependent sources with two controlling inputs. The library contains these new blocks:

- PCCCS2 — Model polynomial current-controlled current source with two controlling inputs
- PCCVS2 — Model polynomial current-controlled voltage source with two controlling inputs

- PVCCS2 — Model polynomial voltage-controlled current source with two controlling inputs
- PVCVS2 — Model polynomial voltage-controlled voltage source with two controlling inputs

## SPICE-Compatible Semiconductors Library

New features and changes introduced in this version are:

### Enhanced NMOS and PMOS Blocks

The NMOS and PMOS blocks now provide the option to model the electrical characteristics of SPICE Level-3 MOSFET devices.

# R2008b

**Version: 1.1**

**New Features**

## New CMOS Logic Gate Blocks

The Logic library (in the Integrated Circuits library) contains blocks for modeling CMOS logic gates behaviorally. The library contains these new blocks:

- CMOS AND
- CMOS Buffer
- CMOS NAND
- CMOS NOR
- CMOS NOT
- CMOS OR
- CMOS XOR

## New Piezo Stack Block

The Actuators & Drivers library now contains a Piezo Stack block to model the electrical and force characteristics of a piezoelectric stacked actuator.

## New Relay Block

The Passive Devices library now contains a Relay block to model the resistive and delay characteristics of a relay controlled by an external physical signal.

## New Fuse Block

The Passive Devices library now contains a Fuse block to model the following fuse characteristics:

- Resistance.
- Rated current at which the fuse blows when exceeded for a specified amount of time.

## New NMOS and PMOS Blocks

The SPICE-Compatible Semiconductors library (in the Semiconductor Devices library) now contains NMOS and PMOS blocks to model the electrical characteristics of SPICE Level-1 MOSFET devices.

# R2008a+

**Version: 1.0**

**New Features**

## Product Introduction

SimElectronics software is a modeling environment for the engineering design and simulation of electronic and electromechanical systems within the Simulink® environment.

Version 1.0 includes these features:

- A library of electronic and electromechanical blocks that model components such as:

  - Sensors
  - Semiconductors
  - Actuators

  For these blocks, you enter key parameter values directly from industry datasheets.

  For more information about the available blocks, see SimElectronics Block Libraries.

- A function, `netlist2sl`, for creating library blocks that represent circuit data in a SPICE netlist.
- Ability to convert SimElectronics models to C code.

  For more information about code generation, see Code Generation  in the Simscape documentation.

- Access to linearization and steady-state solve capabilities in Simscape.

  For more information about linearization, see Linearizing at an Operating Point in the Simscape documentation.

  For more information about how Simscape solves models, see How Simscape Simulation Works in the Simscape documentation.