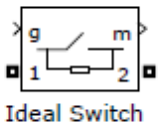
IDEAL SWITCH

Implement ideal switch device

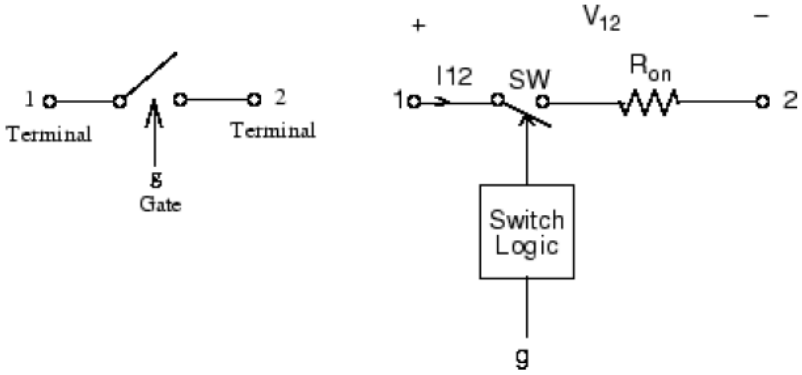
Library

Power Electronics

Description



The Ideal Switch block does not correspond to a particular physical device. When used with appropriate switching logic, it can be used to model simplified semiconductor devices such as a GTO or a MOSFET, or even a power circuit breaker with current chopping. The switch is simulated as a resistor Ron in series with a switch controlled by a logical gate signal g.

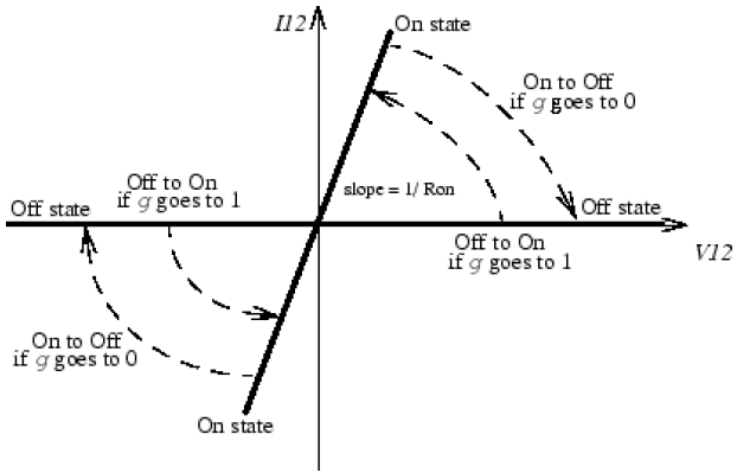


The Ideal Switch block is fully controlled by the gate signal (g > 0 or g = 0). It has the following characteristics:

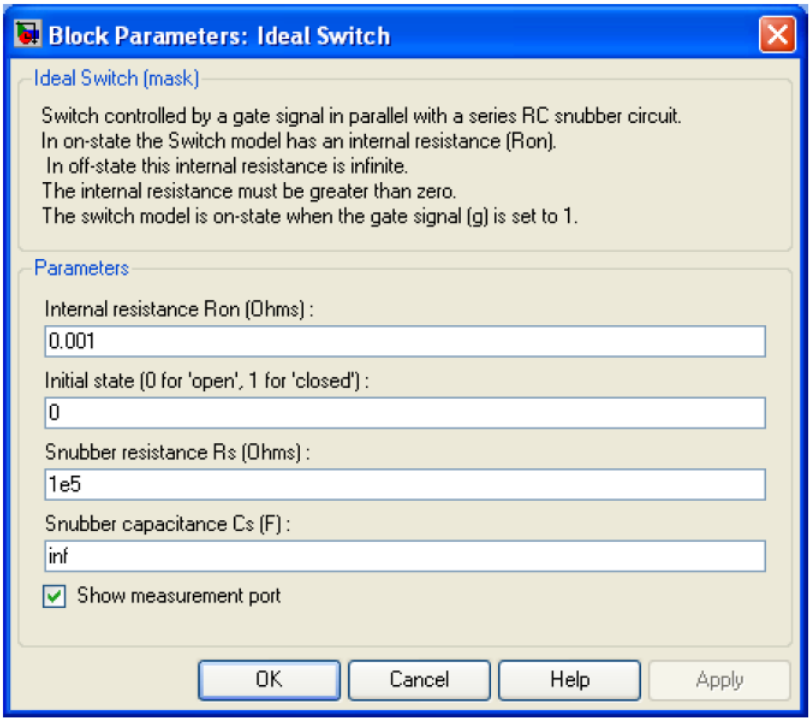
- Blocks any forward or reverse applied voltage with 0 current flow when g = 0
- Conducts any bidirectional current with quasi-zero voltage drop when g > 0
- Switches instantaneously between on and off states when triggered

The Ideal Switch block turns on when a positive signal is present at the gate input (g > 0). It turns off when the gate signal equals 0 (g = 0).

The Ideal Switch block also contains a series Rs-Cs snubber circuit that can be connected in parallel with the ideal switch (between nodes 1 and 2).



Dialog Box and Parameters



Internal resistance Ron

The internal resistance of the switch device, in ohms (Ω). The Internal resistance Ron parameter cannot be set to 0.

Initial state

The initial state of the Ideal Switch block. The initial status of the Ideal Switch block is taken into account in the steady-state calculation.

Snubber resistance Rs

The snubber resistance, in ohms (Ω). Set the Snubber resistance Rs parameter to inf to eliminate the snubber from the model.

Snubber capacitance Cs

The snubber capacitance in farads (F). Set the Snubber capacitance Cs parameter to 0 to eliminate the snubber, or to inf to get a resistive snubber.

Show measurement port

If selected, add a Simulink output to the block returning the ideal switch current and voltage.

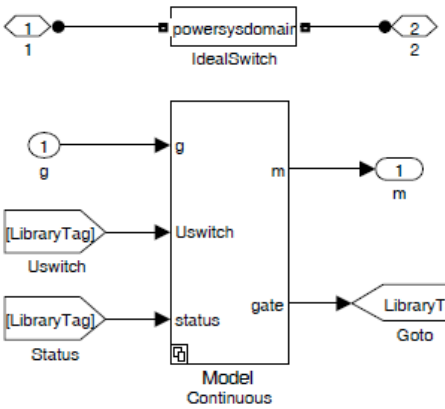
Inputs and Outputs

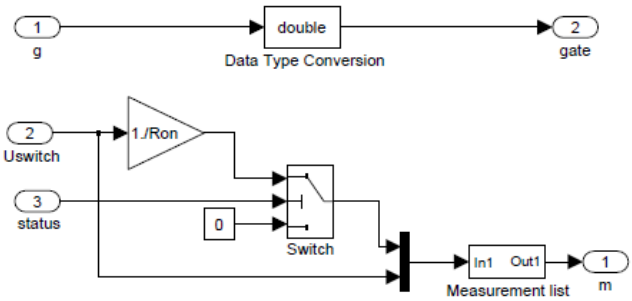
g Simulink signal to control the opening and closing of the switch.

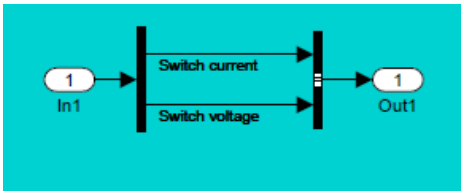
m The Simulink output of the block is a vector containing two signals. You can demultiplex these signals by using the Bus Selector block provided in the Simulink library.

Signal	Definition	Units
1	Ideal switch current	A
2	Ideal switch voltage	V

Look Under Mask







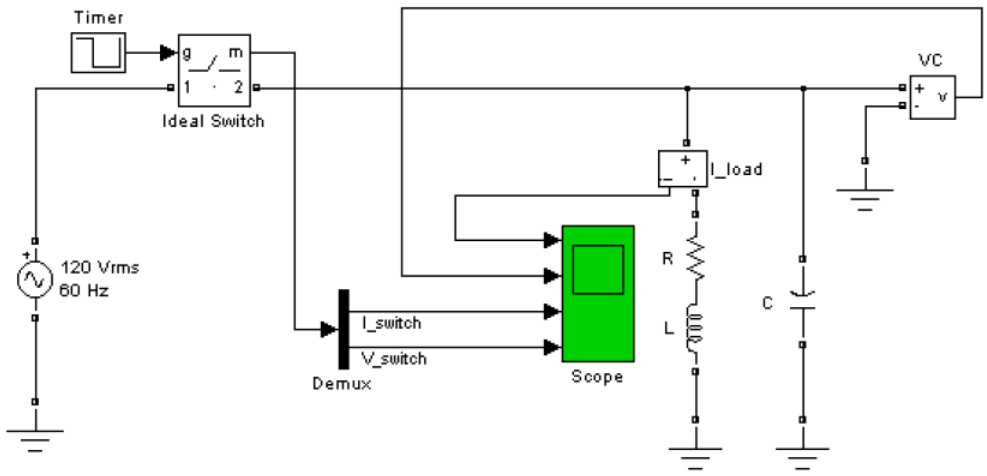
Assumptions and Limitations

The Ideal Switch block is modeled as a current source. It cannot be connected in series with an inductor, a current source, or an open circuit, unless its snubber circuit is in use. See Improving Simulation Performance for more details on this topic.

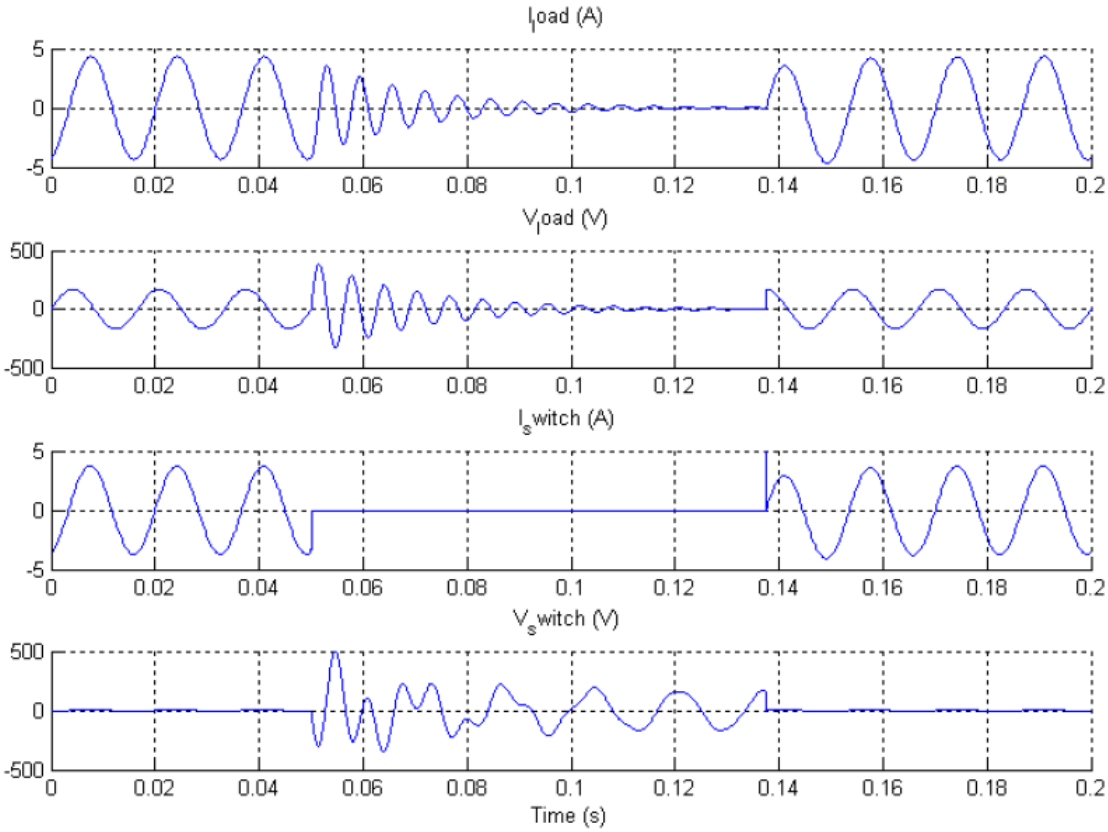
Use the Powergui block to specify either continuous simulation or discretization of your electrical circuit containing ideal switches. When using a continuous model, the ode23tb solver with a relative tolerance of 1e-4 is recommended for best accuracy and simulation speed.

Example

The *power_switch* demo uses the Ideal Switch block to switch an RLC circuit on an AC source (60 Hz). The switch, which is initially closed, is first opened at t = 50 ms (3 cycles) and then reclosed at t = 138 ms (8.25 cycles). The Ideal Switch block has 0.01 ohms resistance and no snubber is used.



Run the simulation and observe the inductor current, the switch current, and the capacitor voltage. Notice the high-frequency overvoltage produced by inductive current chopping. Note also the high switch current spike when the switch is reclosed on the capacitor at maximum source voltage.



References

[1] Mohan, N., T.M. Undeland, and W.P. Robbins, Power Electronics: Converters, Applications, and Design, John Wiley & Sons, Inc., New York, 1995.

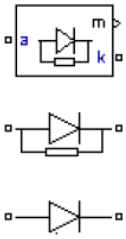
DIODE

Implement diode model

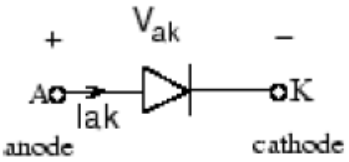
Library

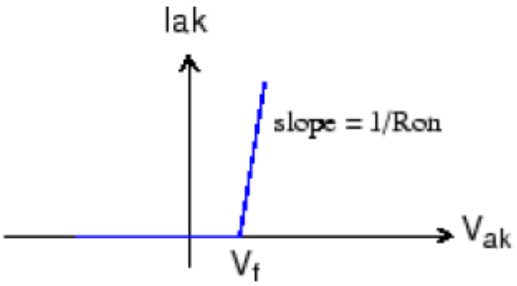
Power Electronics

Description

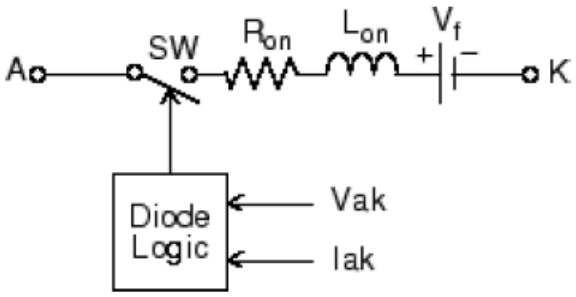


The diode is a semiconductor device that is controlled by its own voltage Vak and current Iak. When a diode is forward biased (Vak > 0), it starts to conduct with a small forward voltage Vf across it. It turns off when the current flow into the device becomes 0. When the diode is reverse biased (Vak < 0), it stays in the off state.



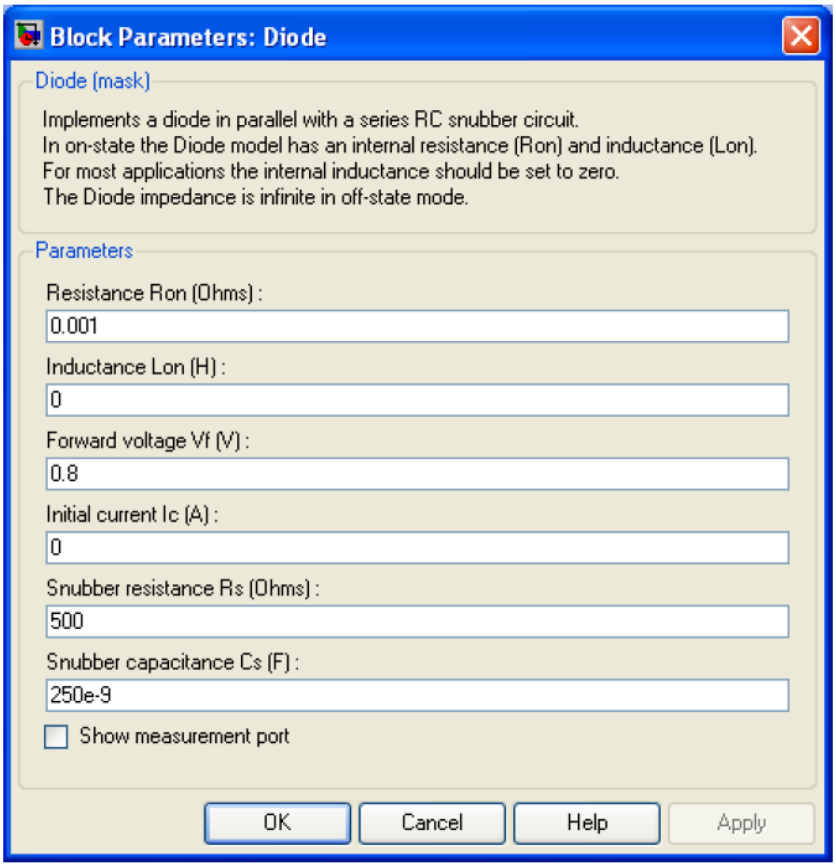


The Diode block is simulated by a resistor, an inductor, and a DC voltage source connected in series with a switch. The switch operation is controlled by the voltage Vak and the current Iak.



The Diode block also contains a series Rs-Cs snubber circuit that can be connected in parallel with the diode device (between nodes A and K).

Dialog Box and Parameters



Resistance Ron

The diode internal resistance Ron, in ohms (Ω). The Resistance Ron parameter cannot be set to 0 when the Inductance Lon parameter is set to 0.

Inductance Lon

The diode internal inductance Lon, in henries (H). The Inductance Lon parameter cannot be set to 0 when the Resistance Ron parameter is set to 0.

Forward voltage Vf

The forward voltage of the diode device, in volts (V).

Initial current Ic

Specifies an initial current flowing in the diode device. It is usually set to 0 in order to start the simulation with the diode device blocked. If the Initial Current IC parameter is set to a value greater than 0, the steady-state calculation considers the initial status of the diode as closed.

Initializing all states of a power electronic converter is a complex task. Therefore, this option is useful only with simple circuits.

Snubber resistance Rs

The snubber resistance, in ohms (Ω). Set the Snubber resistance Rs parameter to inf to eliminate the snubber from the model.

Snubber capacitance Cs

The snubber capacitance in farads (F). Set the Snubber capacitance Cs parameter to 0 to eliminate the snubber, or to inf to get a resistive snubber.

Show measurement port

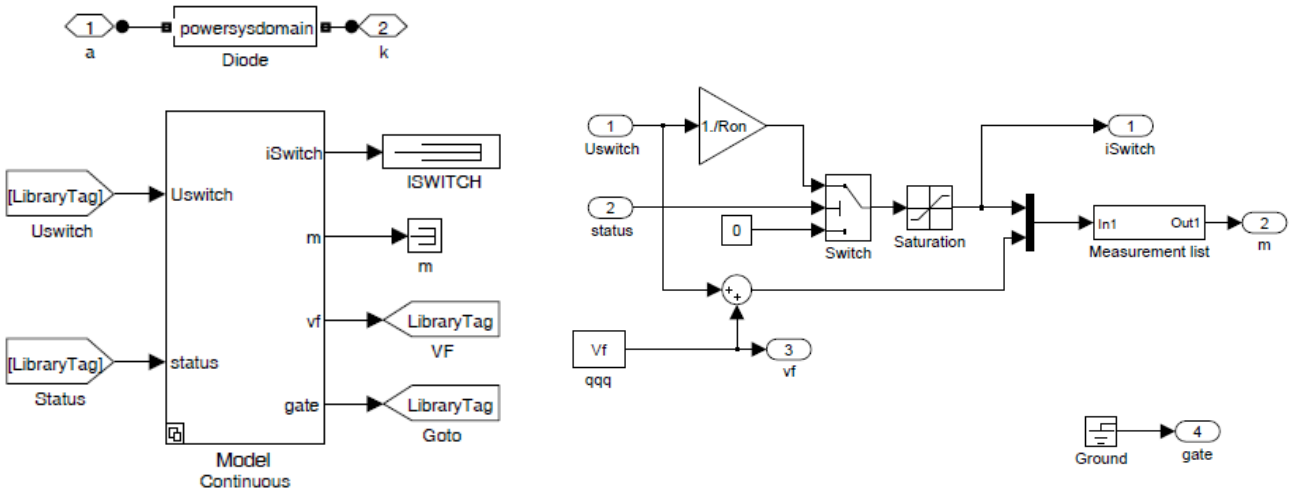
If selected, adds a Simulink output to the block returning the diode current and voltage.

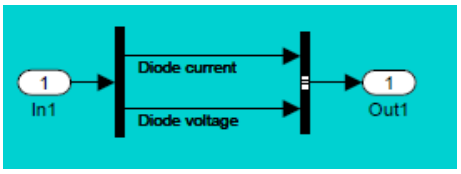
Inputs and Outputs

m The Simulink output of the block is a vector containing two signals. You can demultiplex these signals by using the Bus Selector block provided in the Simulink library.

Signal	Definition	Units
1	Diode current	A
2	Diode voltage	V

Look Under Mask





Assumptions and Limitations

The Diode block implements a macro model of a diode device. It does not take into account either the geometry of the device or the complex physical processes underlying the state change [1]. The leakage current in the blocking state and the reverse-recovery (negative) current are not considered. In most circuits, the reverse current does not affect converter or other device characteristics.

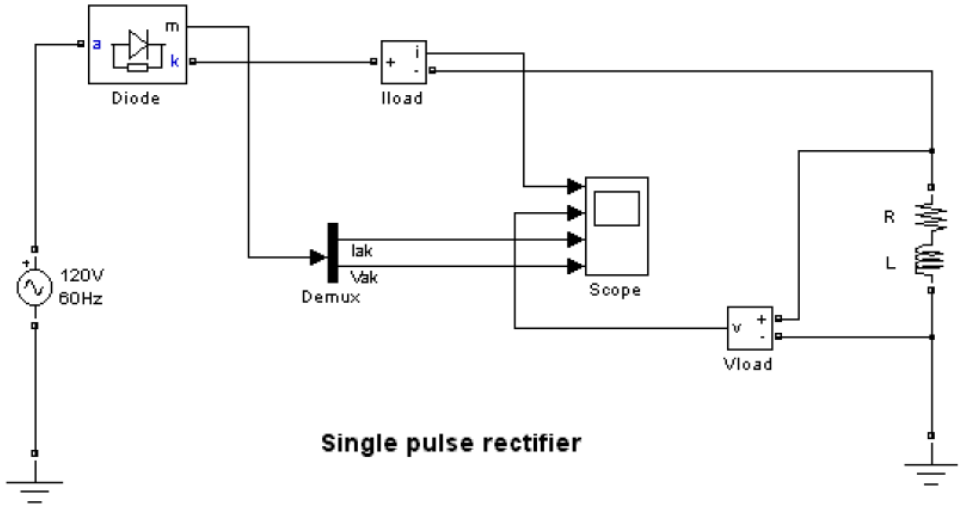
Depending on the value of the inductance Lon, the diode is modeled either as a current source (Lon > 0) or as a variable topology circuit (Lon = 0). The Diode block cannot be connected in series with an inductor, a current source, or an open circuit, unless its snubber circuit is in use. See Improving Simulation Performance for more details on this topic.

Use the powergui block to specify either continuous simulation or discretization of your electrical circuit containing diodes. When using a continuous model, the ode23tb solver with a relative tolerance of 1e-4 is recommended for best accuracy and simulation speed.

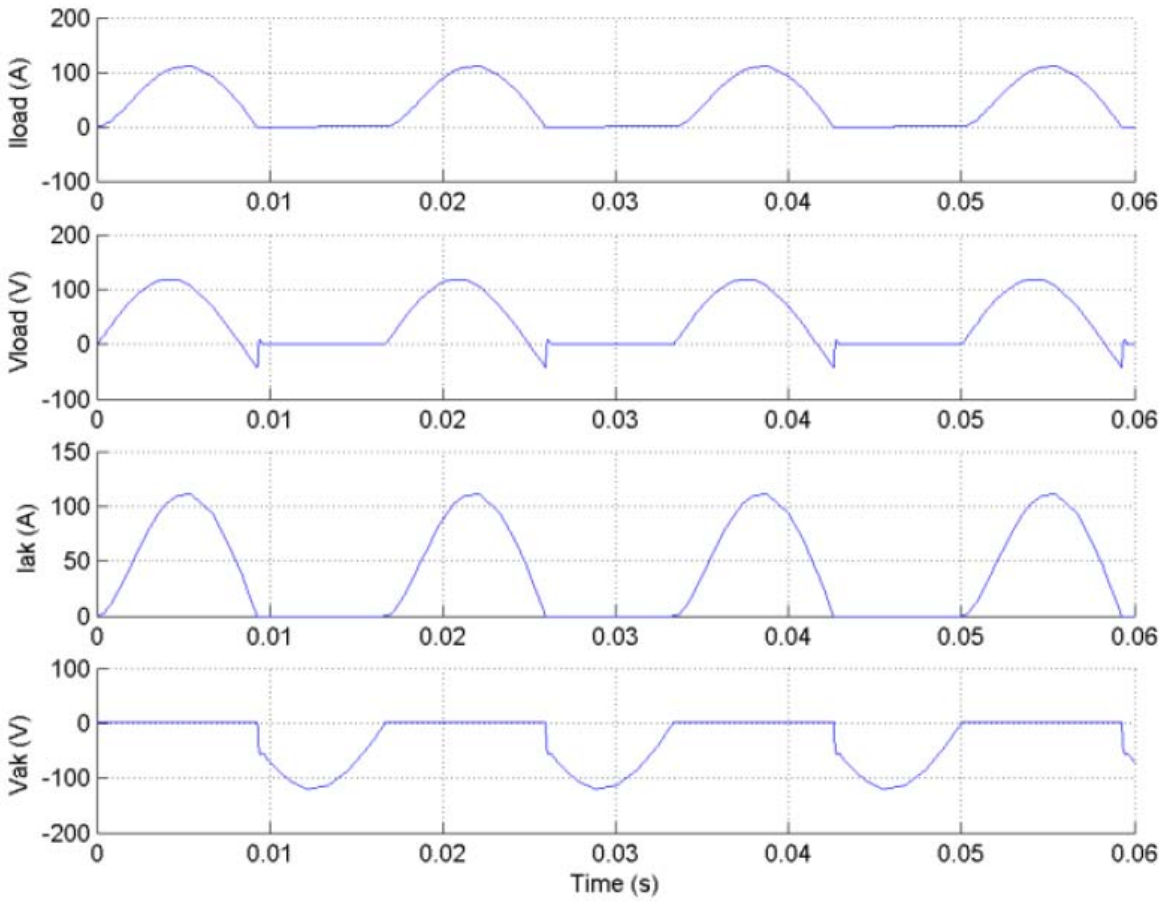
The inductance Lon is forced to 0 if you choose to discretize your circuit.

Example

The power_diode demo illustrates a single pulse rectifier consisting of a Diode block, an RL load, and an AC Voltage source block.



Simulation produces the following results.



References

[1] Rajagopalan, V., Computer-Aided Analysis of Power Electronic Systems, Marcel Dekker, Inc., New York, 1987.

[2] Mohan, N., T.M. Undeland, and W.P. Robbins, Power Electronics: Converters, Applications, and Design, John Wiley & Sons, Inc., New York, 1995.

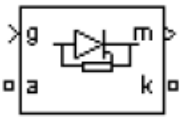
THYRISTOR

Implement thyristor model

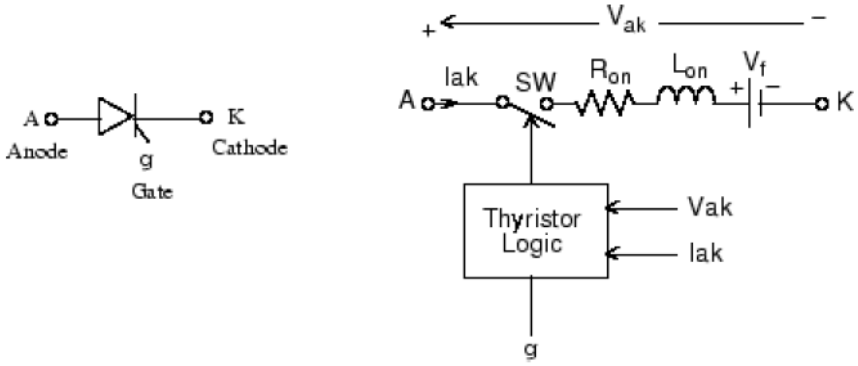
Library

Power Electronics

Description

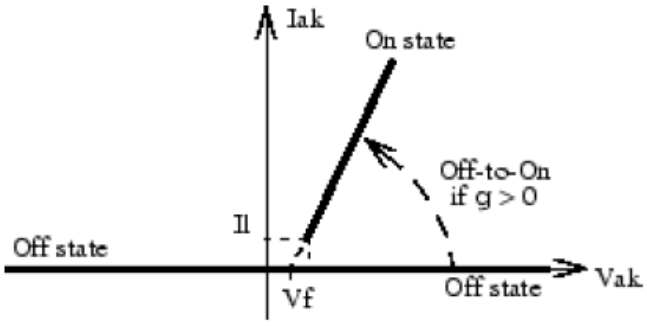


The thyristor is a semiconductor device that can be turned on via a gate signal. The thyristor model is simulated as a resistor Ron, an inductor Lon, and a DC voltage source representing the forward voltage Vf, connected in series with a switch. The switch is controlled by a logical signal depending on the voltage Vak, the current Iak, and the gate signal g.



The Thyristor block also contains a series Rs-Cs snubber circuit that can be connected in parallel with the thyristor device.

The static VI characteristic of this model is shown below.



The thyristor device turns on when the anode-cathode Vak voltage is greater than Vf and a positive pulse signal is applied at the gate input (g > 0). The pulse height must be greater than 0 and last long enough to allow the thyristor anode current to become larger than the latching current *Il*.

The thyristor device turns off when the current flowing in the device becomes 0 (Iak = 0) and a negative voltage appears across the anode and cathode for at least a period of time equal to the turnoff time Tq. If the voltage across the device becomes positive within a period of time less than Tq, the device turns on automatically even if the gate signal is low (g = 0) and the anode current is less than the latching current.

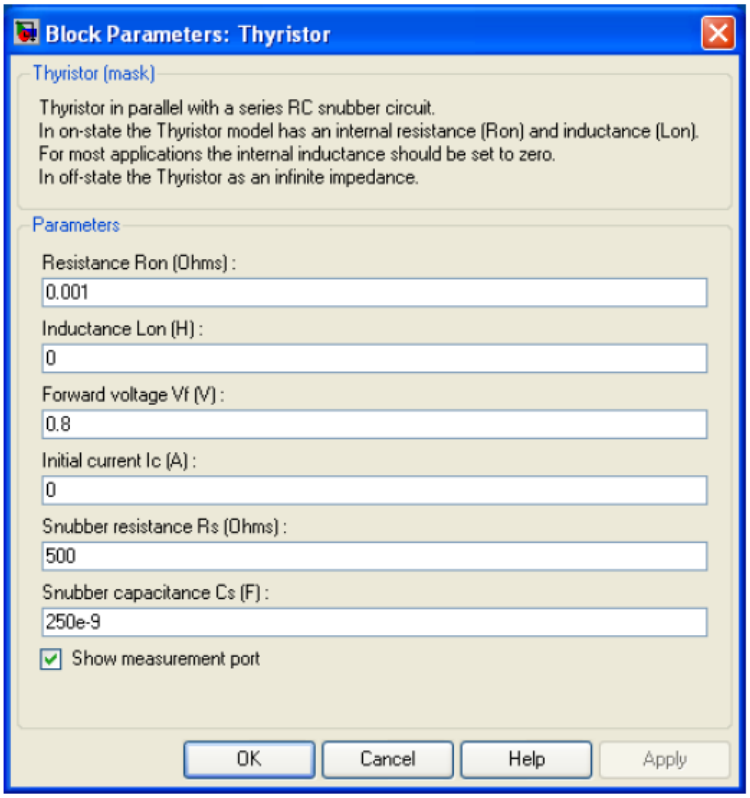
Furthermore, if during turn-on, the device current amplitude stays below the latching current level specified in the dialog box, the device turns off after the gate signal level becomes low (g = 0).

The turnoff time Tq represents the carrier recovery time: it is the time interval between the instant the anode current has decreased to 0 and the instant when the thyristor is capable of withstanding positive voltage Vak without turning on again.

Dialog Box and Parameters

Thyristor Model and Detailed Thyristor Model

In order to optimize simulation speed, two models of thyristors are available: the thyristor model and the detailed thyristor model. For the thyristor model, the latching current Il and recovery time Tq are assumed to be 0.



Resistance Ron

The thyristor internal resistance Ron, in ohms (Ω). The Resistance Ron parameter cannot be set to 0 when the Inductance Lon parameter is set to 0.

Inductance Lon

The thyristor internal inductance Lon, in henries (H). The Inductance Lon parameter is normally set to 0 except when the Resistance Ron parameter is set to 0.

Forward voltage Vf

The forward voltage of the thyristor, in volts (V).

Initial current Ic

When the Inductance Lon parameter is greater than 0, you can specify an initial current flowing in the thyristor. It is usually set to 0 in order to start the simulation with the thyristor blocked.

You can specify an Initial current Ic value corresponding to a particular state of the circuit. In such a case all states of the linear circuit must be set accordingly. Initializing all states of a power electronic converter is a complex task. Therefore, this option is useful only with simple circuits.

Snubber resistance Rs

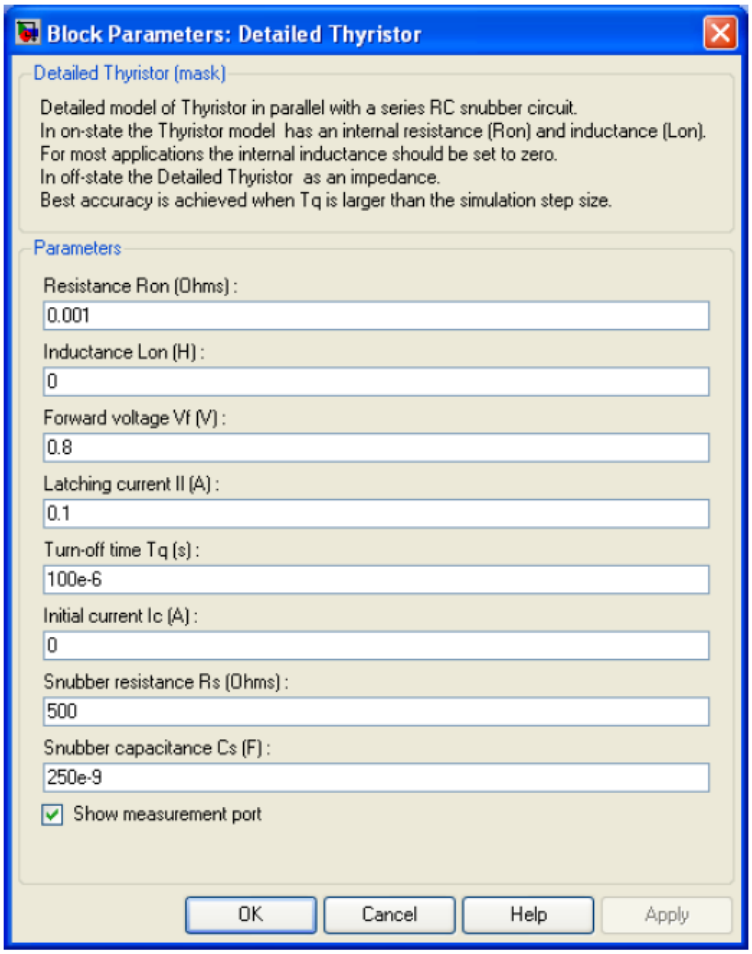
The snubber resistance, in ohms (Ω). Set the Snubber resistance Rs parameter to inf to eliminate the snubber from the model.

Snubber capacitance Cs

The snubber capacitance in farads (F). Set the Snubber capacitance Cs parameter to 0 to eliminate the snubber, or to inf to get a resistive snubber.

Show measurement port

If selected, add a Simulink output to the block returning the thyristor current and voltage.



Latching current Il

The latching current of the detailed thyristor model, in amperes (A).

Turn-off time Tq

The turnoff time Tq of the detailed thyristor model, in amperes (A).

Inputs and Outputs

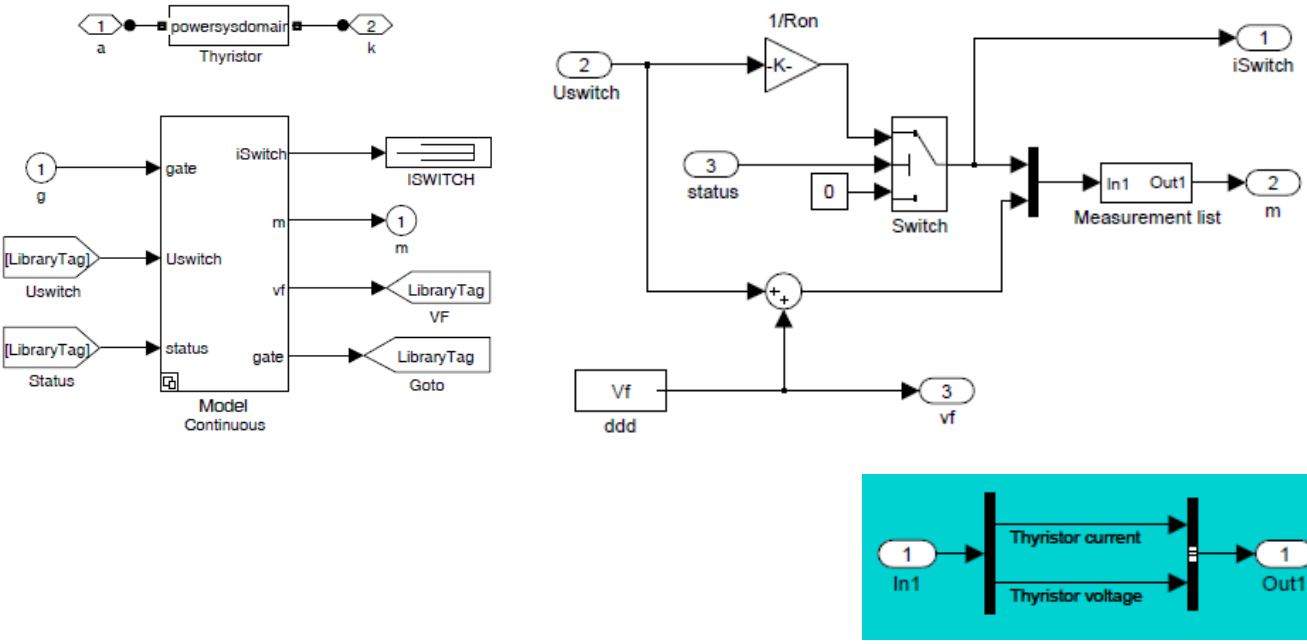
g Simulink signal to control the gate of the Thyristor.

m The Simulink output of the block is a vector containing two signals. You can demultiplex these signals by using the Bus Selector block provided in the Simulink library.

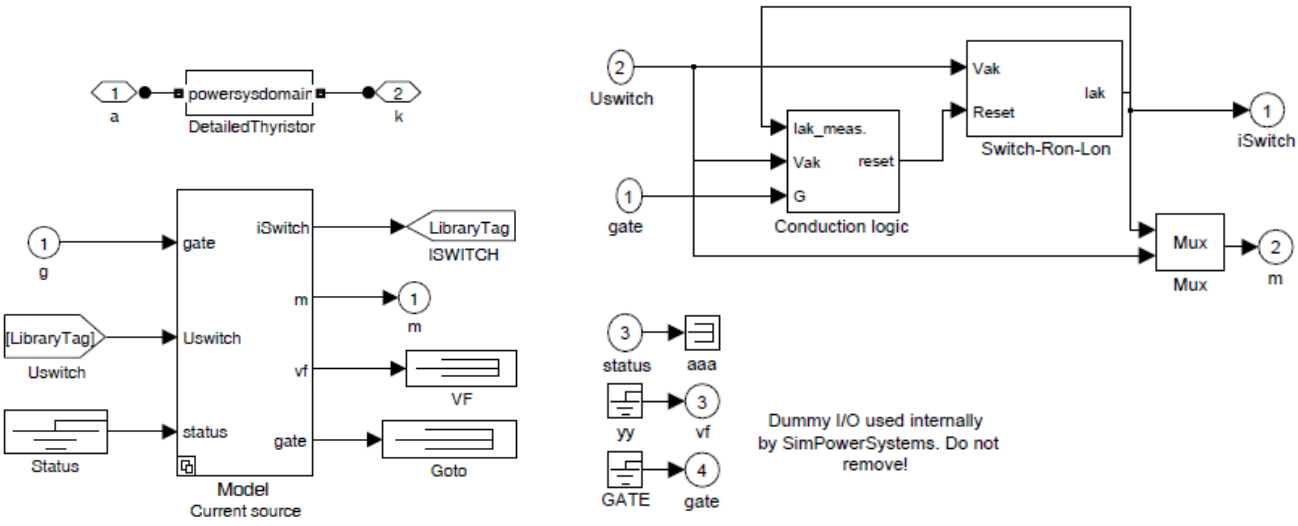
Signal	Definition	Units
1	Thyristor current	A
2	Thyristor voltage	V

Look Under Mask

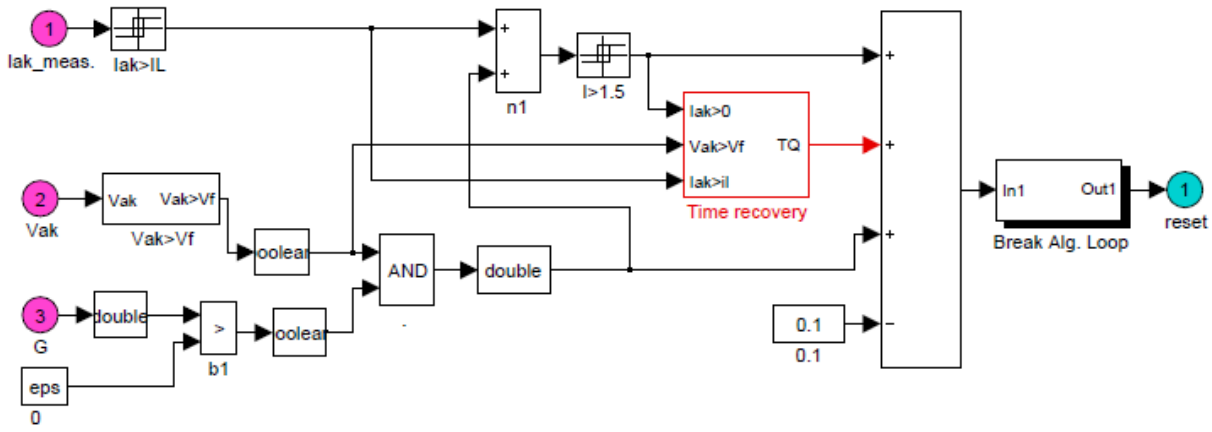
Thyristor



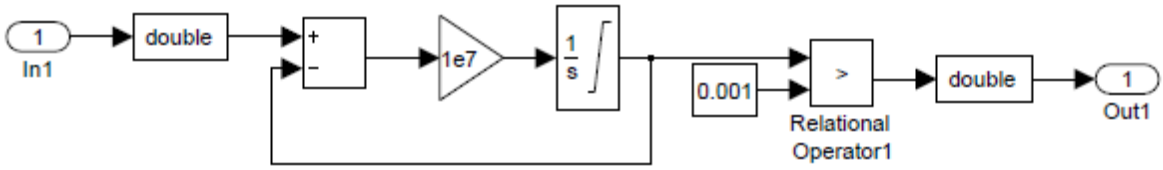
Detailed thyiristor



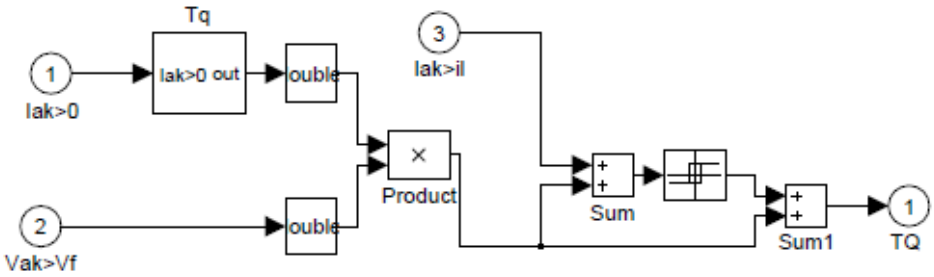
Conduction logic



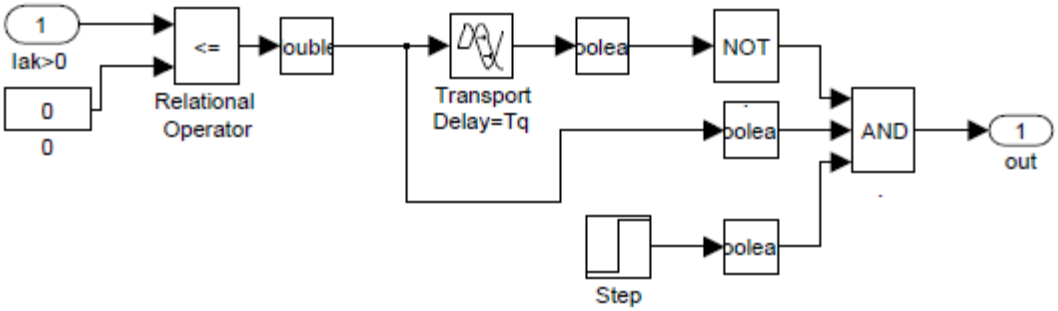
- Break Alg. Loop



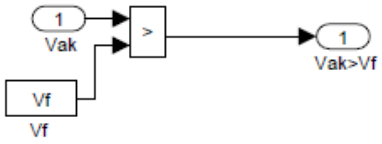
- Time recovery



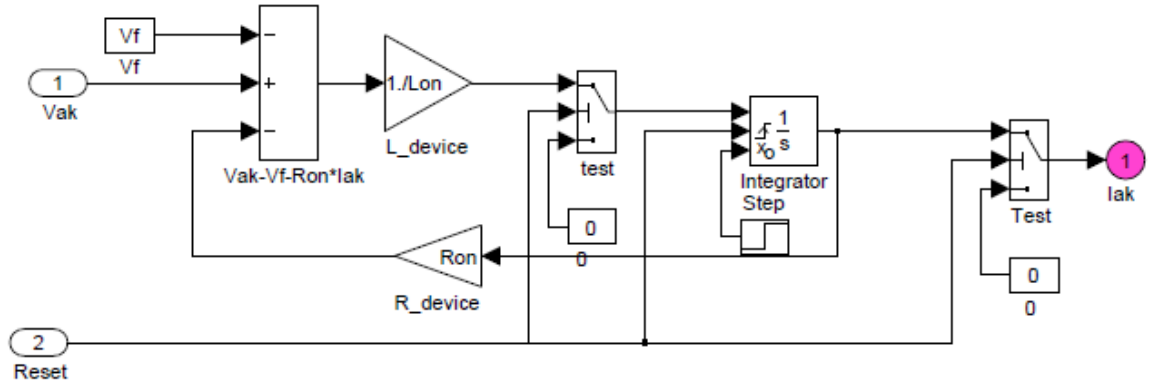
  - **Tq**



- Vak>Vf



Switch-Ron-Lon



Assumptions and Limitations

The Thyristor block implements a macro model of the real thyristor. It does not take into account either the geometry of the device or complex physical processes that model the behavior of the device [1, 2]. The forward breakover voltage and the critical value of the derivative of the reapplied anode-cathode voltage are not considered by the model.

Depending on the value of the inductance Lon, the Thyristor block is modeled either as a current source (Lon > 0) or as a variable topology circuit (Lon = 0). The Thyristor block cannot be connected in series with an inductor, a current source, or an open circuit, unless its snubber circuit is in use. See Improving Simulation Performance for more details on this topic.

Use the Powergui block to specify either continuous simulation or discretization of your electrical circuit containing Thyristor blocks. When using a continuous model, the ode23tb solver with a relative tolerance of 1e-4 is recommended for best accuracy and simulation speed.

The inductance Lon is forced to 0 if you choose to discretize your circuit.

Example

In the power_thyristor demo a single-pulse thyristor rectifier is used to feed an RL load. The gate pulses are obtained from a pulse generator synchronized on the source voltage. The following parameters are used:

R 1 Ω

L 10 mH

Thyristor block:

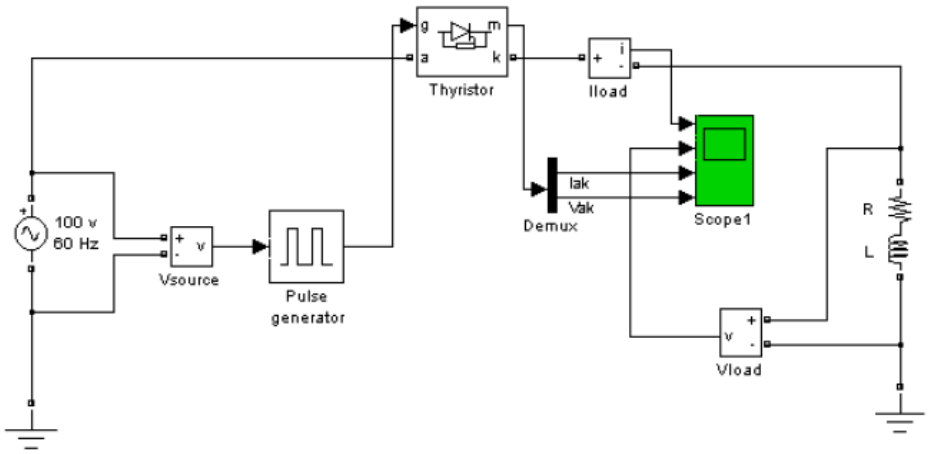
Ron 0.001 W

Lon 0 H

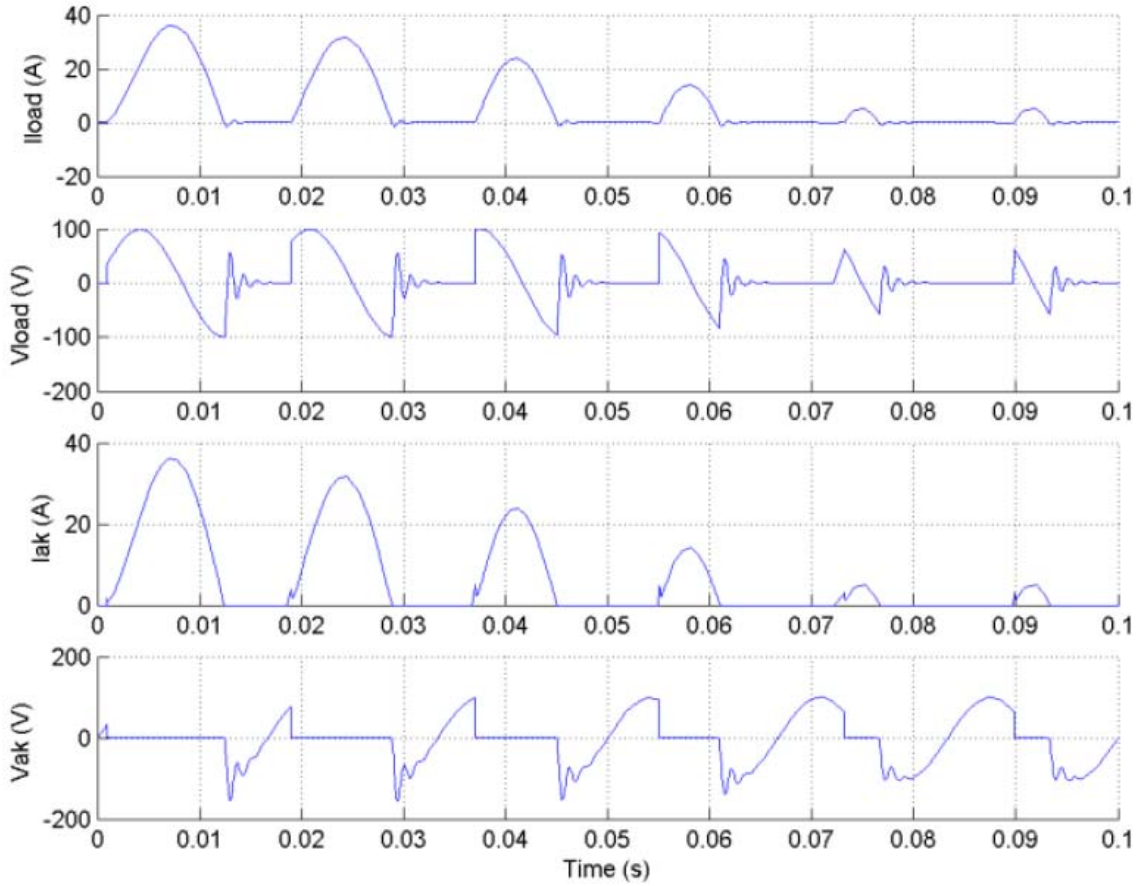
Vf 0.8 V

Rs 20 Ω

Cs 4e-6 F



The firing angle is varied by a pulse generator synchronized on the voltage source. Run the simulation and observe the load current and load voltage, as well as the thyristor current and voltage.



References

[1] Rajagopalan, V., Computer-Aided Analysis of Power Electronic Systems, Marcel Dekker, Inc., New York, 1987.

[2] Mohan, N., T.M. Undeland, and W.P. Robbins, Power Electronics: Converters, Applications, and Design, John Wiley & Sons, Inc., New York, 1995.

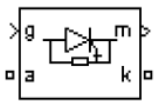
GTO

Implement gate turn off (GTO) thyristor model

Library

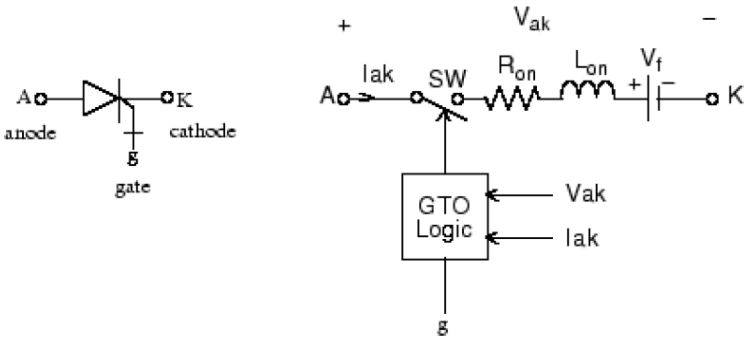
Power Electronics

Description



The gate turnoff (GTO) thyristor is a semiconductor device that can be turned on and off via a gate signal. Like a conventional thyristor, the GTO thyristor can be turned on by a positive gate signal (g > 0). However, unlike the thyristor, which can be turned off only at a zero crossing of current, the GTO can be turned off at any time by the application of a gate signal equal to 0.

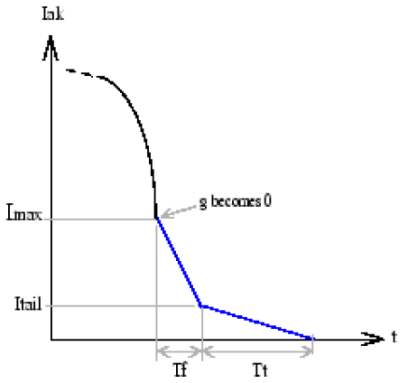
The GTO thyristor is simulated as a resistor Ron, an inductor Lon, and a DC voltage source Vf connected in series with a switch. The switch is controlled by a logical signal depending on the voltage Vak, the current Iak, and the gate signal g.



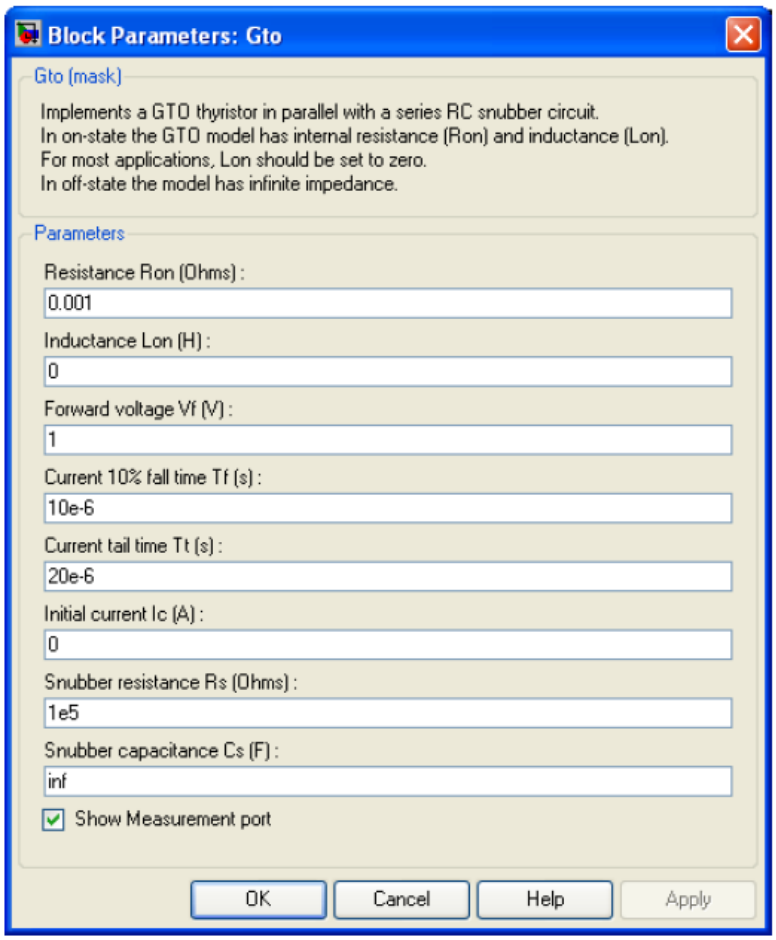
The Vf, Ron, and Lon parameters are the forward voltage drop while in conduction, the forward conducting resistance, and the inductance of the device. The GTO block also contains a series Rs-Cs snubber circuit that can be connected in parallel with the GTO device (between terminal ports A and K).

The GTO thyristor turns on when the anode-cathode voltage is greater than Vf and a positive pulse signal is present at the gate input (g > 0). When the gate signal is set to 0, the GTO thyristor starts to block but its current does not stop instantaneously.

Because the current extinction process of a GTO thyristor contributes significantly to the turnoff losses, the turnoff characteristic is built into the model. The current decrease is approximated by two segments. When the gate signal becomes 0, the current Iak first decreases from the value Imax (value of Iak when the GTO thyristor starts to open) to Imax/10, during the fall time (Tf), and then from Imax/10 to 0 during the tail time (Tt). The GTO thyristor turns off when the current Iak becomes 0. The latching and holding currents are not considered.



Dialog Box and Parameters



Resistance Ron

The internal resistance Ron, in ohms (Ω).

Inductance Lon

The internal inductance Lon, in henries (H). The Inductance Lon parameter cannot be set to 0.

Forward voltage Vf

The forward voltage of the GTO thyristor device, in volts (V).

Current 10% fall time

The current fall time Tf, in seconds (s).

Current tail time

The current tail time Tt, in seconds (s).

Initial current Ic

You can specify an initial current flowing in the GTO thyristor. It is usually set to 0 in order to start the simulation with the device blocked.

If the Initial Current IC parameter is set to a value greater than 0, the steady-state calculation considers the initial status of the GTO as closed. Initializing all states of a power electronic converter is a complex task. Therefore, this option is useful only with simple circuits.

Snubber resistance Rs

The snubber resistance, in ohms (Ω). Set the Snubber resistance Rs parameter to inf to eliminate the snubber from the model.

Snubber capacitance Cs

The snubber capacitance, in farads (F). Set the Snubber capacitance Cs parameter to 0 to eliminate the snubber, or to inf to get a resistive snubber.

Show measurement port

If selected, add a Simulink output to the block returning the GTO current and voltage.

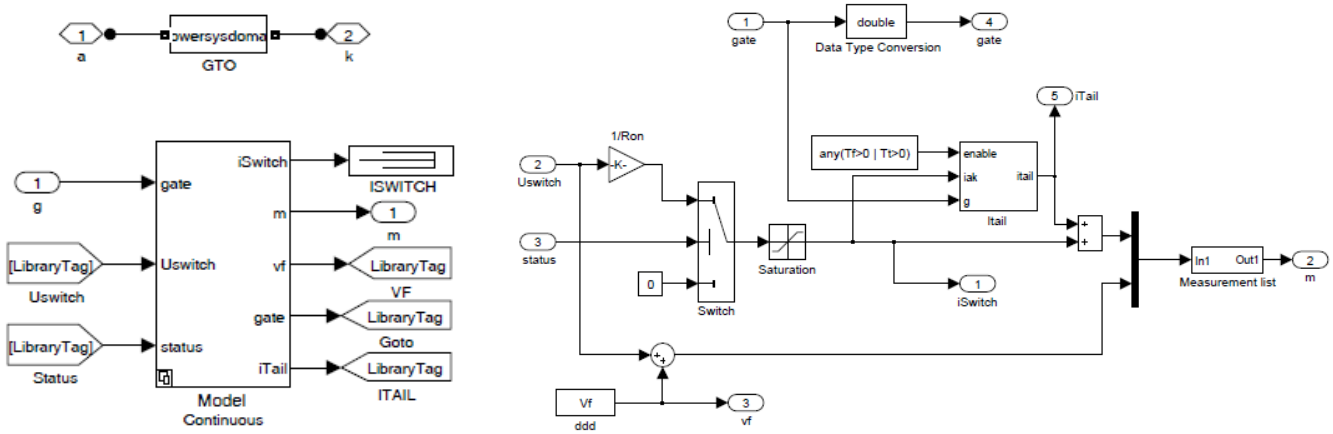
Inputs and Outputs

g Simulink signal to control the gate of the GTO.

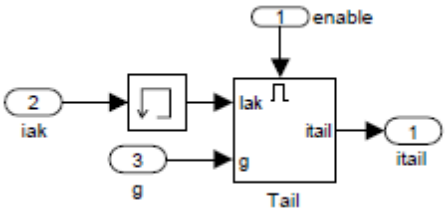
m The Simulink output of the block is a vector containing two signals. You can demultiplex these signals by using the Bus Selector block provided in the Simulink library.

Signal	Definition	Units
1	GTO current	A
2	GTO voltage	V

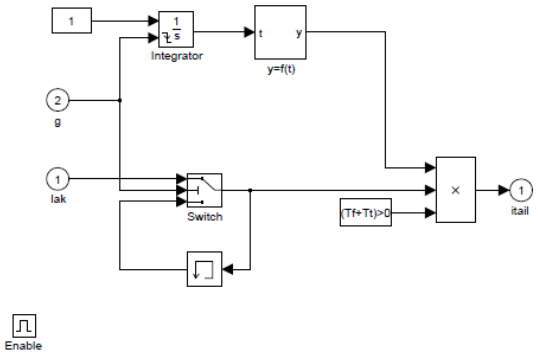
Look Under Mask



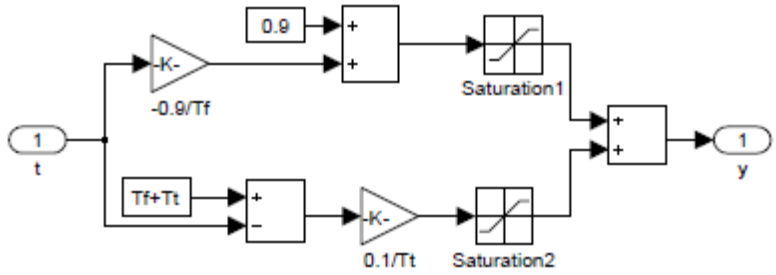
Itail



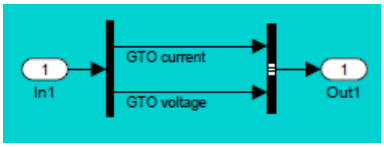
- Tail



- y=f(t)



Measurement list



Assumptions and Limitations

The GTO block implements a macro model of a real GTO thyristor. It does not take into account either the geometry of the device or the underlying physical processes of the device [1].

The GTO block requires a continuous application of the gate signal (g > 0) in order to be in the on state (with Iak > 0). The latching current and the holding current are not considered. The critical value of the derivative of the reapplied anode-cathode voltage is not considered.

Depending on the value of the inductance Lon, the GTO is modeled either as a current source (Lon > 0) or as a variable topology circuit (Lon = 0). The GTO block cannot be connected in series with an inductor, a current source, or an open circuit, unless its snubber circuit is in use. See Improving Simulation Performance for more details on this topic.

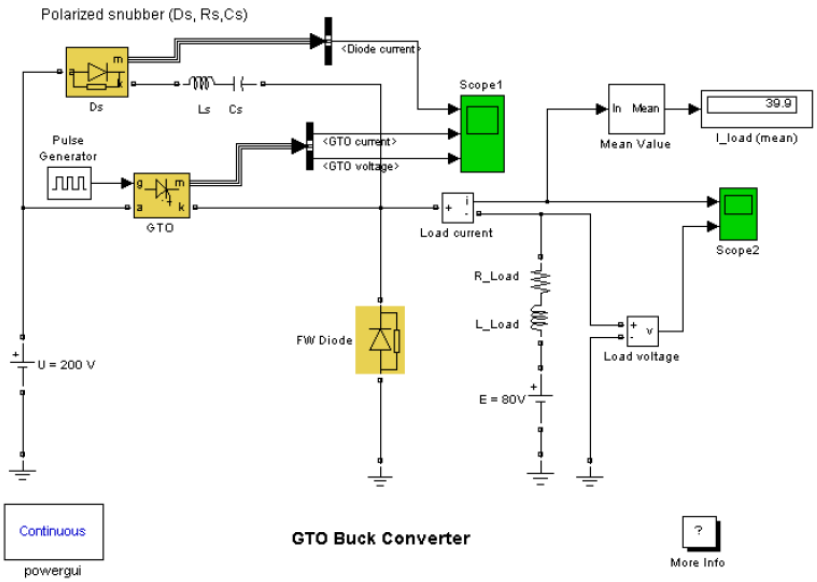
Use the Powergui block to specify either continuous simulation or discretization of your electrical circuit containing GTO blocks. When using a continuous model, the ode23tb solver with a relative tolerance of 1e-4 is recommended for best accuracy and simulation speed.

The inductance Lon is forced to 0 if you choose to discretize your circuit.

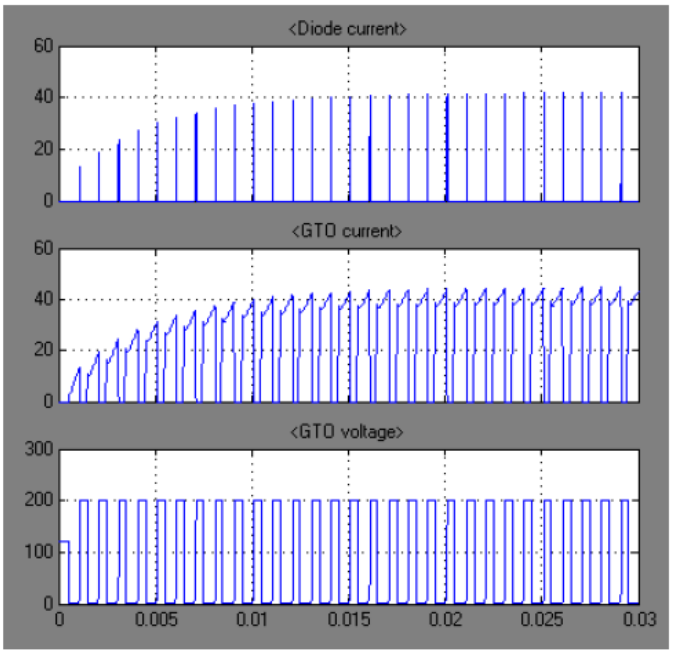
Example

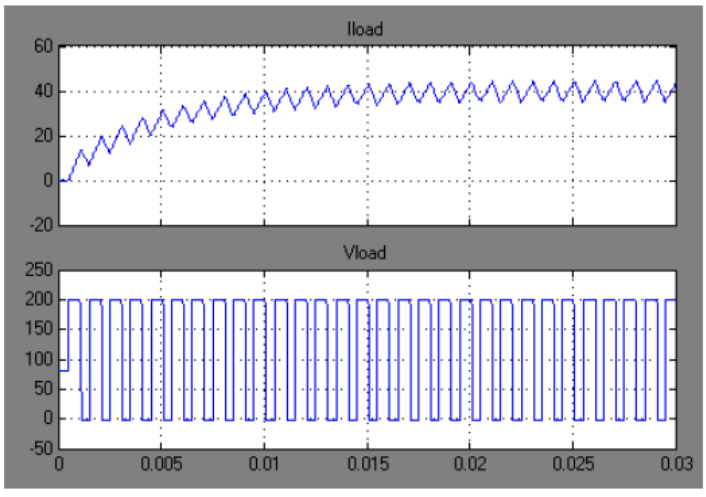
The power_buckconv demo illustrates the use of the GTO block in a buck converter topology. The basic polarized snubber circuit is connected across the GTO block. The snubber circuit consists of a capacitor Cs, a resistor Rs, and a diode Ds. The parasitic inductance Ls of the snubber circuit is also taken into consideration.

The parameters of the GTO block are those found in the dialog box section, except for the internal snubber, which is not used (Rs = inf; Cs = 0). The switching frequency is 1000 Hz and the pulse width is 216 degrees (duty cycle: 60%).



Run the simulation. Observe the GTO voltage and current as well as the load voltage and current.





References

[1] Mohan, N., T.M. Undeland, and W.P. Robbins, Power Electronics: Converters, Applications, and Design, John Wiley & Sons, Inc., New York, 1995.

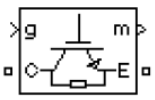
IGBT

Implement insulated gate bipolar transistor (IGBT)

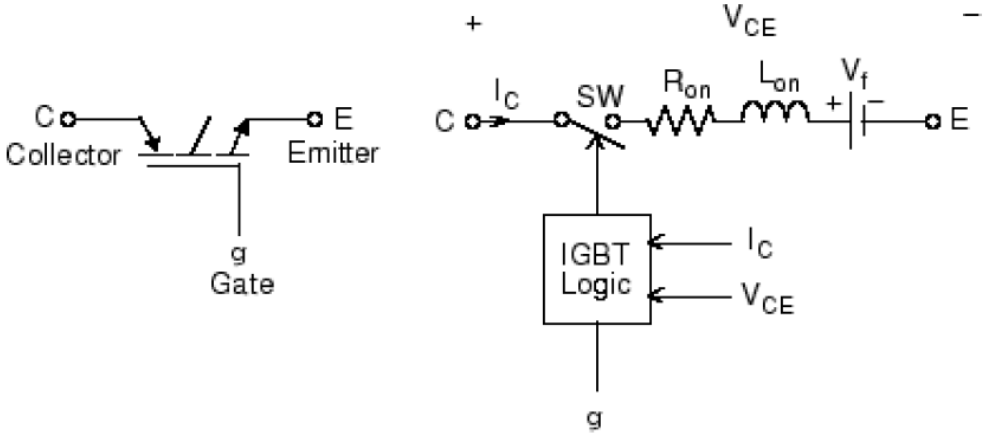
Library

Power Electronics

Description



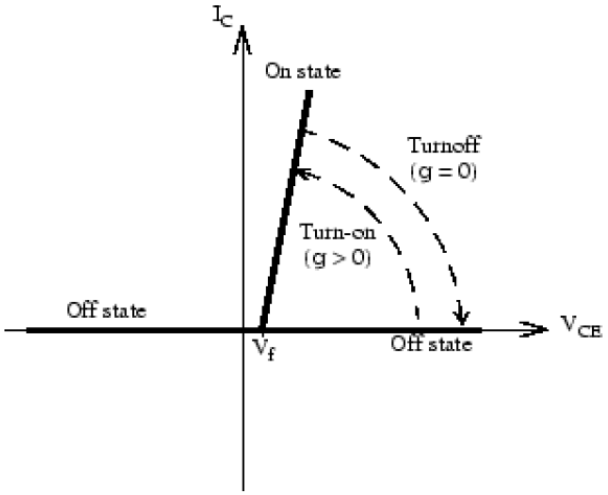
The IGBT block implements a semiconductor device controllable by the gate signal. The IGBT is simulated as a series combination of a resistor Ron, inductor Lon, and a DC voltage source Vf in series with a switch controlled by a logical signal (g > 0 or g = 0)



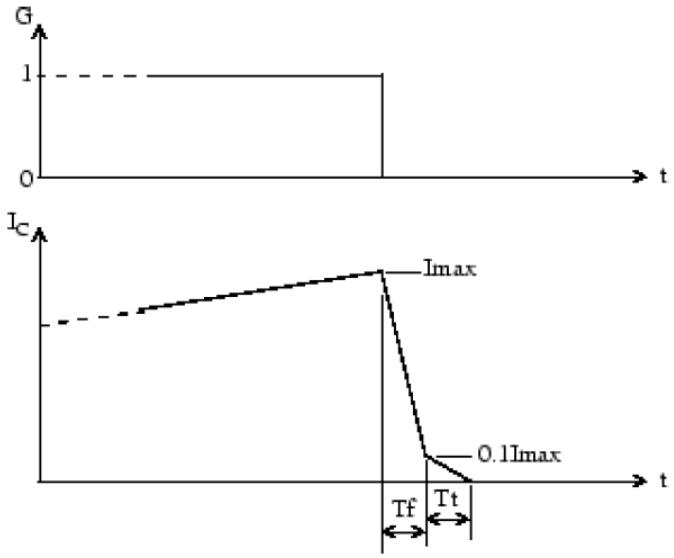
The IGBT turns on when the collector-emitter voltage is positive and greater than Vf and a positive signal is applied at the gate input (g > 0). It turns off when the collector-emitter voltage is positive and a 0 signal is applied at the gate input (g = 0).

The IGBT device is in the off state when the collector-emitter voltage is negative. Note that many commercial IGBTs do not have the reverse blocking capability. Therefore, they are usually used with an antiparallel diode.

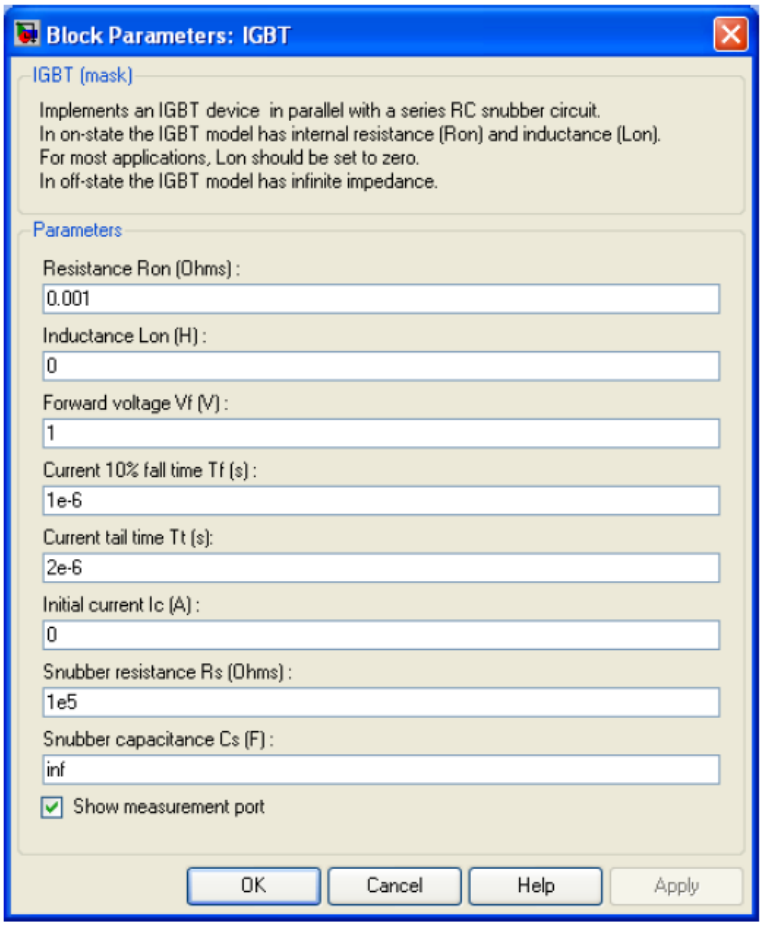
The IGBT block contains a series Rs-Cs snubber circuit, which is connected in parallel with the IGBT device (between terminals C and E).



The turnoff characteristic of the IGBT model is approximated by two segments. When the gate signal falls to 0, the collector current decreases from Imax to 0.1 Imax during the fall time (Tf), and then from 0.1 Imax to 0 during the tail time (Tt).



Dialog Box and Parameters



Resistance Ron

The internal resistance Ron, in ohms (Ω).

Inductance Lon

The internal inductance Lon, in henries (H). The Inductance Lon parameter cannot be set to 0.

Forward voltage Vf

The forward voltage of the IGBT device, in volts (V).

Current 10% fall time

The current fall time Tf, in seconds (s).

Current tail time

The current tail time Tt, in seconds (s).

Initial current Ic

You can specify an initial current flowing in the IGBT. It is usually set to 0 in order to start the simulation with the device blocked.

If the Initial Current IC parameter is set to a value greater than 0, the steady-state calculation considers the initial status of the IGBT as closed. Initializing all states of a power electronic converter is a complex task. Therefore, this option is useful only with simple circuits.

Snubber resistance Rs

The snubber resistance, in ohms (Ω). Set the Snubber resistance Rs parameter to inf to eliminate the snubber from the model.

Snubber capacitance Cs

The snubber capacitance in farads (F). Set the Snubber capacitance Cs parameter to 0 to eliminate the snubber, or to inf to get a resistive snubber.

Show measurement port

If selected, add a Simulink output to the block returning the diode IGBT current and voltage.

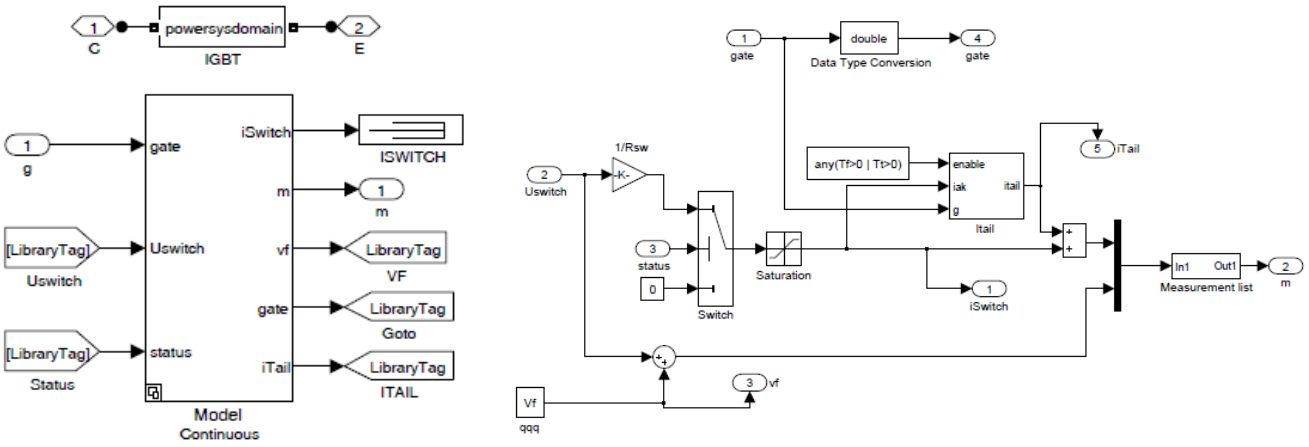
Inputs and Outputs

g Simulink signal to control the opening and closing of the IGBT.

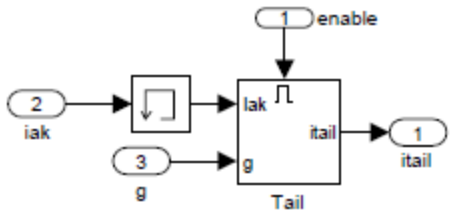
m The Simulink output of the block is a vector containing two signals. You can demultiplex these signals by using the Bus Selector block provided in the Simulink library.

Signal	Definition	Units
1	IGBT current	A
2	IGBT voltage	V

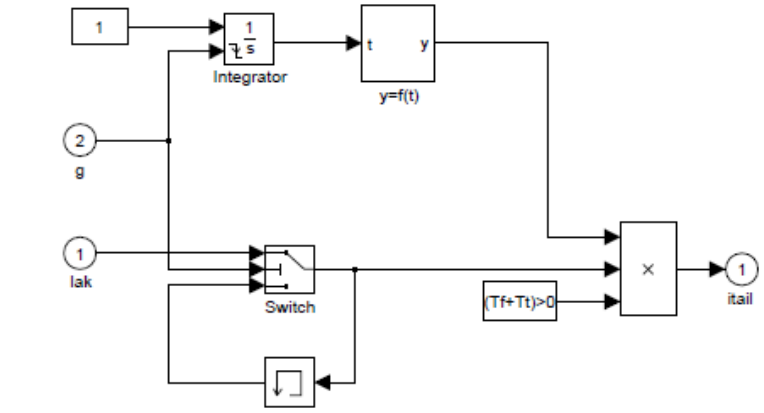
Look Under Mask



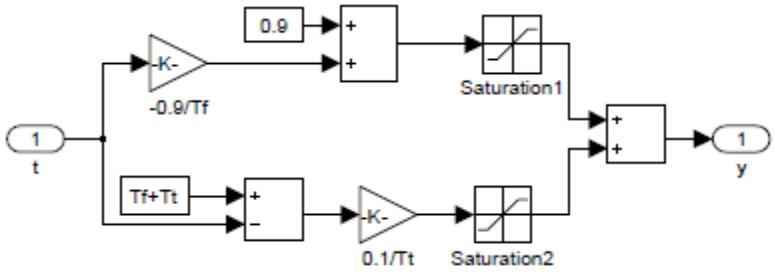
Itail



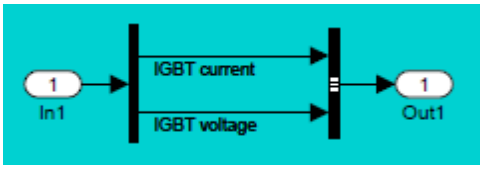
- Tail



o y=f(t)



Measurament list



Assumptions and Limitations

The IGBT block implements a macro model of the real IGBT device. It does not take into account either the geometry of the device or the complex physical processes [1].

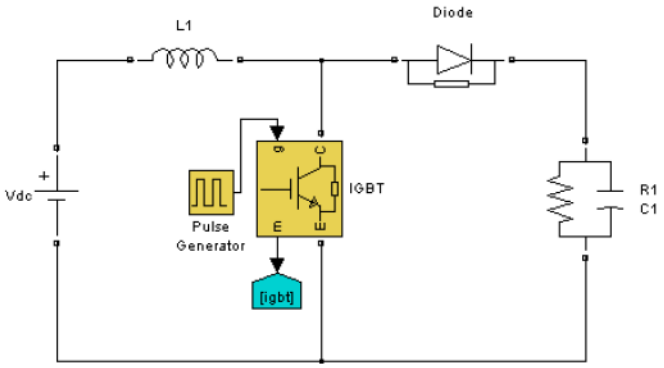
Depending on the value of the inductance Lon, the IGBT is modeled either as a current source (Lon > 0) or as a variable topology circuit (Lon = 0). The IGBT block cannot be connected in series with an inductor, a current source, or an open circuit, unless its snubber circuit is in use. See Improving Simulation Performance for more details on this topic.

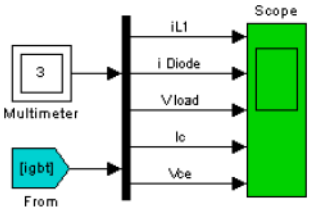
Use the Powergui block to specify either continuous simulation or discretization of your electrical circuit containing IGBT blocks. When using a continuous model, the ode23tb solver with a relative tolerance of 1e-4 is recommended for best accuracy and simulation speed.

The inductance Lon is forced to 0 if you choose to discretize your circuit.

Example

The power_igbtconv demo illustrates the use of the IGBT block in a boost DC-DC converter. The IGBT is switched on and off at a frequency of 10 kHz to transfer energy from the DC source to the load (RC). The average output voltage (VR) is a function of the duty cycle (α) of the IGBT switch:



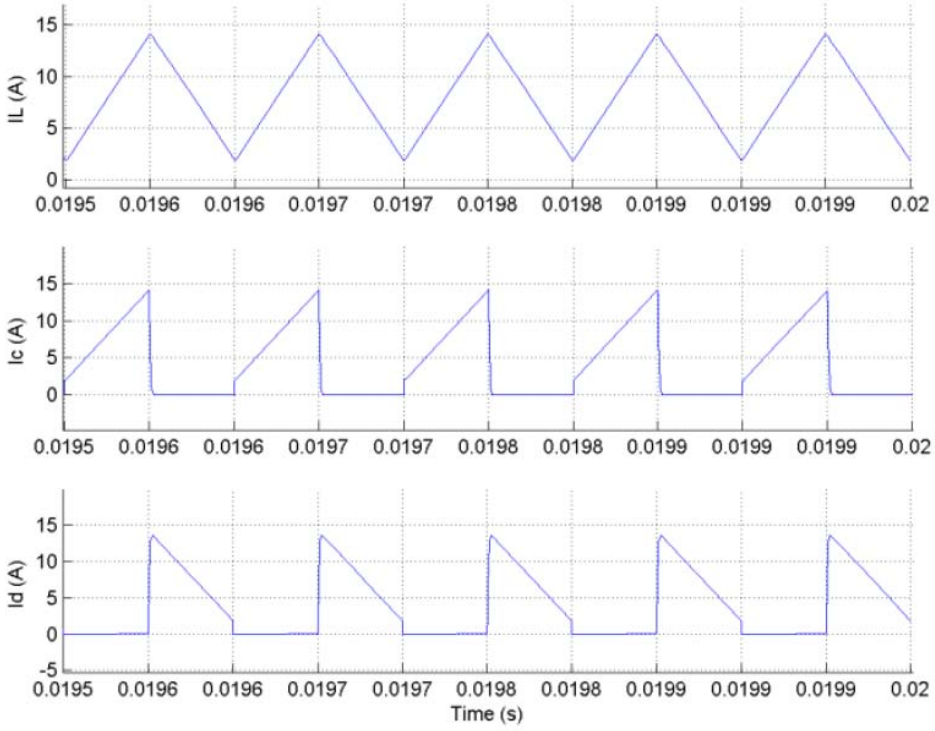


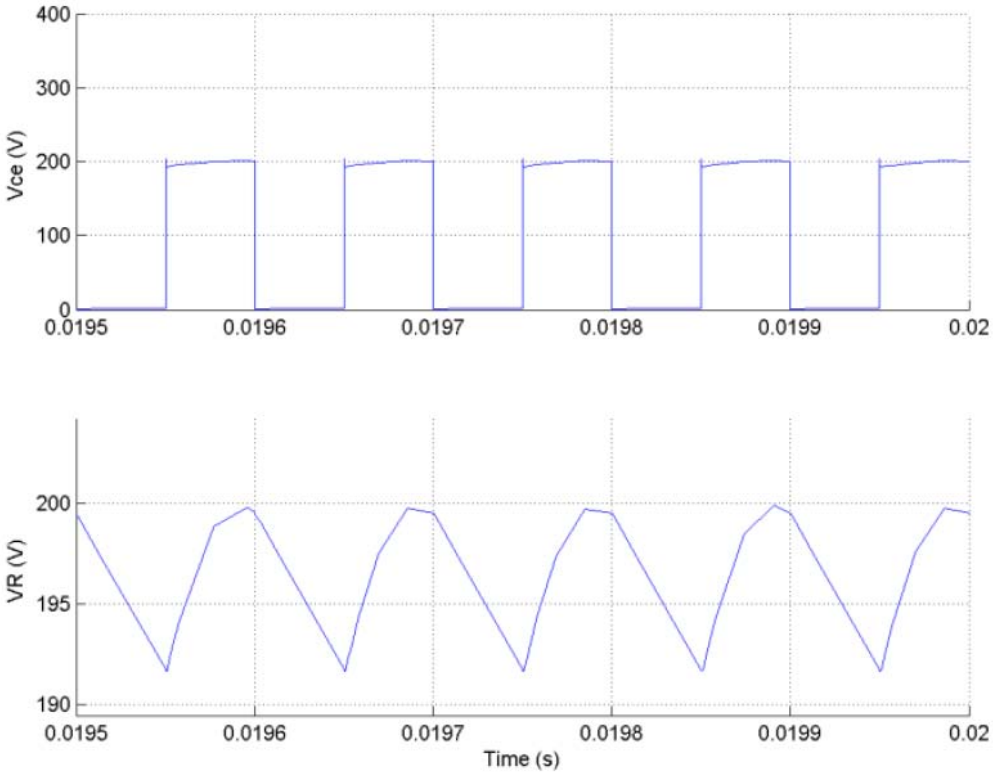
$$V_R = \frac{1}{1-\alpha} V_{dc}$$

In our example, α = 0.5 so that the theoretical value of VR is 200 V, assuming no voltage drop across the diode and the IGBT.

Run the simulation and observe the inductor current (IL), the IGBT collector current (IC), the diode current (ID), the IGBT device collector-emitter voltage (VCE), and the load voltage (VR).

The load voltage (197 V) is slightly lower than the theoretical value (200 V) mainly because of the forward voltage (Vf) of the diode (0.8 V) and of the IGBT (Vf = 1 V).





References

[1] Mohan, N., T.M. Undeland, and W.P. Robbins, Power Electronics: Converters, Applications, and Design, John Wiley & Sons, Inc., New York, 1995.

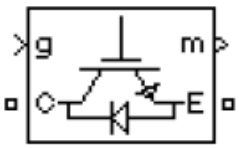
IGBT/DIODE

Implements ideal IGBT, GTO, or MOSFET and antiparallel diode

Library

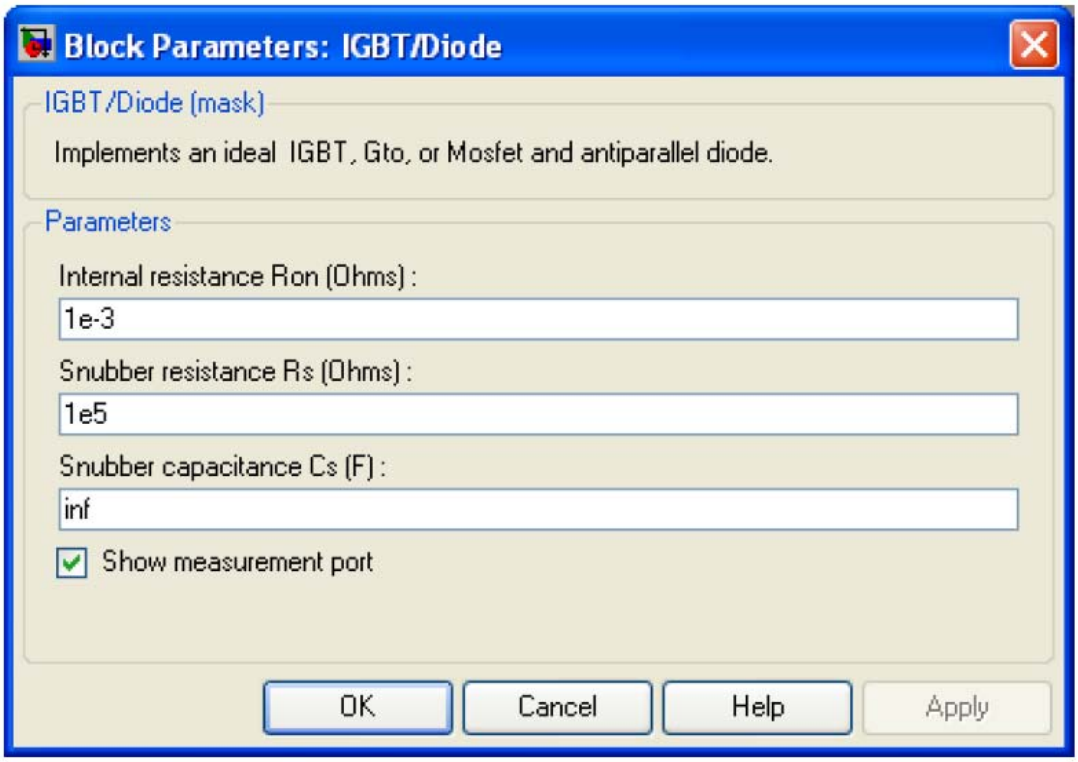
Power Electronics

Description



The IGBT/Diode block is a simplified mode of an IGBT (or GTO or MOSFET)/Diode pair where the forward voltages of the forced-commutated device and diode are ignored.

Dialog Box and Parameters



Internal resistance Ron

The internal resistance Ron of the IGBT device, in ohms (Ω).

Snubber resistance Rs

The snubber resistance, in ohms (Ω). Set the Snubber resistance Rs parameter to inf to eliminate the snubber from the model.

Snubber capacitance Cs

The snubber capacitance in farads (F). Set the Snubber capacitance Cs parameter to 0 to eliminate the snubber, or to inf to get a resistive snubber.

Show measurement port

If selected, add a Simulink output to the block returning the diode IGBT current and voltage.

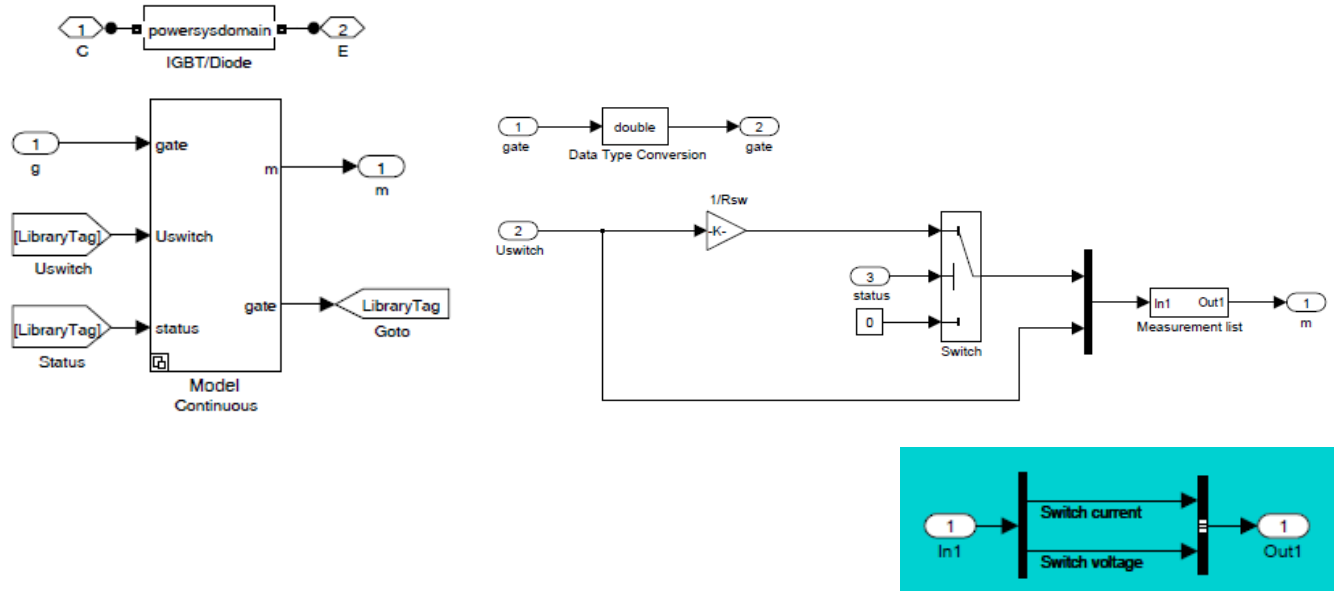
Inputs and Outputs

g Simulink signal to control the opening and closing of the IGBT.

m The Simulink output of the block is a vector containing two signals. You can demultiplex these signals by using the Bus Selector block provided in the Simulink library.

Signal	Definition	Units
1	IGBT/Diode current	A
2	IGBT/diode voltage	V

Look Under Mask



Assumptions and Limitations

The IGBT/Diode block implements a macro model of the real IGBT and Diode devices. It does not take into account either the geometry of the devices or the complex physical processes [1].

The IGBT/Diode block cannot be connected in series with an inductor, a current source, or an open circuit, unless its snubber circuit is in use. See Improving Simulation Performance for more details on this topic.

Use the Powergui block to specify either continuous simulation or discretization of your electrical circuit containing IGBT/Diode blocks. When using a continuous model, the ode23tb solver with a relative tolerance of 1e-4 is recommended for best accuracy and simulation speed.

Example

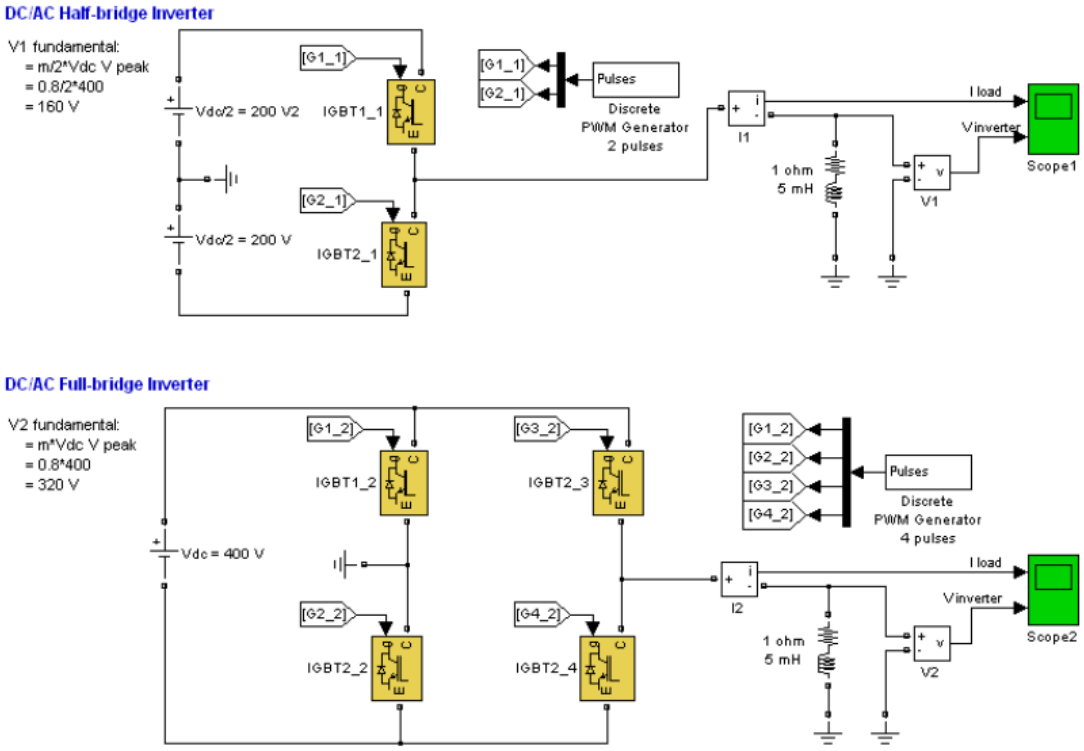
The power_1phPWM_IGBT demo illustrates use of the IGBT/Diode block in voltage-sourced converters. The system consists of two independent circuits illustrating single-phase PWM voltage-sourced converters (VSC):

1. Half-bridge converter
2. Full-bridge converter

The converters are built with the IGBT/Diode block which is the basic building block of all VSCs. You may replace these blocks by individual IGBT and diode blocks for a more detailed representation.

VSCs are controlled in open loop with the Discrete PWM Generator block available in the Extras/Discrete Control Blocks library.

The two circuits use the same DC voltage of 400 Volts, carrier frequency of 1080 Hz and modulation index of 0.8.



Run the simulation and observe the current into the load (trace 1) and the voltage generated by the PWM inverter (trace 2) on the Scope blocks.

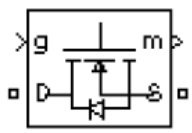
MOSFET

Implement MOSFET model

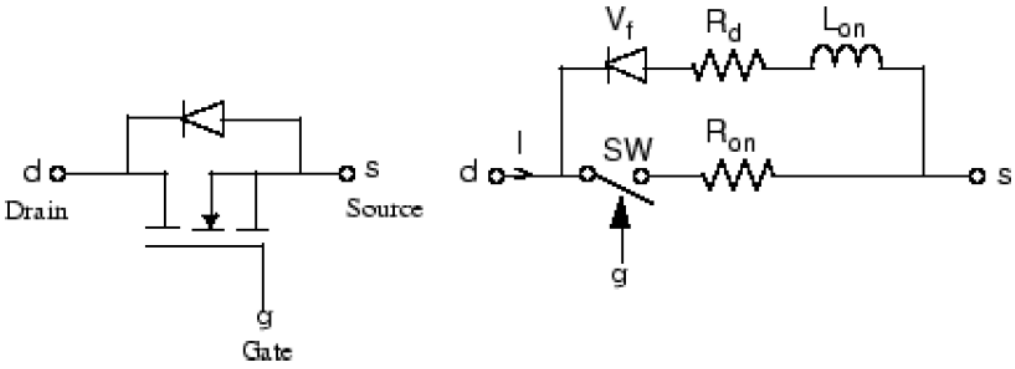
Library

Power Electronics

Description



The metal-oxide semiconductor field-effect transistor (MOSFET) is a semiconductor device controllable by the gate signal (g > 0). The MOSFET device is connected in parallel with an internal diode that turns on when the MOSFET device is reverse biased (Vds < 0) and no gate signal is applied (g=0). The model is simulated by an ideal switch controlled by a logical signal (g > 0 or g = 0), with a diode connected in parallel.



The MOSFET device turns on when a positive signal is applied at the gate input (g > 0) whether the drain-source voltage is positive or negative. If no signal is applied at the gate input (g=0), only the internal diode conducts when voltage exceeds its forward voltage Vf.

With a positive or negative current flowing through the device, the MOSFET turns off when the gate input becomes 0. If the current I is negative and flowing in the internal diode (no gate signal or g = 0), the switch turns off when the current I becomes 0.

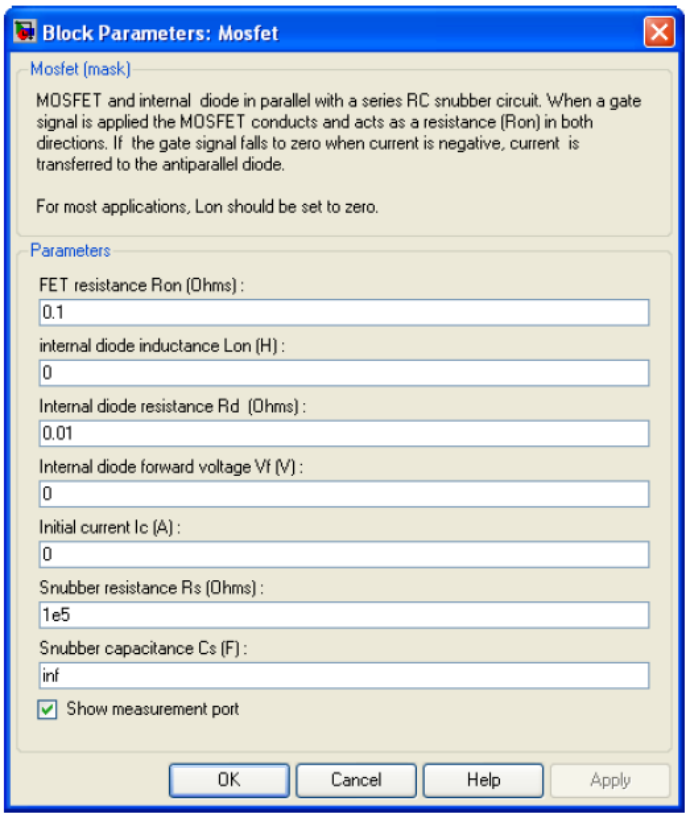
The on state voltage Vds varies

- Vds = Ron*I when a positive signal is applied at the gate input.
- Vds = Rd*I-Vf +Lon*dI/dt when the antiparallel diode is conducting (no gate signal).

The Lon diode inductance is available only with the continuous model. For most applications, Lon should be set to zero for both continuous and discrete models.

The MOSFET block also contains a series Rs-Cs snubber circuit that can be connected in parallel with the MOSFET (between nodes d and s).

Dialog Box and Parameters



FET Resistance Ron

The internal resistance Ron, in ohms (Ω).

Internal diode inductance Lon

The internal inductance Lon, in henries (H). The Inductance Lon parameter cannot be set to 0.

Internal diode resistance Rd

The internal resistance of the internal diode, in ohms (Ω).

Internal diode forward voltage Vf

The forward voltage of the internal diode, in volts (V).

Initial current Ic

You can specify an initial current flowing in the MOSFET device. It is usually set to 0 in order to start the simulation with the device blocked.

If the Initial current IC parameter is set to a value greater than 0, the steady-state calculation considers the initial status of the MOSFET as closed. Initializing all states of a power electronic converter is a complex task. Therefore, this option is useful only with simple circuits.

Snubber resistance Rs

The snubber resistance, in ohms (Ω). Set the Snubber resistance Rs parameter to inf to eliminate the snubber from the model.

Snubber capacitance Cs

The snubber capacitance, in farads (F). Set the Snubber capacitance Cs parameter to 0 to eliminate the snubber, or to inf to get a resistive snubber.

Show measurement port

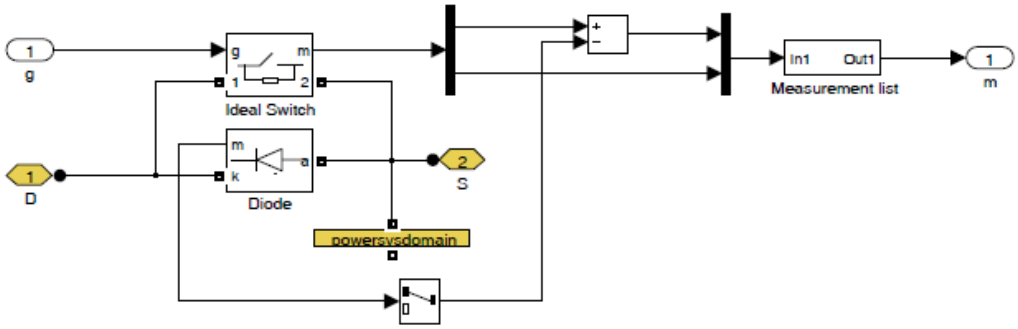
If selected, add a Simulink output to the block returning the MOSFET current and voltage.

Inputs and Outputs

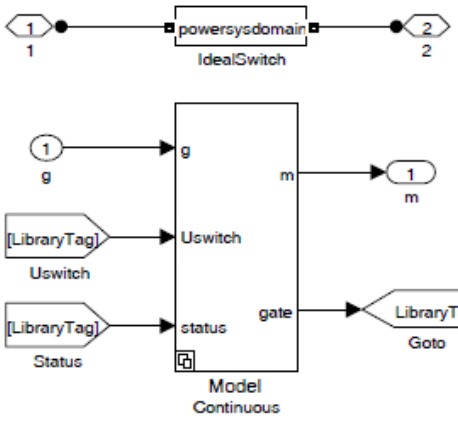
g Simulink signal to control the opening and closing of the MOSFET.

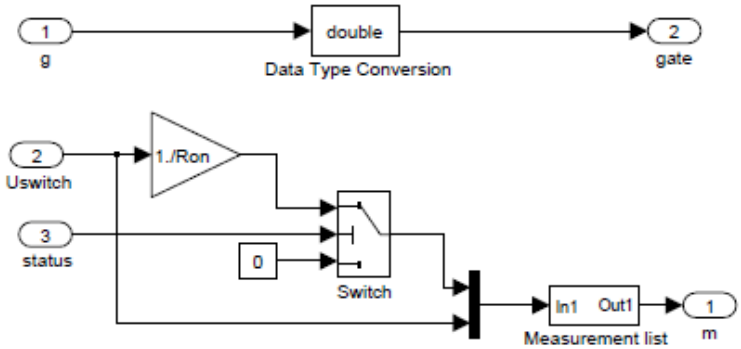
m The Simulink output of the block is a vector containing 2 signals. You can demultiplex these signals by using the Bus Selector block provided in the Simulink library.

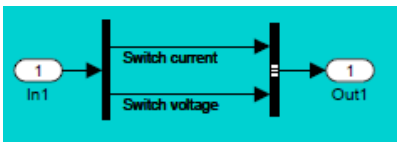
Look Under Mask



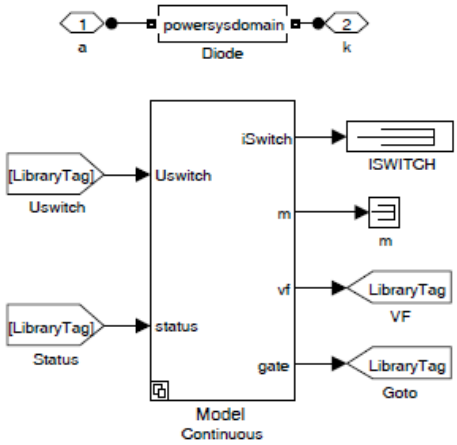
Ideal Switch

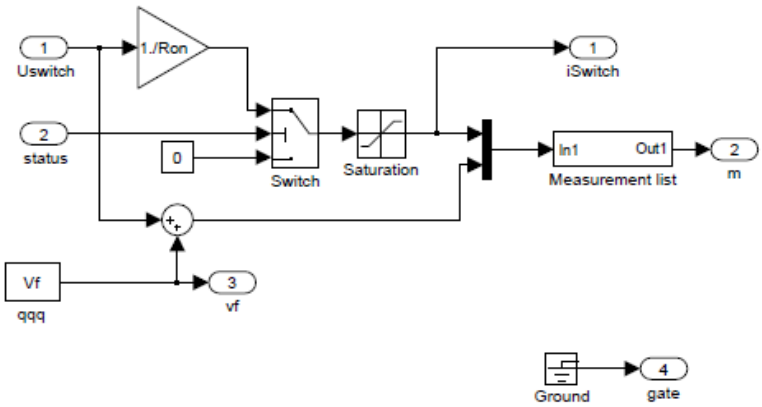


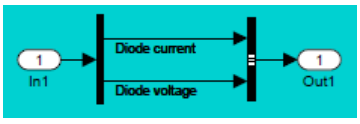




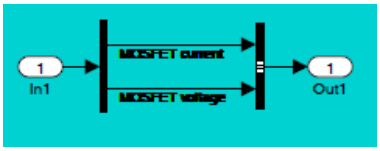
Diode







Measurement list



Assumptions and Limitations

The MOSFET block implements a macro model of the real MOSFET device. It does not take into account either the geometry of the device or the complex physical processes [1].

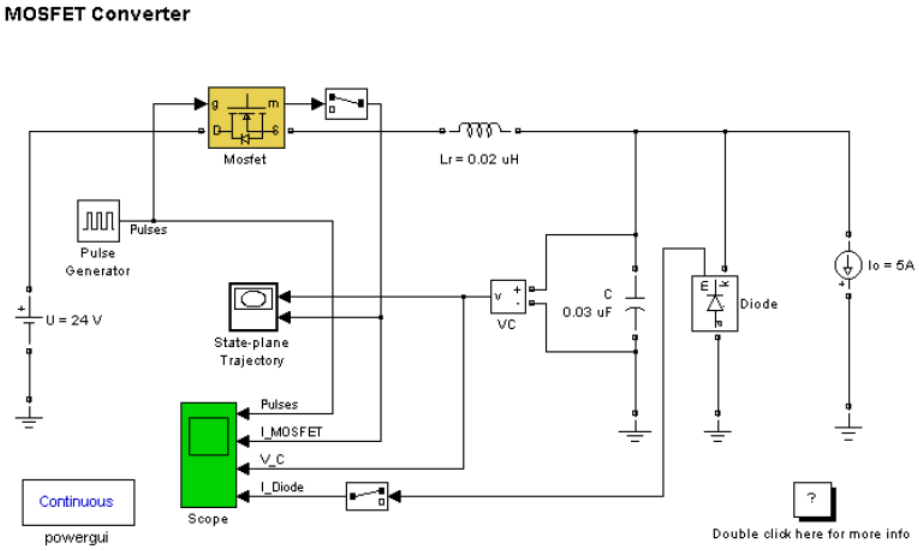
Depending on the value of the inductance Lon, the MOSFET is modeled either as a current source (Lon > 0) or as a variable topology circuit (Lon = 0). The MOSFET block cannot be connected in series with an inductor, a current source, or an open circuit, unless its snubber circuit is in use. See Improving Simulation Performance for more details on this topic.

Use the Powergui block to specify either continuous simulation or discretization of your electrical circuit containing MOSFET blocks. When using a continuous model, the ode23tb solver with a relative tolerance of 1e-4 is recommended for best accuracy and simulation speed.

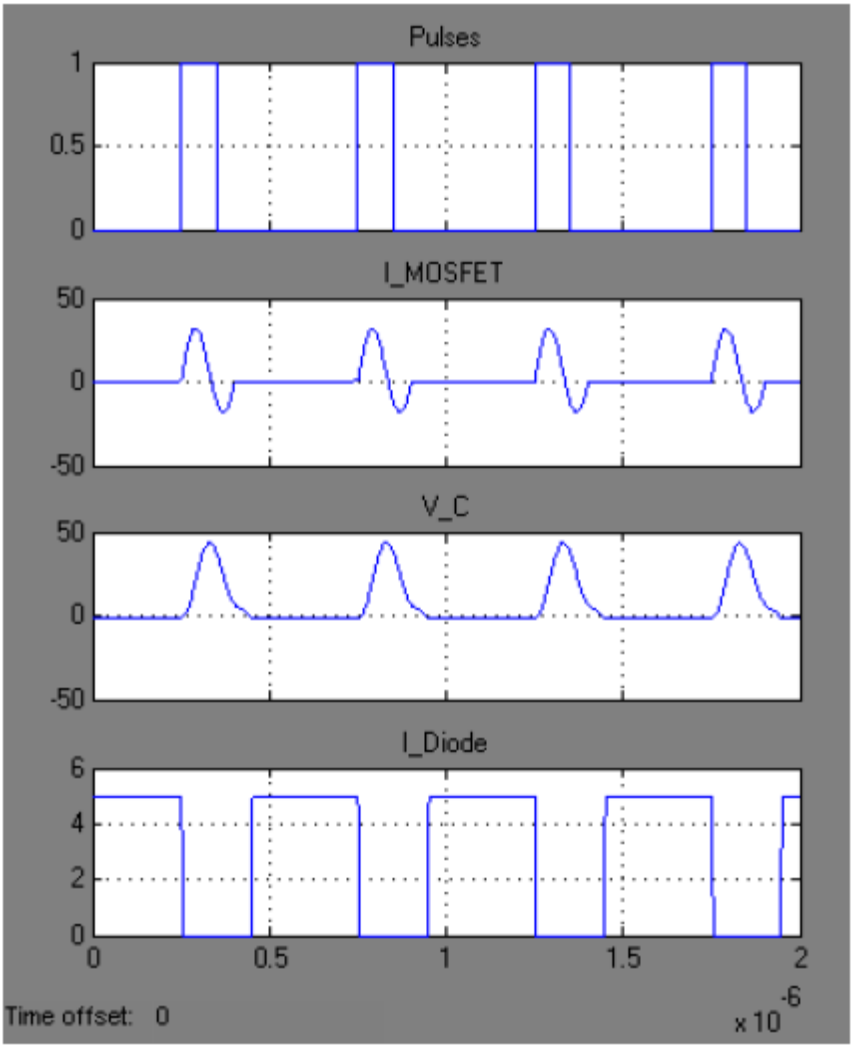
The inductance Lon is forced to 0 if you choose to discretize your circuit.

Example

The power_mosconv demo illustrates the use of the MOSFET block in a zero-current quasi-resonant switch converter. In such a converter, the current produced by the Lr-Cr resonant circuit flows through the MOSFET and internal diode. The negative current flows through the internal diode that turns off at 0 current [1]. The switching frequency is 2 MHz and the pulse width is 72 degrees (duty cycle: 20%).



Run the simulation and observe the gate pulse signal, the MOSFET current, the capacitor voltage, and the diode current on the four-trace Scope block.



References

[1] Mohan, N., T.M. Undeland, and W.P. Robbins, Power Electronics: Converters, Applications, and Design, John Wiley & Sons, Inc., New York, 1995.

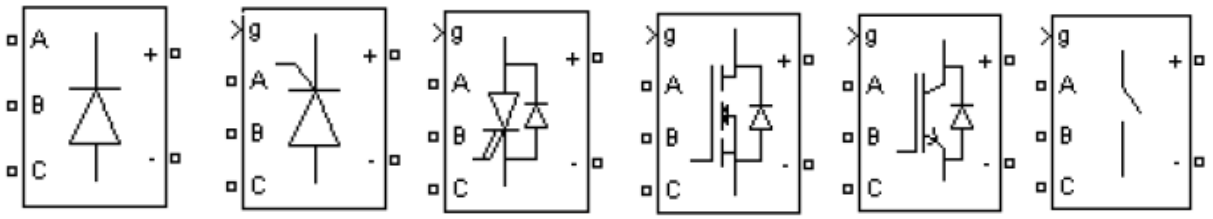
UNIVERSAL BRIDGE

Implement universal power converter with selectable topologies and power electronic devices

Library

Power Electronics

Description

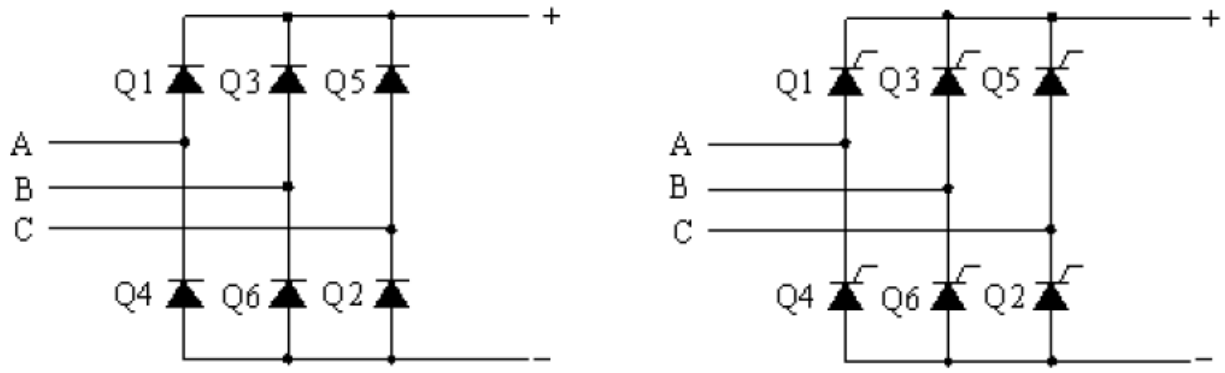


The Universal Bridge block implements a universal three-phase power converter that consists of up to six power switches connected in a bridge configuration. The type of power switch and converter configuration are selectable from the dialog box.

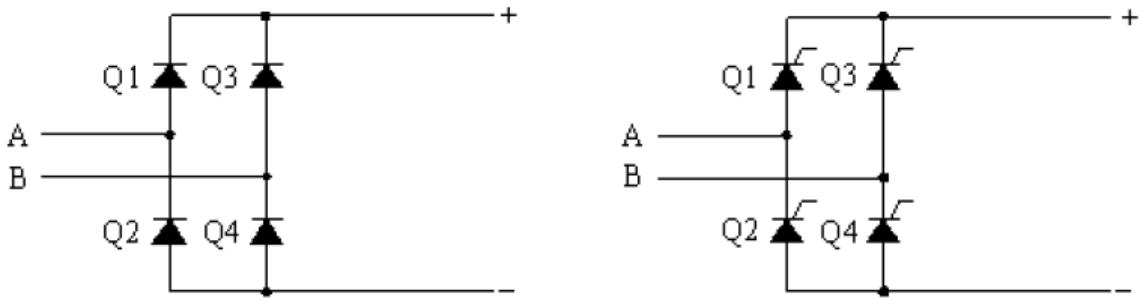
The Universal Bridge block allows simulation of converters using both naturally commutated (or line-commutated) power electronic devices (diodes or thyristors) and forced-commutated devices (GTO, IGBT, MOSFET).

The Universal Bridge block is the basic block for building two-level voltage-sourced converters (VSC).

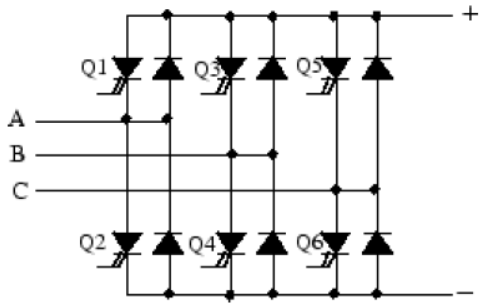
The device numbering is different if the power electronic devices are naturally commutated or forced-commutated. For a naturally commutated three-phase converter (diode and thyristor), numbering follows the natural order of commutation:



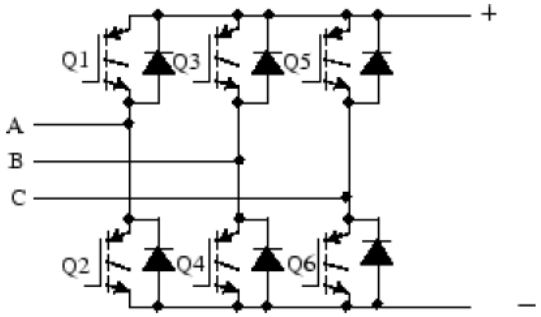
For the case of a two-phase diode or thyristor bridge, and for any other bridge configuration, the order of commutation is the following:



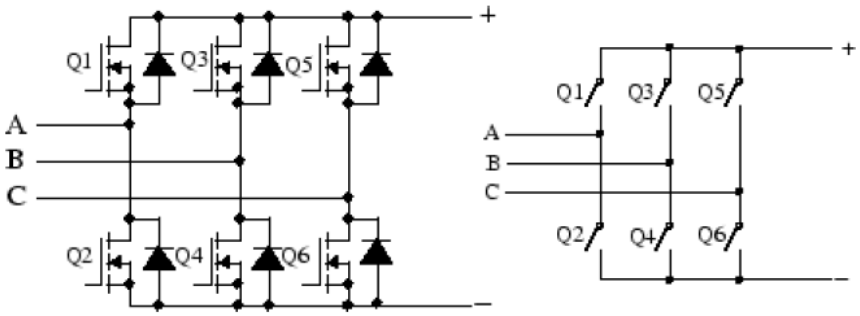
GTO-Diode bridge:



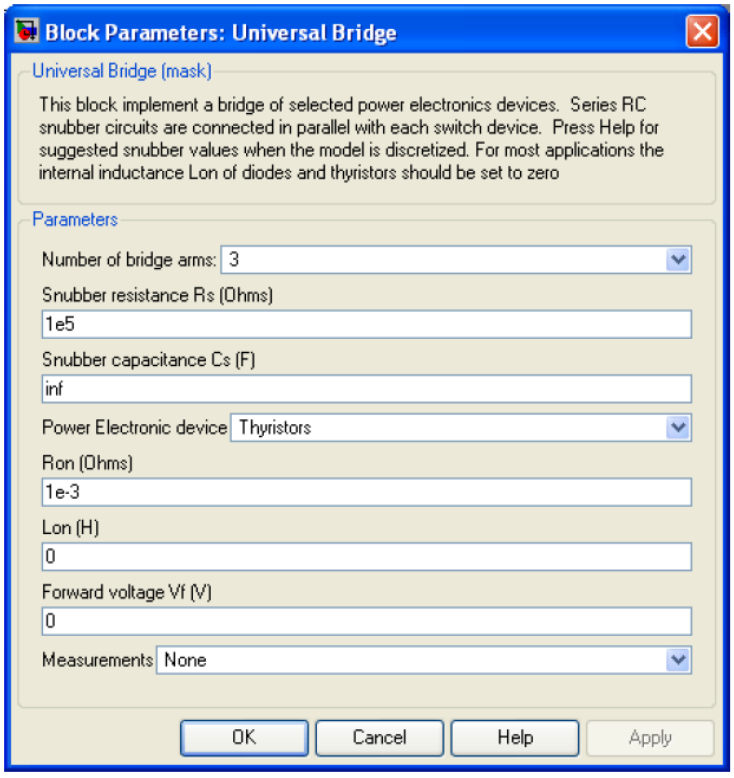
IGBT-Diode bridge:



MOSFET-Diode and Ideal Switch bridges:



Dialog Box and Parameters



Number of bridge arms

Set to 1 or 2 to get a single-phase converter (two or four switching devices). Set to 3 to get a three-phase converter connected in Graetz bridge configuration (six switching devices).

Snubber resistance Rs

The snubber resistance, in ohms (Ω). Set the Snubber resistance Rs parameter to inf to eliminate the snubbers from the model.

Snubber capacitance Cs

The snubber capacitance, in farads (F). Set the Snubber capacitance Cs parameter to 0 to eliminate the snubbers, or to inf to get a resistive snubber.

In order to avoid numerical oscillations when your system is discretized, you need to specify Rs and Cs snubber values for diode and thyristor bridges. For forced-commutated devices (GTO, IGBT, or MOSFET), the bridge operates satisfactorily with purely resistive snubbers as long as firing pulses are sent to switching devices.

If firing pulses to forced-commutated devices are blocked, only antiparallel diodes operate, and the bridge operates as a diode rectifier. In this condition appropriate values of Rs and Cs must also be used.

When the system is discretized, use the following formulas to compute approximate values of Rs and Cs:

$$Rs > 2\frac{Ts}{Cs}$$

$$Cs < \frac{Pn}{1000(2\pi f)Vn^2}$$

where

P_n = Nominal power of single or three phase converter (VA)
Vn = Nominal line-to-line AC voltage (Vrms)
f = Fundamental frequency (Hz)
T_s = Sample Time (s)

These Rs and Cs values are derived from the following two criteria:

- The snubber leakage current at fundamental frequency is less than 0.1% of nominal current when power electronic devices are not conducting.
- The RC time constant of snubbers is higher than two times the sample time Ts.

These Rs and Cs values that guarantee numerical stability of the discretized bridge can be different from actual values used in a physical circuit.

Power electronic device

Select the type of power electronic device to use in the bridge.

When you select Switching-function based VSC, a switching-function voltage source converter type equivalent model is used, where switches are replaced by two voltage sources on the AC side and a current source on the DC side. This model uses the same firing pulses as for other power electronic devices and it correctly represents harmonics normally generated by the bridge.

When you select Average-model based VSC, an average-model type of voltage source converter is used to represent the power-electronic switches. Unlike the other power electronic devices, this model uses the reference signals (uref) representing the average voltages generated at the ABC terminals of the bridge. This model does not represent harmonics. It can be used with larger sample times while preserving the average voltage dynamics.

See the power_sfavg demo for an example comparing these two models to an Universal Bridge block using IGBT/Diode device.

Ron

Internal resistance of the selected device, in ohms (Ω).

Lon

Internal inductance, in henries (H), for the diode or the thyristor device. When the bridge is discretized, the Lon parameter must be set to zero.

Forward voltage Vf

This parameter is available only when the selected Power electronic device is Diodes or Thyristors.

Forward voltage, in volts (V), across the device when it is conducting.

Forward voltages [Device Vf, Diode Vfd]

This parameter is available when the selected Power electronic device is GTO/Diodes or IGBT/Diodes.

Forward voltages, in volts (V), of the forced-commutated devices (GTO, MOSFET, or IGBT) and of the antiparallel diodes.

[Tf (s) Tt (s)]

Fall time Tf and tail time Tt, in seconds (s), for the GTO or the IGBT devices.

Measurements

Select Device voltages to measure the voltages across the six power electronic device terminals.

Select Device currents to measure the currents flowing through the six power electronic devices. If antiparallel diodes are used, the measured current is the total current in the forced-commutated device (GTO, MOSFET, or IGBT) and in the antiparallel diode. A positive current therefore indicates a current flowing in the forced-commutated device and a negative current indicates a current flowing in the diode. If snubber devices are defined, the measured currents are the ones flowing through the power electronic devices only.

Select UAB UBC UCA UDC voltages to measure the terminal voltages (AC and DC) of the Universal Bridge block.

Select All voltages and currents to measure all voltages and currents defined for the Universal Bridge block.

Place a Multimeter block in your model to display the selected measurements during the simulation. In the Available Measurements menu of the Multimeter block, the measurement is identified by a label followed by the block name.

Measurement	Label
Device voltages	`Usw1:, Usw2:,Usw3:,Usw4:,Usw5:,Usw6:`
Branch current	`Isw1:, Isw2:, Isw3:, Isw4:, Isw5:, Isw6:`
Terminal voltages	`Uab:, Ubc:, Uca:, Udc:`

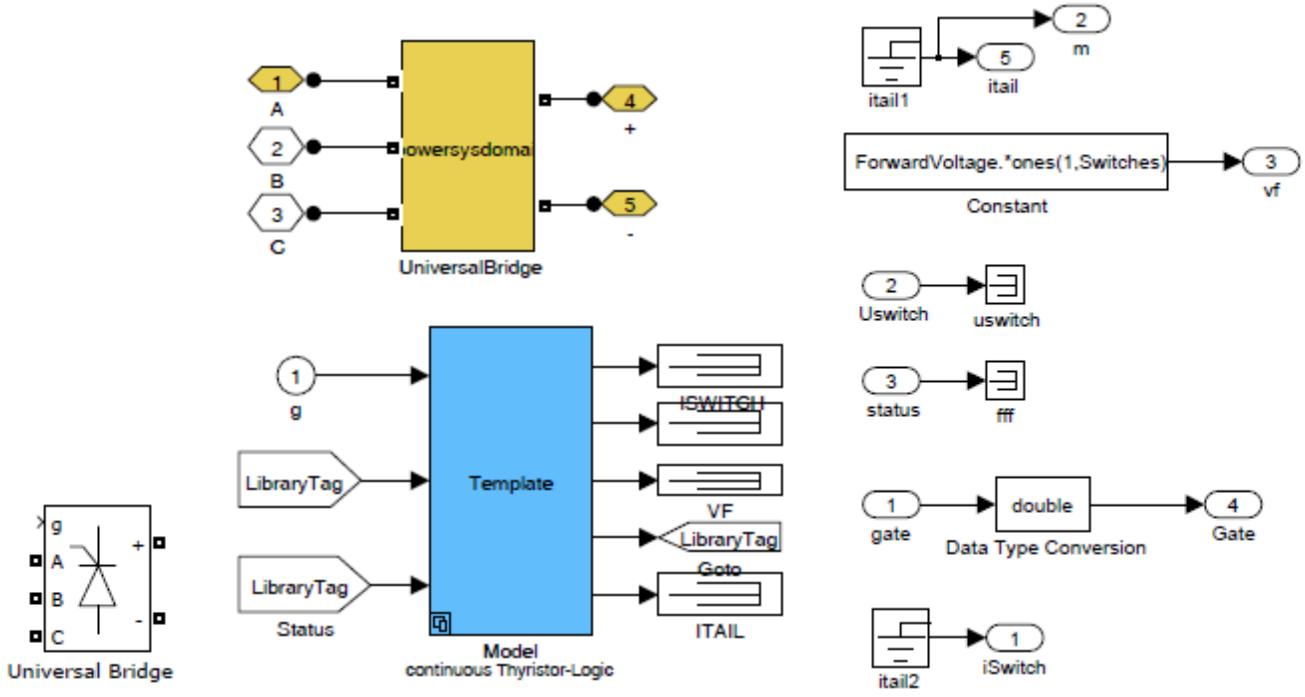
Inputs and Outputs

g — The gate input for the controlled switch devices. The pulse ordering in the vector of the gate signals corresponds to the switch number indicated in the six circuits shown in the Description section. For the diode and thyristor bridges, the pulse ordering corresponds to the natural order of commutation. For all other forced-commutated switches, pulses are sent to upper and lower switches of phases A, B, and C.

Topology	Pulse Vector of Input g
one arm	`[Q1,Q2]`
two arms	`[Q1,Q2,Q3,Q4]`
three arms	`[Q1,Q2,Q3,Q4,Q5,Q6]`

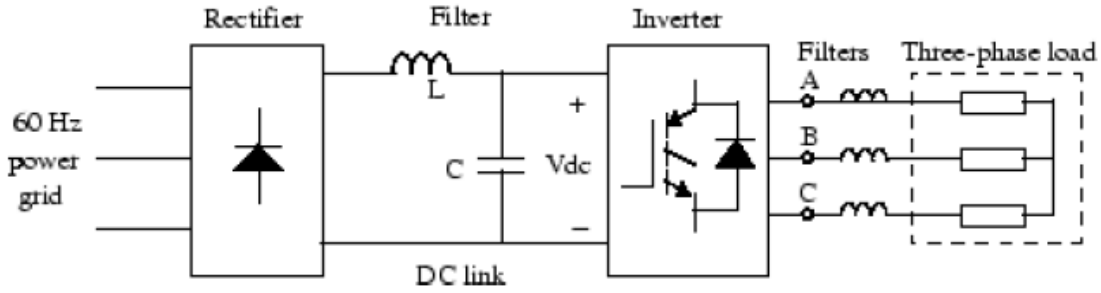
Look Under Mask

Uradjen za primjer tiristorskog mosta, a postoje slike i seme za sve ostale kombinacije.



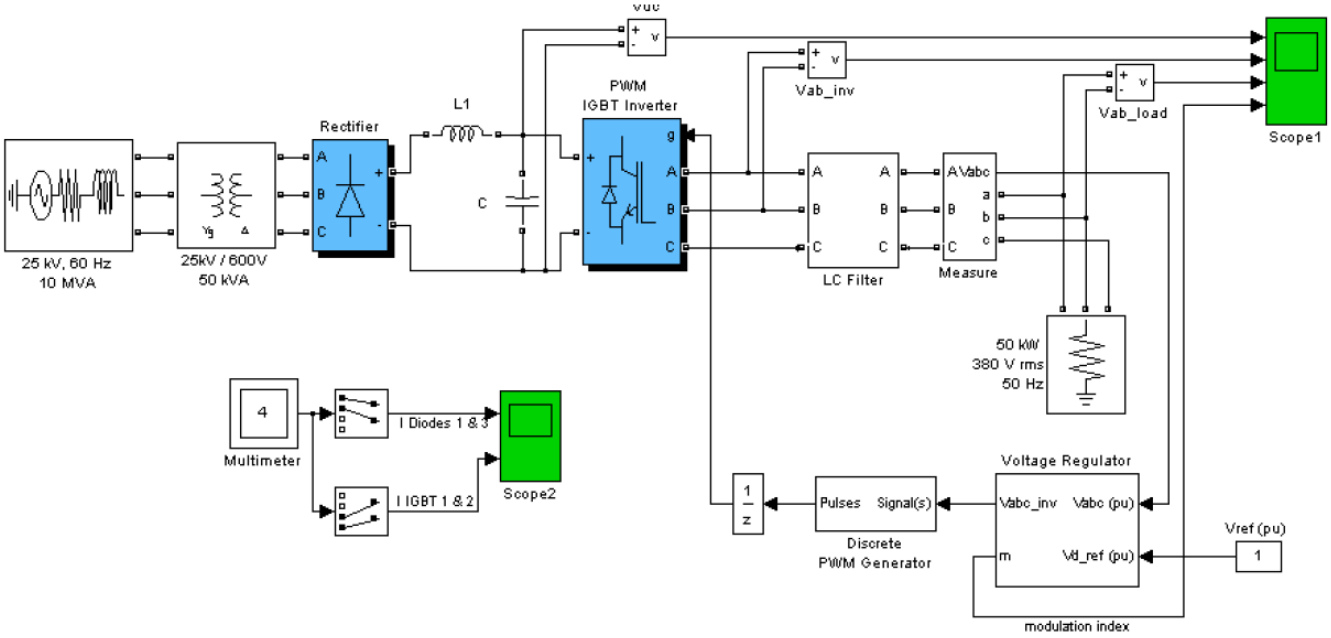
Example

The power_bridges demo illustrates the use of two Universal Bridge blocks in an ac/dc/ac converter consisting of a rectifier feeding an IGBT inverter through a DC link. The inverter is pulse-width modulated (PWM) to produce a three-phase 50 Hz sinusoidal voltage to the load. In this example the inverter chopping frequency is 2000 Hz.



The IGBT inverter is controlled with a PI regulator in order to maintain a 1 pu voltage (380 Vrms, 50 Hz) at the load terminals.

A Multimeter block is used to observe commutation of currents between diodes 1 and 3 in the diode bridge and between IGBT/Diodes switches 1 and 2 in the IGBT bridge.

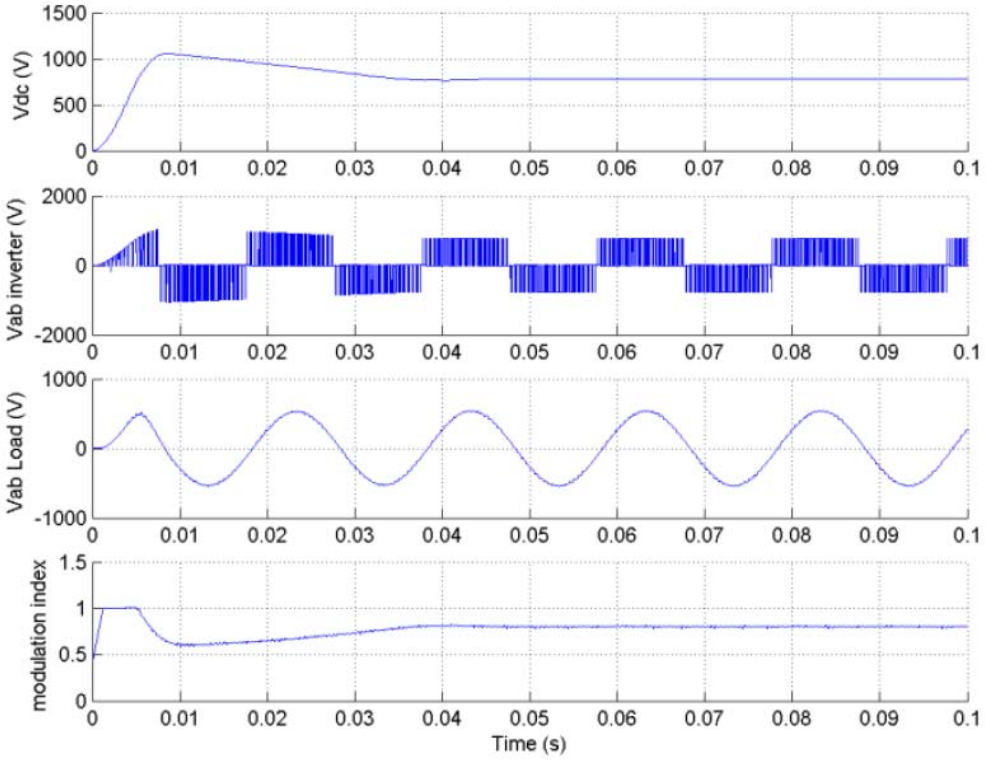


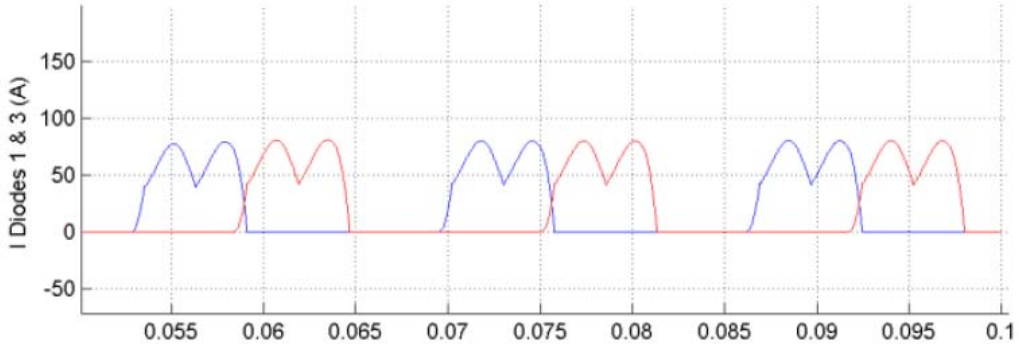
Start simulation. After a transient period of approximately 40 ms, the system reaches a steady state. Observe voltage waveforms at DC bus, inverter output, and load on Scope1. The harmonics generated by the inverter around multiples of 2 kHz are filtered by the LC filter. As expected the peak value of the load voltage is 537 V (380 V RMS).

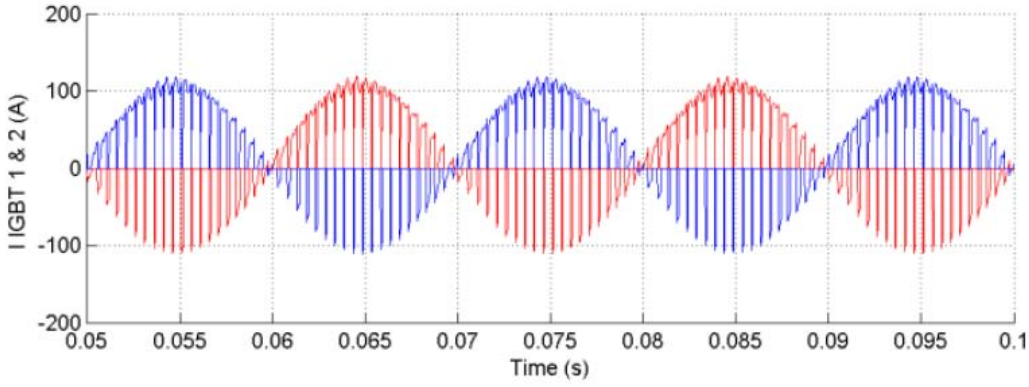
In steady state the mean value of the modulation index is m = 0.8, and the mean value of the DC voltage is 778 V. The fundamental component of 50 Hz voltage buried in the chopped inverter voltage is therefore

Vab = 778 V * 0.612 * 0.80 = 381 V RMS

Observe diode currents on trace 1 of Scope2, showing commutation from diode 1 to diode 3. Also observe on trace 2 currents in switches 1 and 2 of the IGBT/Diode bridge (upper and lower switches connected to phase A). These two currents are complementary. A positive current indicates a current flowing in the IGBT, whereas a negative current indicates a current flowing in the antiparallel diode.


Vdc (V)
1500
1000
500
0
0 0.01 0.02 0.03 0.04 0.05 0.06 0.07 0.08 0.09 0.1
Vab inverter (V)
2000
0
-2000
0 0.01 0.02 0.03 0.04 0.05 0.06 0.07 0.08 0.09 0.1
Vab Load (V)
1000
0
-1000
0 0.01 0.02 0.03 0.04 0.05 0.06 0.07 0.08 0.09 0.1
modulation index
1.5
1
0.5
0
0 0.01 0.02 0.03 0.04 0.05 0.06 0.07 0.08 0.09 0.1
Time (s)


I Diodes 1 & 3 (A)
150
100
50
0
-50
0.055 0.06 0.065 0.07 0.075 0.08 0.085 0.09 0.095 0.1


I IGBT 1 & 2 (A)
200
100
0
-100
-200
0.05 0.055 0.06 0.065 0.07 0.075 0.08 0.085 0.09 0.095 0.1
Time (s)

THREE-LEVEL BRIDGE

Ovo mi je jos ostalo .....