Electric Machines and Power Electronics Toolbox

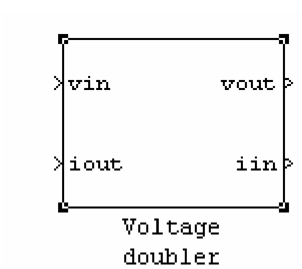
Version 1.0

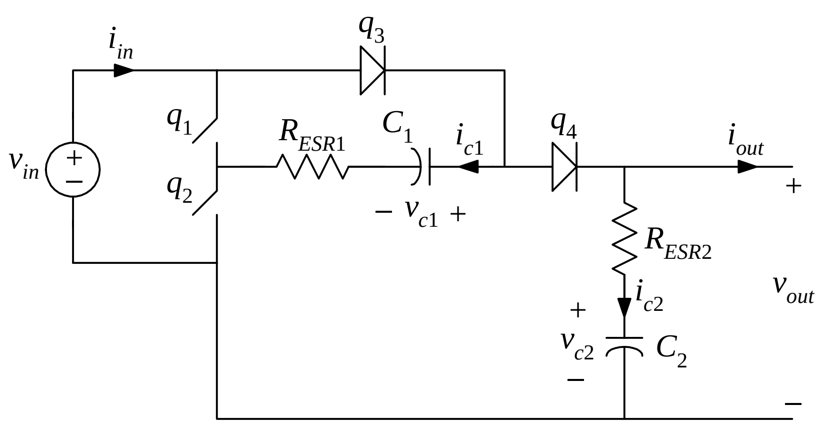
Dc-dc Converters

Charge Pump

Voltage Doubler

Switched capacitor voltage doubler. Inputs: input voltage and output current. Outputs: output voltage and input current. This model does not include transistor or diode losses.





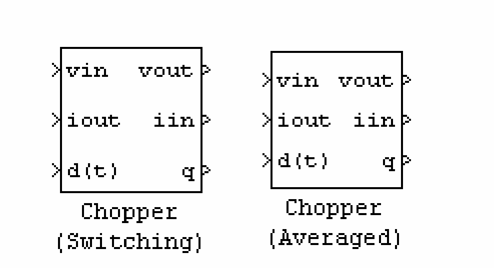
Switching Models and Average Models

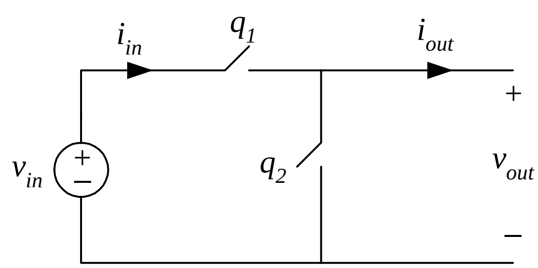
This library contains switching and average models of five dc-dc converter topologies: buck, boost, buck-boost, boost-buck, SEPIC. There are two varieties for each topology, switching and average models. For each variety, there are two versions: (i) an 'ideal' version which does not include any parasitic loss elements; (ii) a 'lossy' version which includes static parasitic losses (inductor and capacitor equivalent series resistances; conduction resistances for transistors and diodes; junction voltage for diodes).

Only the switching models are capable of discontinuous current mode (DCM) operation. The average models are based on strictly continuous current mode (CCM) models.

Chopper

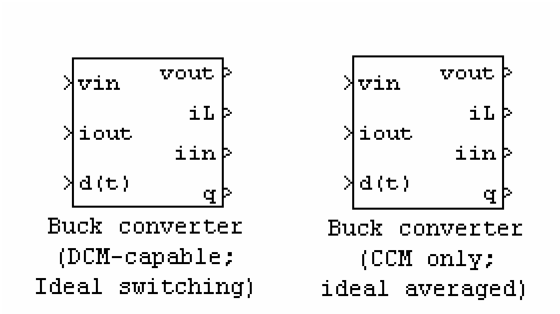
These models do not contain any parasitic elements.

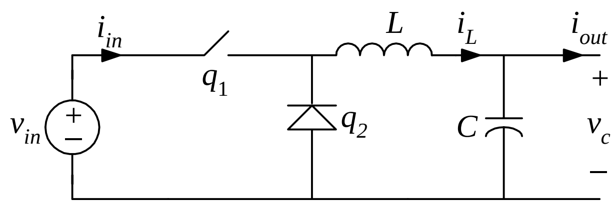




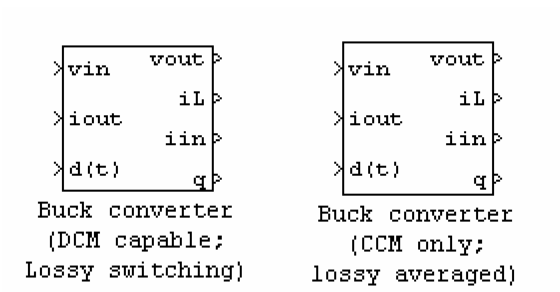
Buck converter

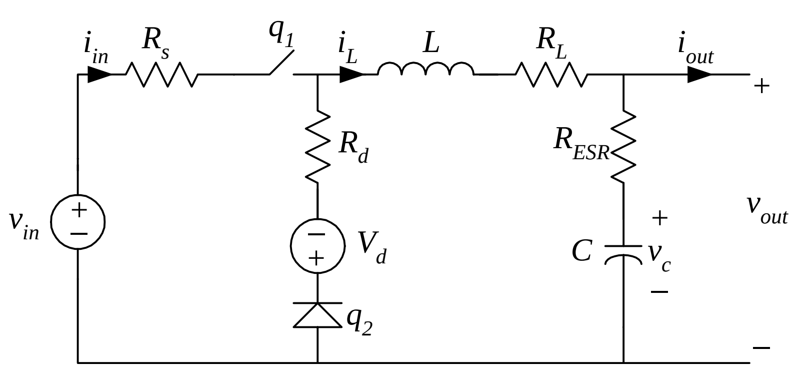
Ideal





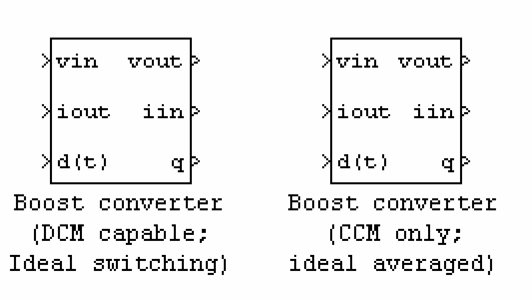
Lossy

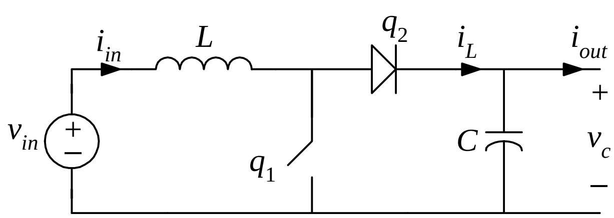




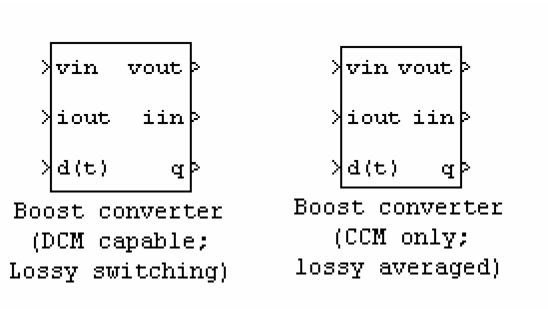
Boost Converter

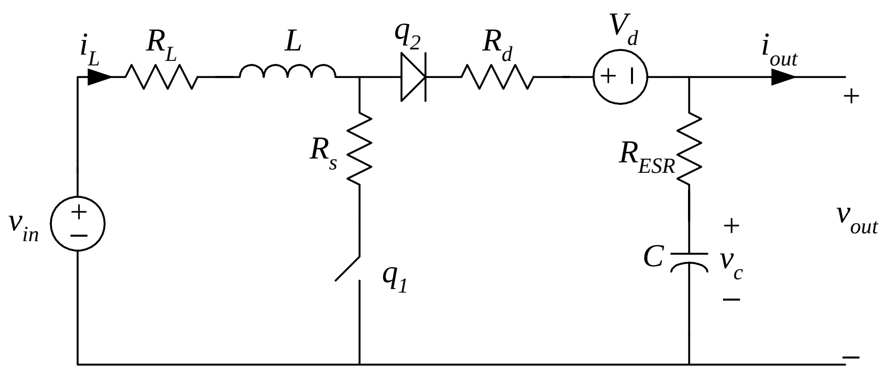
Ideal





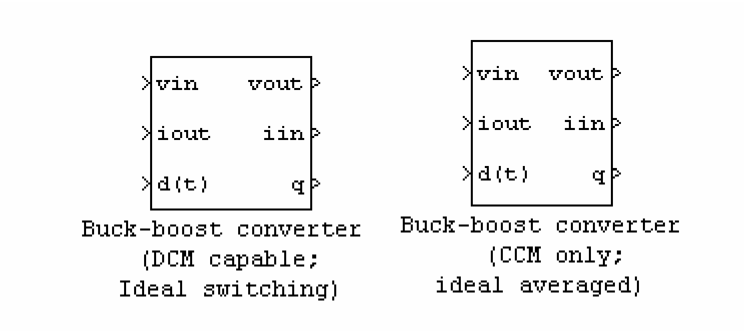
Lossy

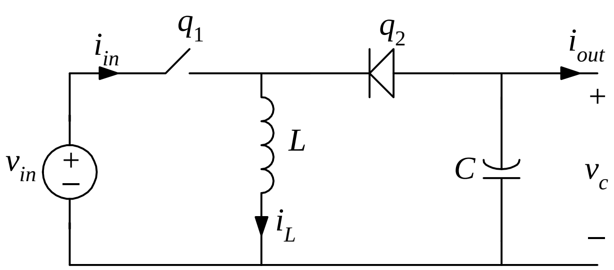




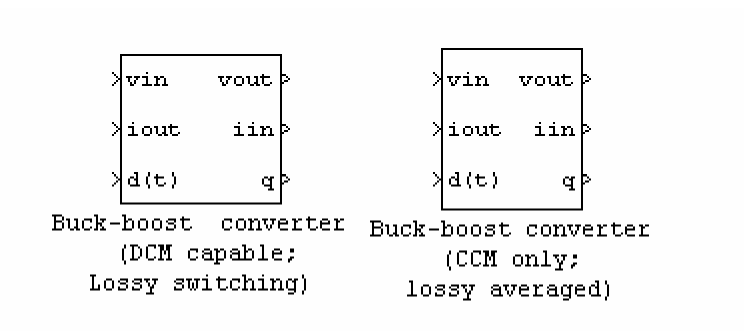
Buck-boost Converter

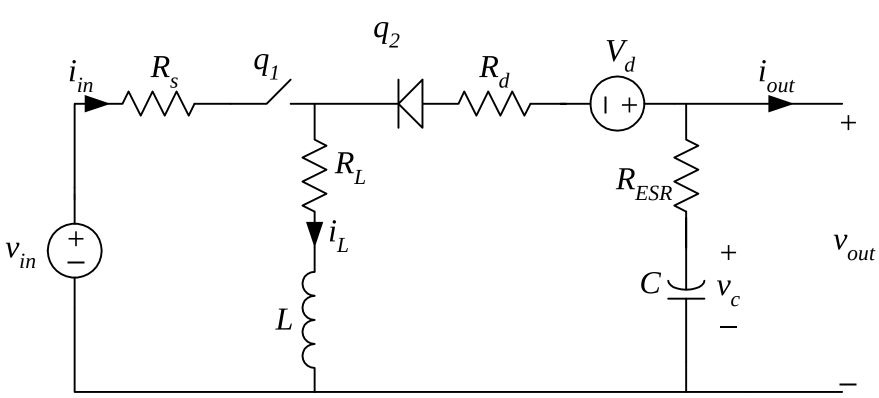
Ideal





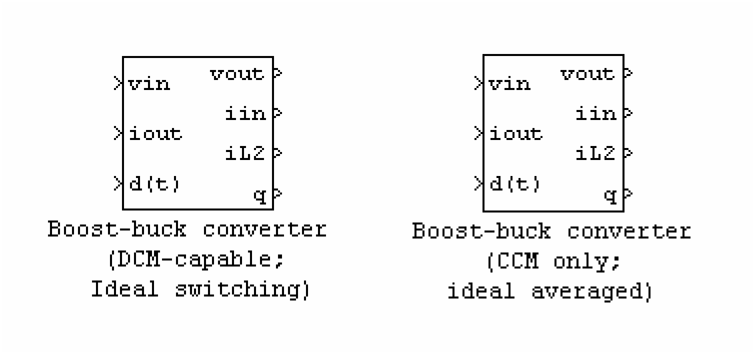
Lossy

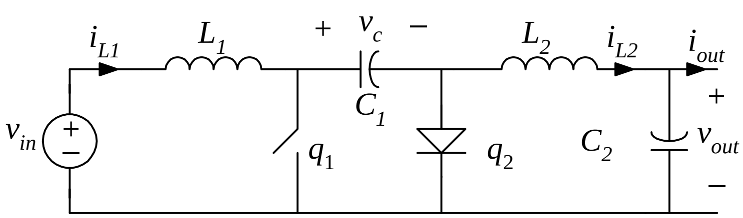




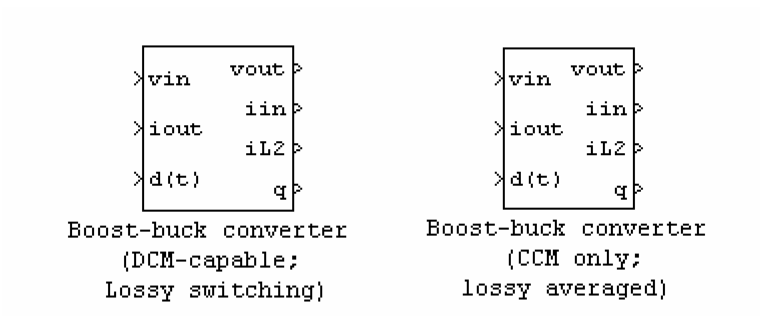
Boost-buck Converter

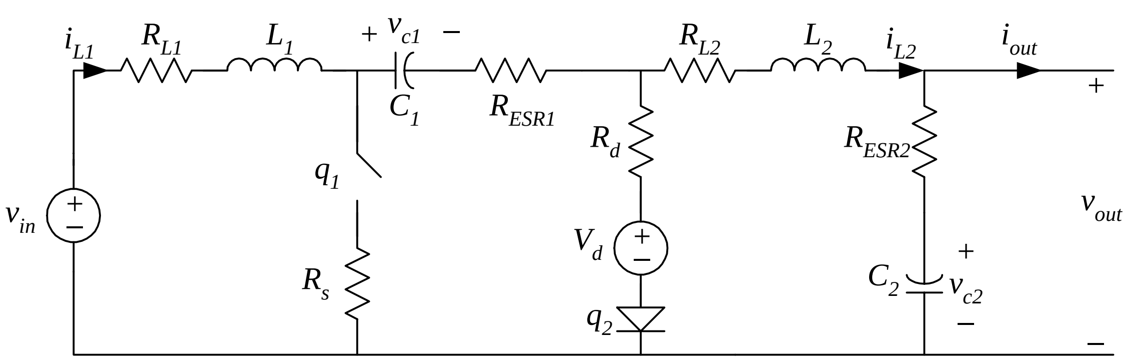
Ideal





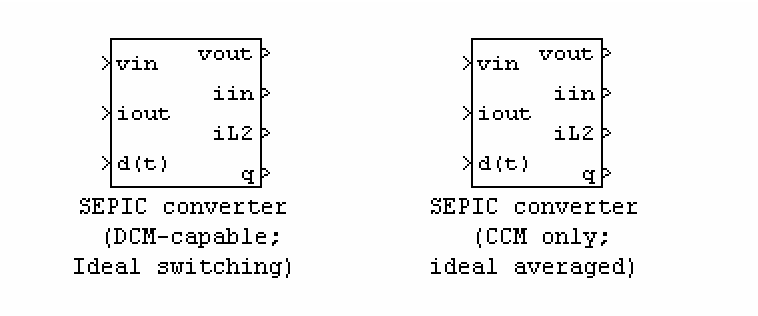
Lossy

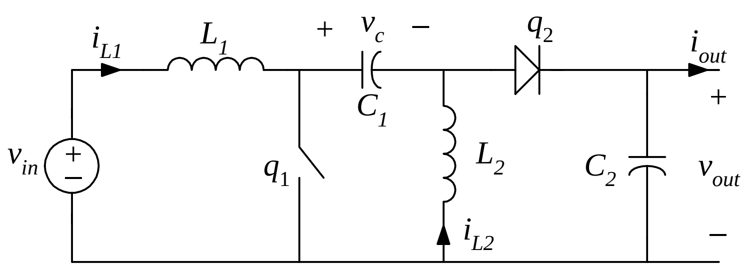




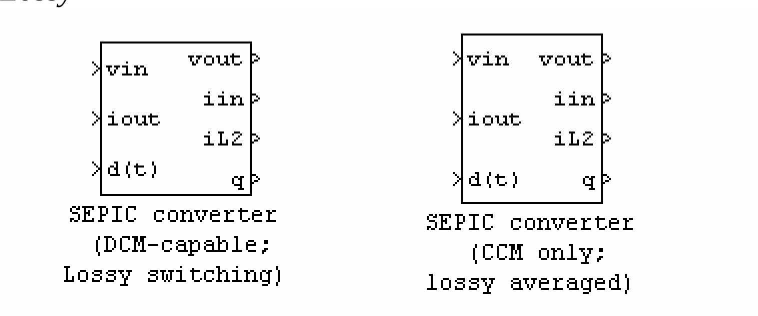
SEPIC Converter

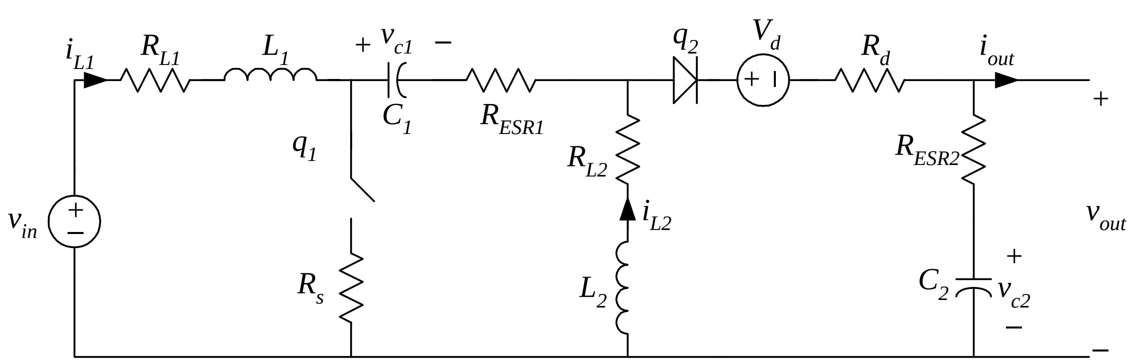
Ideal





Lossy





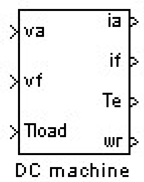
Electric Machines

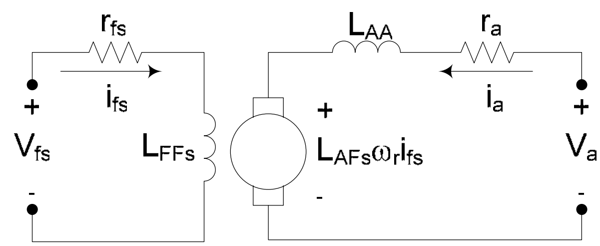
DC Machines

Dynamic Models

DC machine

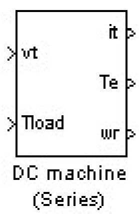
Basic dc machine block. Three-state dynamic model. Separately excited model.

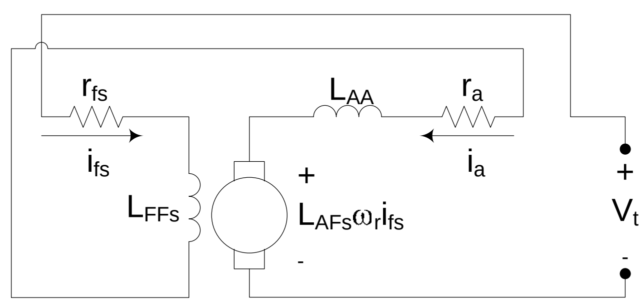




DC machine (Series)

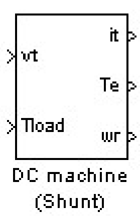
Series-field dc machine block. This block contains only two states: one for the armature current (field is in series) and the shaft speed.

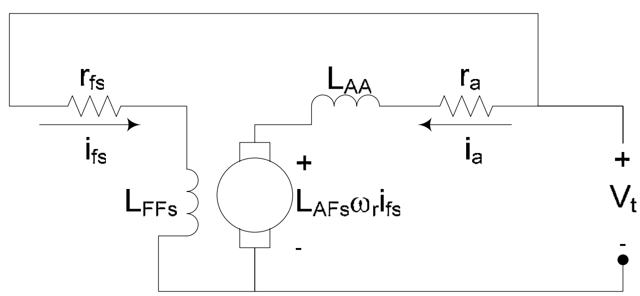




DC machine (Shunt)

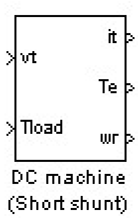
Shunt-field dc machine. This model contains three states: one for the field current, one for the armature current, and one for the shaft speed.

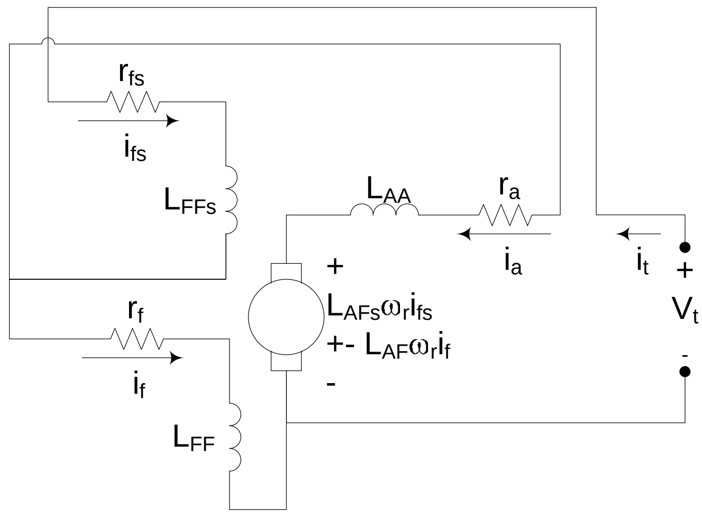




DC machine (Short shunt)

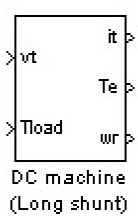
Short-shunt cumulative-compound dc machine. This model contains three states: the field current, the armature current (which is equal to the series-field current), and the shaft speed.

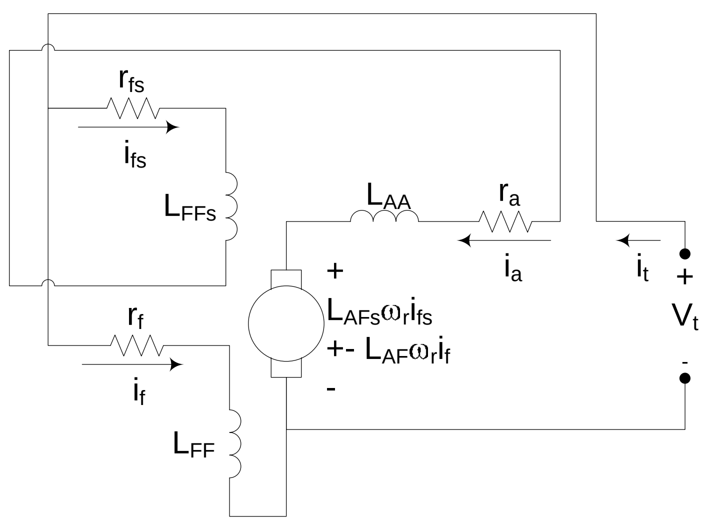




DC machine (Long shunt)

Long-shunt cumulative-compound dc machine. This model contains three states: the field current, the armature current (which is equal to the series-field current), and the shaft speed.

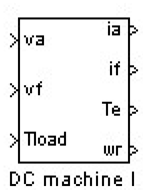


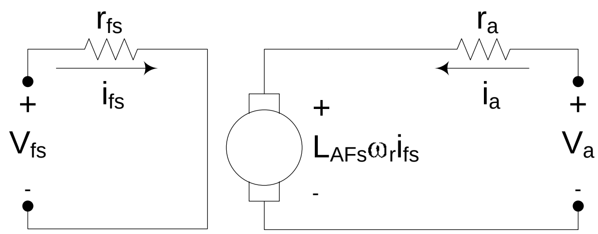


Steady State Models

DC machine

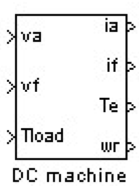
Steady-state separately-excited dc machine. Contains only one dynamic state: the shaft speed.

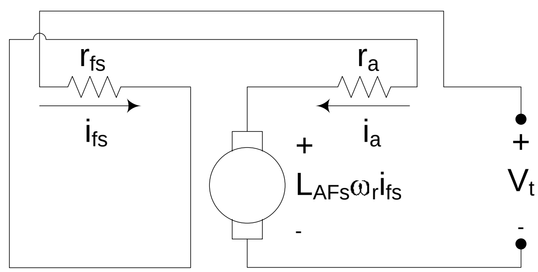




DC machine (Series)

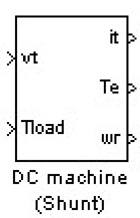
Steady-state series-field dc machine. Contains only one dynamic state: the shaft speed.

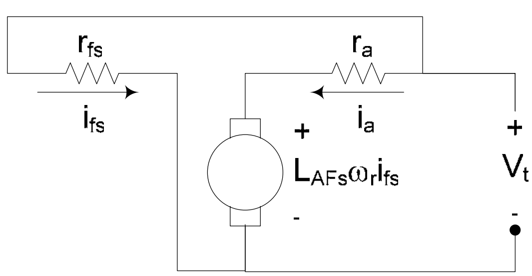




DC machine (Shunt)

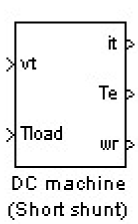
Steady-state shunt-field dc machine.. Contains only one dynamic state: the shaft speed.

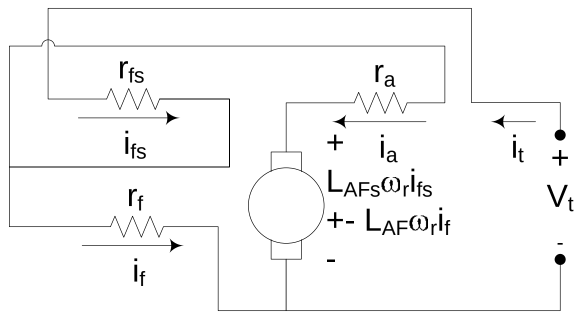




DC machine (Short shunt)

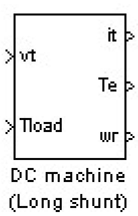
Steady-state short-shunt cumulative-compound dc machine.. Contains only one dynamic state: the shaft speed.

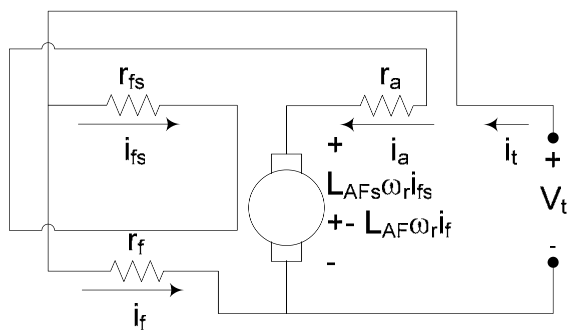




DC machine (Long shunt)

Steady-state long-shunt cumulative-compound dc machine.. Contains only one dynamic state: the shaft speed.

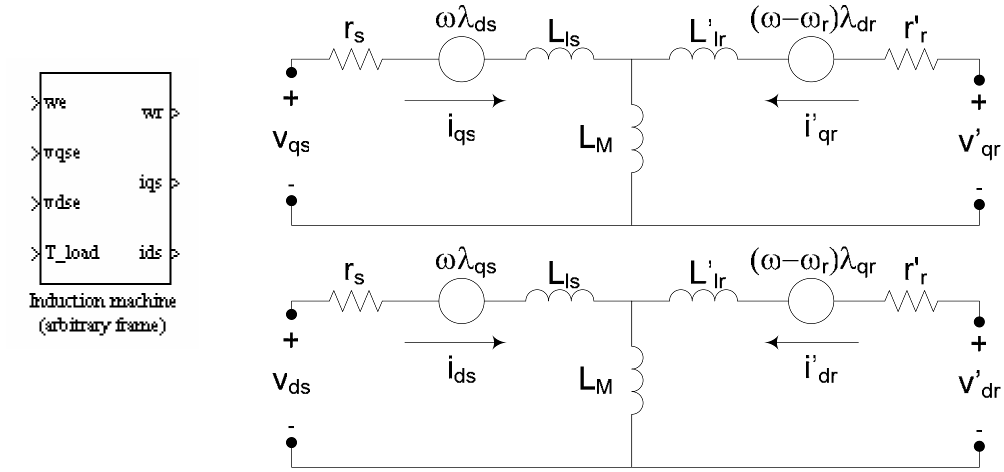




Induction Machines

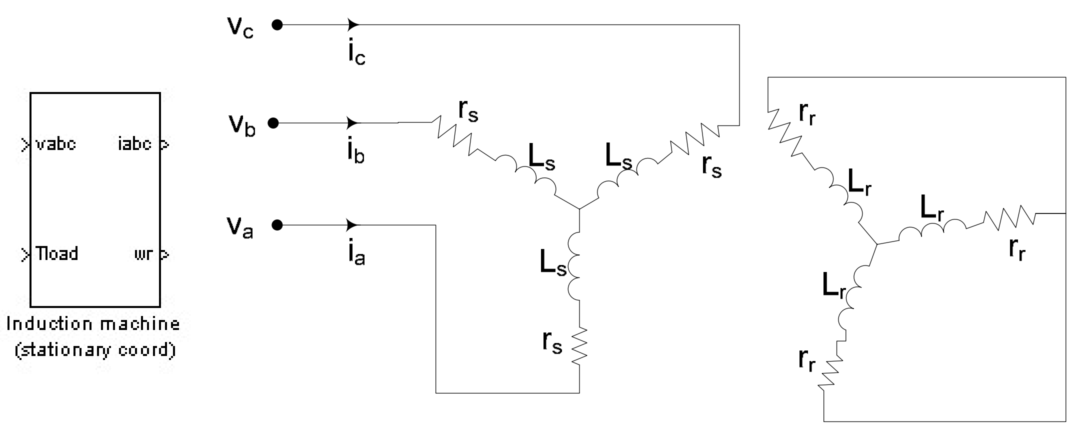
Induction machine (arbitrary frame)

Basic induction machine block. The machine is modeled in the synchronous reference frame and includes saturation.



Induction machine (stationary coord)

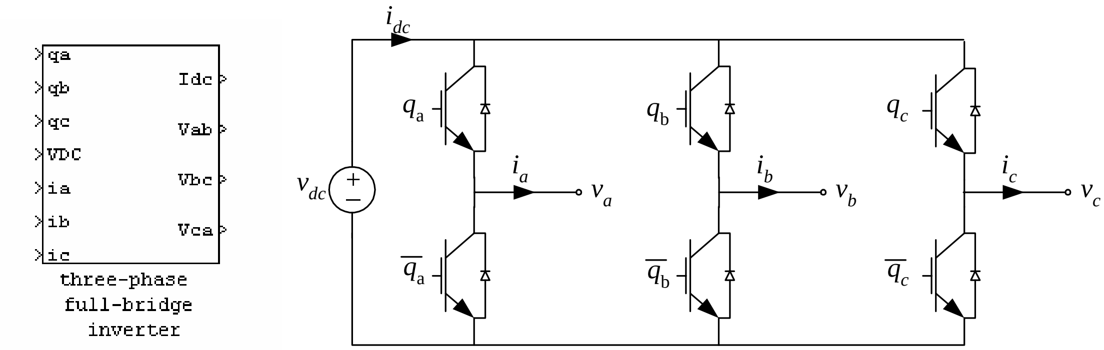
Induction machine in abc coordinates modeled in stationary reference frame. Linear magnetic model.



Inverters

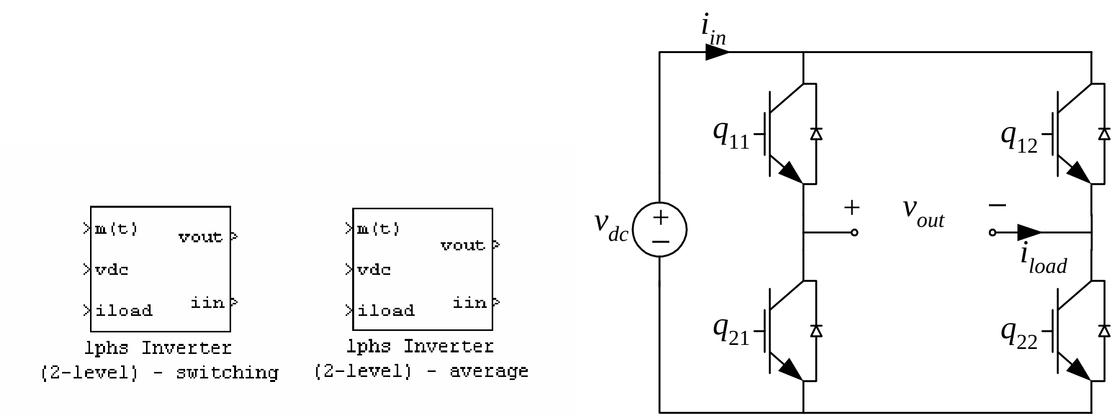
Three-phase inverter

Lossless ideal switching three-phase inverter model. Switching input functions ($q_a(t)$, $q_b(t)$, $q_c(t)$), input voltage (v_{dc}), and load currents (i_a, i_b, i_c) are simulation inputs. Line-to-line output voltages (v_{ab}, v_{bc}, v_{ca}) and input current (i_{dc}) are simulation output signals.



Single-phase inverter

Lossless switching and average single-phase inverter models. Modulating function input $m(t)$, input voltage (v_{dc}), and load current (i_{load}) are simulation inputs. Output voltage and input current are simulation output signals.

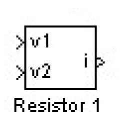


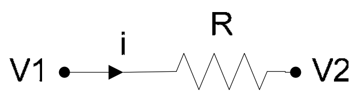
Passive Components

L,C,R

Resistor 1

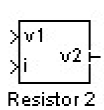
Inputs are terminal voltages, and output is current.





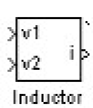
Resistor 2

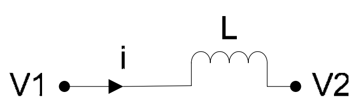
Inputs are the terminal 1 voltage and the current. The output is the terminal 2 voltage.



Inductor

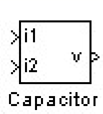
Inputs are the inductor terminal voltage, and the output is the inductor current. The initial current can be set, and current limits imposed.

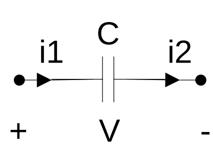




Capacitor

Inputs are the current into and out of the capacitor. The output is the capacitor voltage.

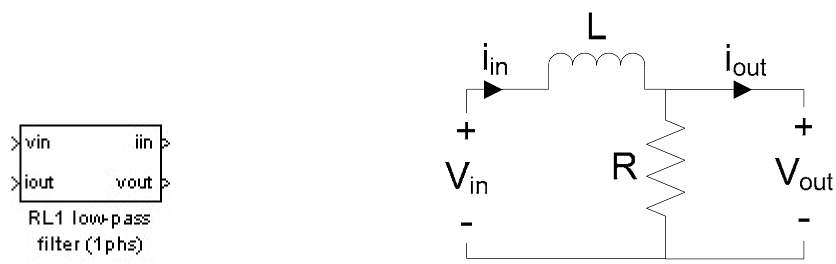




Filters

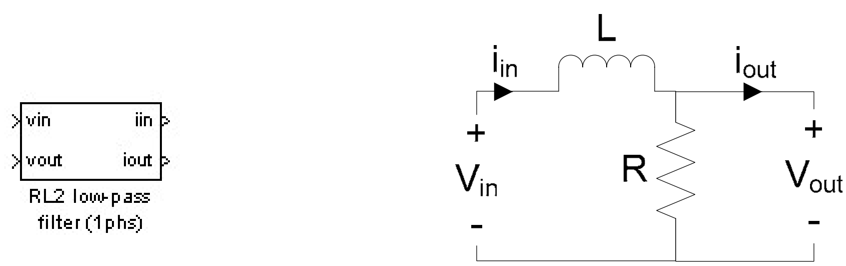
RL1 low-pass filter (1phs)

Series RL filter.



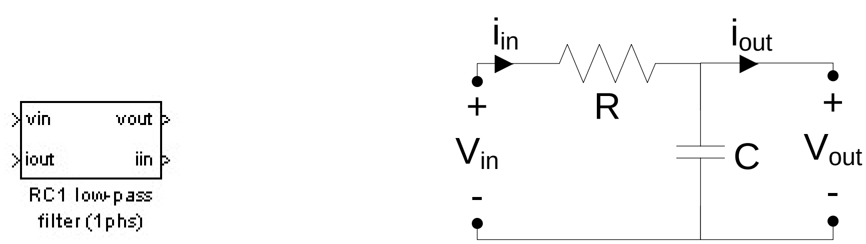
RL2 low-pass filter (1phs)

Series RL filter.



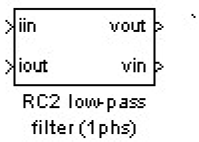
RC1 low-pass filter (1phs)

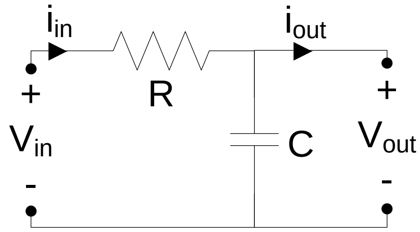
RC low-pass filter. Inputs are input voltage and output current; outputs are output voltage and input current.



RC2 low-pass filter (1phs)

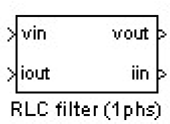
RC low-pass filter. Inputs are input voltage and output current; outputs are output voltage and input current.

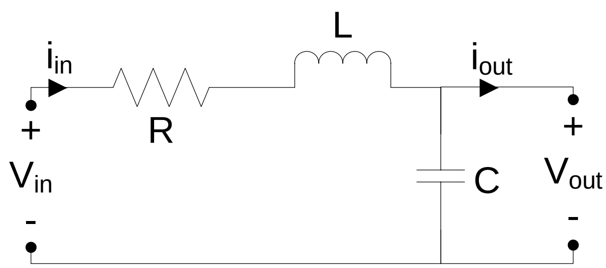




RLC filter (1phs)

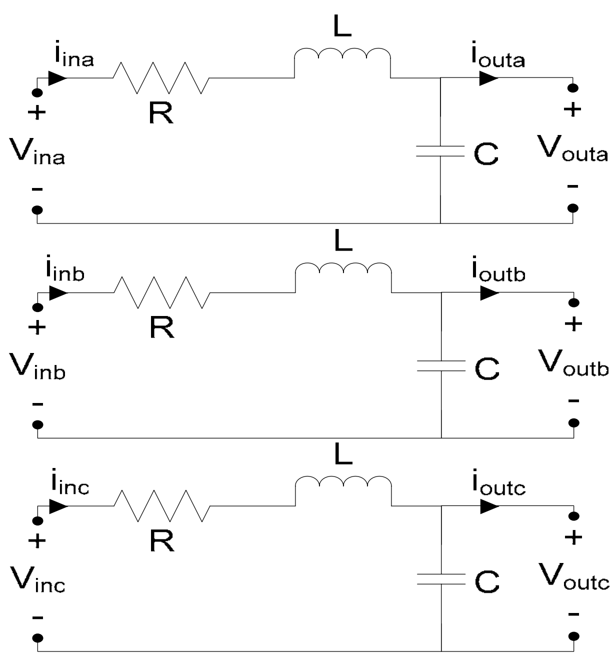
Series RL-shunt C filter.

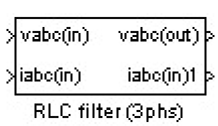




RLC filter (3phs)

Series RL-shunt C filters.





Power Factor Correction (PFC)

Single phase hysteretic PFC controller

Function: conventional hysterestic current control, where the reference current waveform is taken to be (Vin*control).

Inputs:

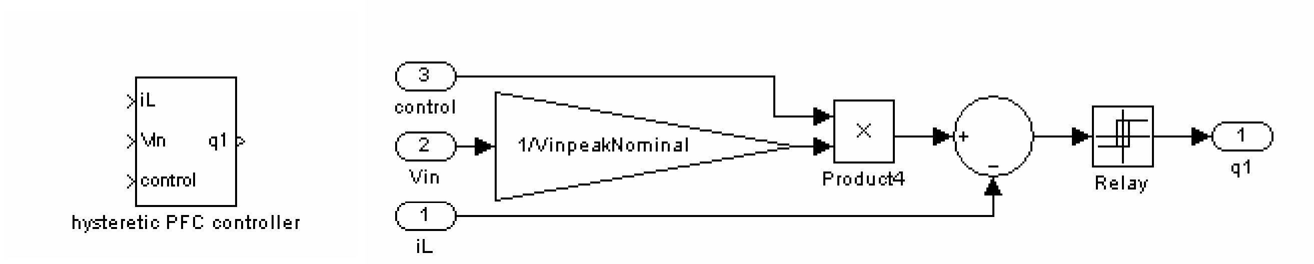
- line voltage (Vin) [V]
- input current (iL) [A]
- control input – commanded current amplitude

Output:

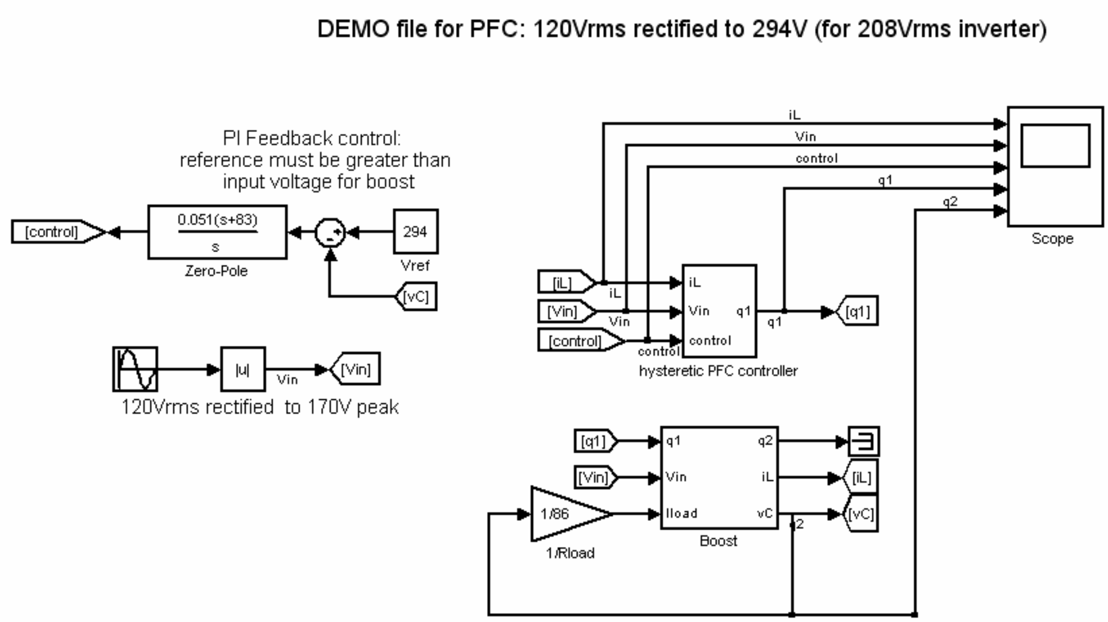
- switching function (q1)

Parameters:

- nominal peak line voltage [V] (default = 170V)
- upper limit of hysteretic current error (default = 100 e-3) [A]
- lower limit of hysteretic current error (default = -100 e-3) [A]



(See demonstration file example hysteretic_boostpfc.mdl)

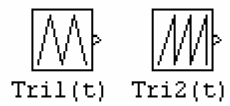


PWM components

Tri1 and Tri2

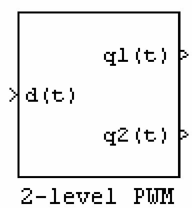
Tri1(t): Generates an equilateral triangle output at the set frequency.

Tri2(t): Generates a repeating ramp at the given frequency. Ramp generation is accomplished through the integration of the switching frequency with reset.



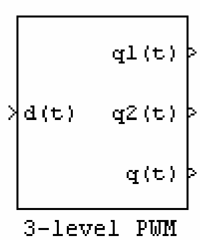
Two-level PWM

Two-level PWM block: PWM waveforms constructed by triangle comparison. Switching frequency adjustable. Duty ratio input is between 0 and 1. q1(t) and q2(t) are complementary switching function outputs that can be used for implementing two-level inverter switching (*ie*. Inverter output voltage alternates between V_{dc} and $–V_{dc}$).



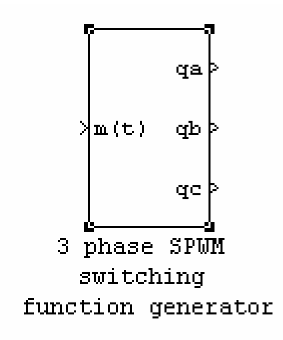
Three-level PWM

Three-level PWM generator. The input signal is between -1 and 1. q1(t) and q2(t) are switching function outputs that can be used for three-level inverter switching (*ie*. Inverter output voltage alternates between V_{dc} , 0, and $–V_{dc}$). q(t) is a output q1(t)-q2(t), which represents the normalized inverter output voltage.

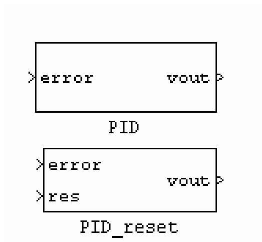


Three-phase SPWM switching function generator

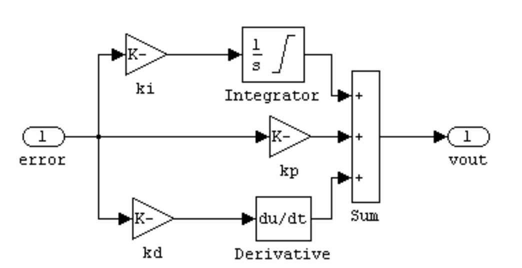
Three-phase sinusoidal PWM switching function generator. Uses a slowly time varying modulation index ($0 \le m(t) \le 1$) to generate sinusoidal PWM switching functions q_a, q_b, q_c.

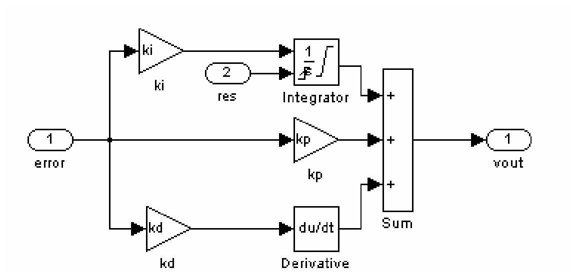


Proportional – Integral – Derivative (PID) controller



Standard PID controller with integrator initialization and limiting (for anti-windup). The *PID_reset* version has an integrator that can be dynamically reset by the additional reset line (res) that is positive-edge triggered.



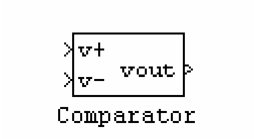


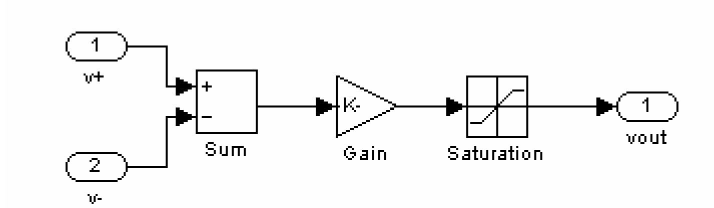
Block diagram of PID controller

Block diagram of PID controller with reset

Comparator

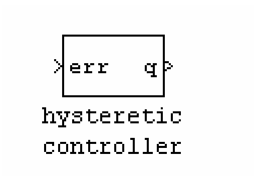
Parameters include gain (*K*) and the saturation limits of the comparator. As *K* grows large, the behavior of the comparator tends to approximate a Heaviside operator, which has a step discontinuity at $v_+ = v_-$.

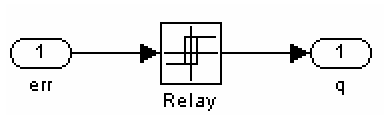


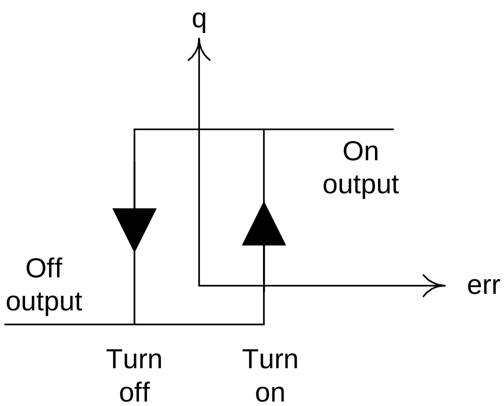


Hysteretic Controller

Parameters include turn-on and turn-off points, and the corresponding output values.



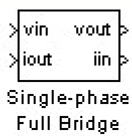


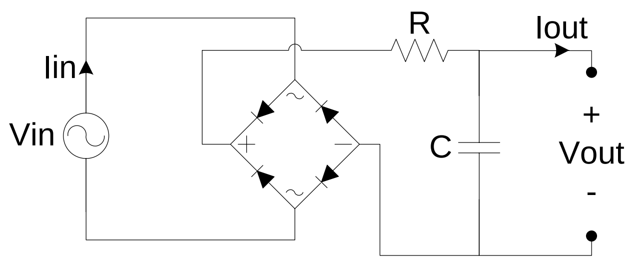


Rectifiers

Single-phase Full Bridge

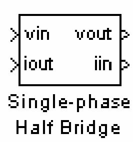
Single-phase bridge rectifier. Lead resistance is added to make simulation possible.

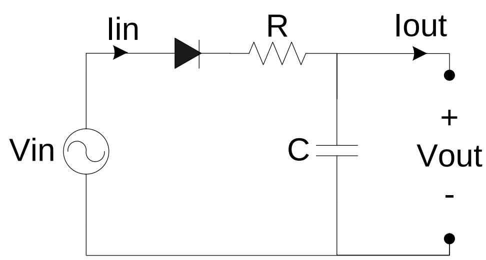




Single-phase Half Bridge

Lead resistance is added to make simulation possible.



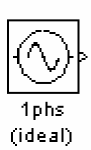


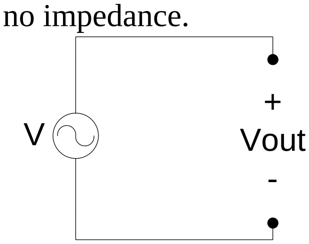
Sources

Simple Sources

1phs (ideal)

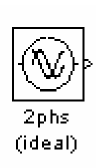
Single-phase ac source with no impedance.

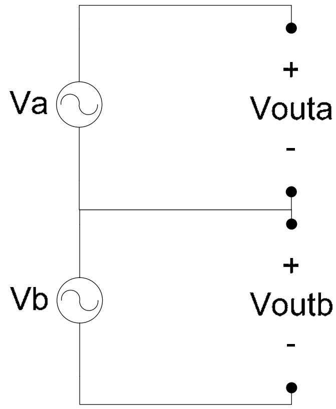




2phs (ideal)

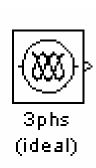
Two-phase ac source with no impedance.

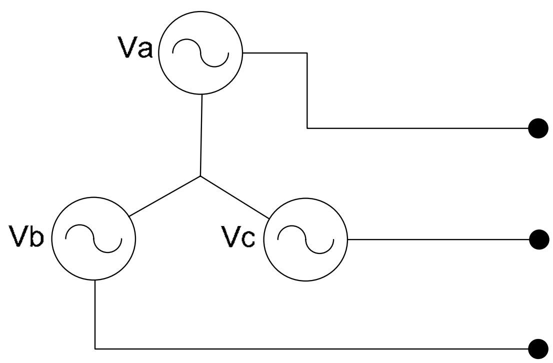




3phs (ideal)

Three-phase ac source with no impedance.

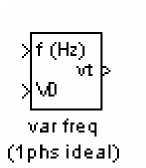


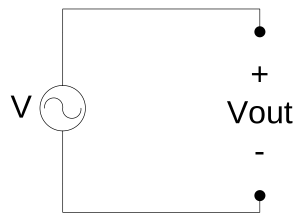


Variable Sources

var freq (1phs ideal)

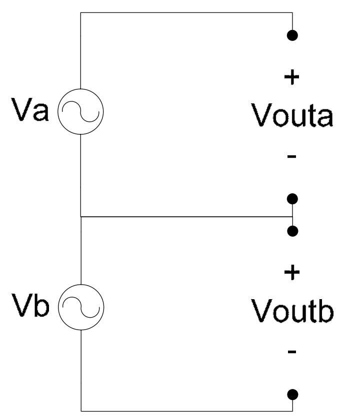
Single-phase variable frequency, variable amplitude ideal voltage source with no impedance.

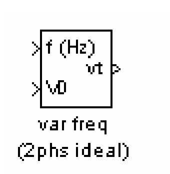




var freq (2phs ideal)

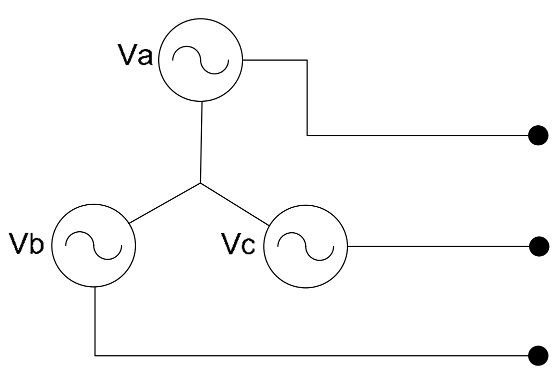
Two-phase variable frequency, variable amplitude ideal voltage source with no impedance.

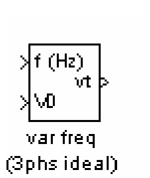




var freq (3phs ideal)

Three-phase variable frequency, variable amplitude ideal voltage source with no impedance.

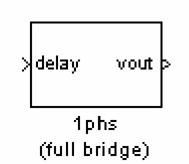


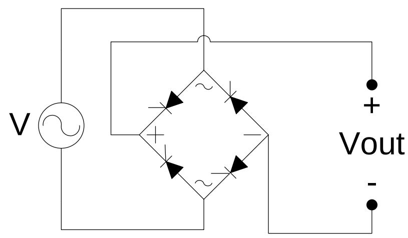


Rectified Sources

1phs (full bridge)

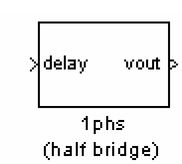
Full-bridge controlled rectifier. The frequency and amplitude of the internal source are set by double-clicking the block. The phase-delay for the rectifier is the only input. The delay cannot exceed 2pi radians. Continuous current conduction is assumed.

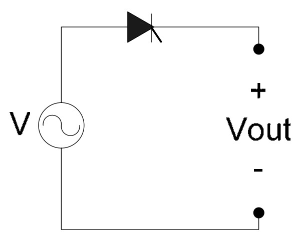




1phs (half bridge)

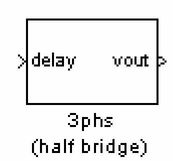
Half-bridge controlled rectifier. The frequency and amplitude of the internal source are set by double-clicking the block. The phase-delay for the rectifier is the only input. The delay cannot exceed 2pi radians. Continuous current conduction is assumed.

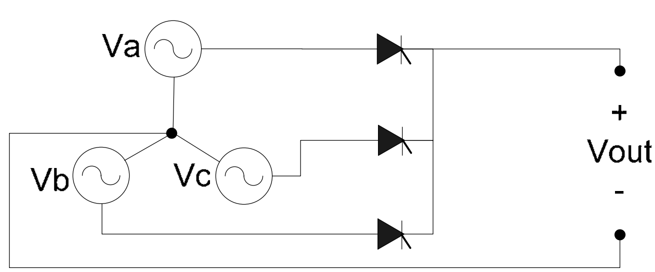




3phs (half bridge)

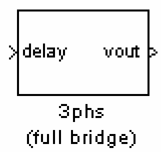
Three phase half-bridge controlled rectifier. The frequency and amplitude of the internal source are set by double-clicking the block. The phase-delay for the rectifier is the only input. The delay cannot exceed 2pi radians. Continuous current conduction is assumed.

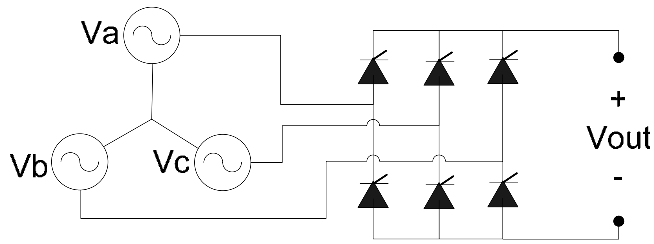




3phs (full bridge)

Three phase full-bridge controlled rectifier. The frequency and amplitude of the internal source are set by double-clicking the block. The phase-delay for the rectifier is the only input. The delay cannot exceed 2pi radians. Continuous current conduction is assumed.

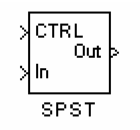


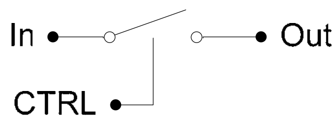


Switches

SPST

If CTRL is positive then In is passed to Out, otherwise Out is zero.





SPDT

If CTRL is positive then In 1 is passed to Out, otherwise In 2 is passed.