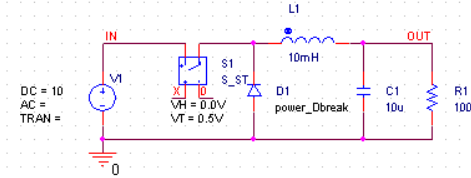


Introduction to ControlBlock Library for PSpice and LTspice Control Library

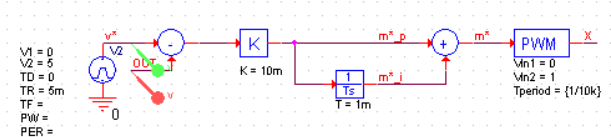
Features

- **Automatic time step adjustment** suitable for switching circuit
- Support for **discrete-time modeling** such as latch and sample & hold
- **Motor models and motor control elements** such as coordinate transformation

Circuit



Controller



ControlBlock Library for PSpice and LTspice Control Library provide a set of control elements, that allows to **design the controller of a circuit by drawing a control block diagram** and simulate the circuit and the controller on PSpice/LTspice.

The libraries make it easier to **design a complicated controller which is difficult to implement with the built-in libraries** of PSpice/LTspice. And it makes the circuit simulator more useful **for circuit designers and controller designers**.

The libraries are designed to work fast. The automatic time step adjustment suitable for switching circuit is the most distinctive feature related to the fast analysis.

The libraries have **the interface similar to each other**. LTspice Control Library can be used free. Therefore, it is possible to try what you can do using the libraries with the free circuit simulator LTspice and the free library.

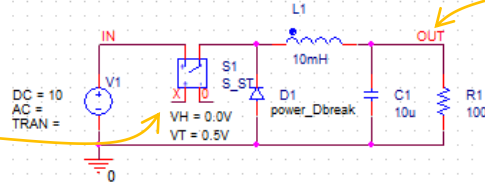
The libraries have a lot of examples which help you to get started. Some examples are shown later in this document.

Feature 1. Automatic time step adjustment suitable for switching circuit

ControlBlock Library for PSpice

Buck Converter

Circuit



Output Voltage

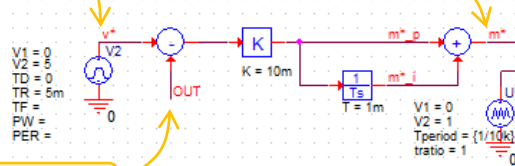
Switching Pulse

This is an example of buck converter control using ControlBlock Library for PSpice. Comparator included in the library can adjust time step automatically. Therefore, it gives the accurate analysis result of the switching circuit faster without the setting of maximum step size.

Reference Voltage

Controller

Modulation Ratio



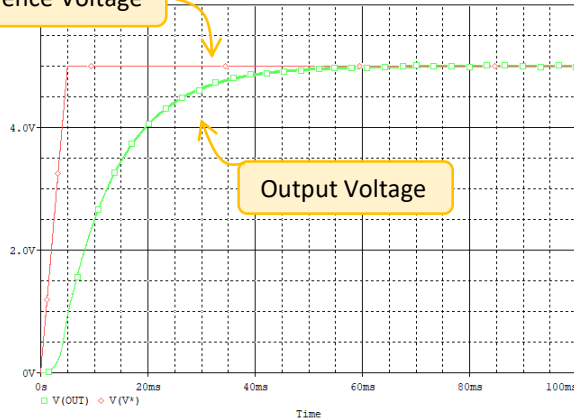
Comparator included in ControlBlock Library for PSpice **can adjust time step automatically**

Switching Pulse

Saw-tooth PWM Carrier

Output Voltage

Reference Voltage



Output Voltage

Maximum step size: **null**
 Analysis result: **accurate**
 Analysis elapsed time: **8s**

Feature 1. Automatic time step adjustment suitable for switching circuit

Built-in library of PSpice

Buck Converter

Circuit

Output Voltage

Switching Pulse

Reference Voltage

Modulation Ratio

Controller

Comparator using built-in library (ABM) can NOT adjust time step

Switching Pulse

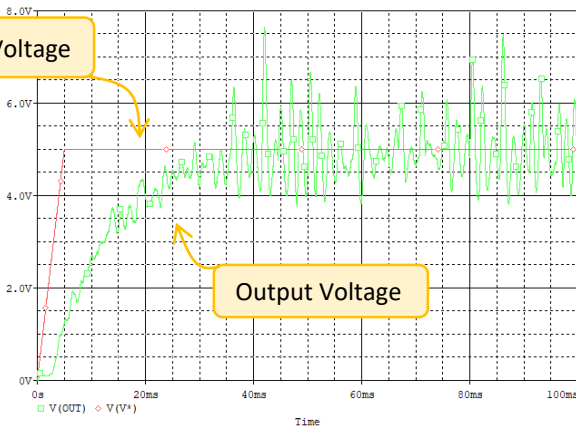
Output Voltage

Saw-tooth PWM Carrier

Reference Voltage

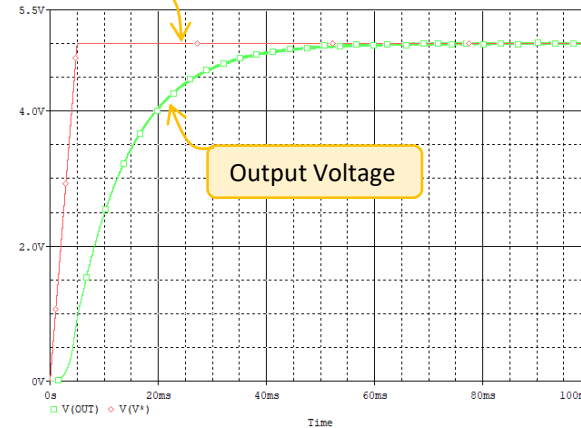
Reference Voltage

Output Voltage



Maximum step size: **null**
 Analysis result: **inaccurate**
 Analysis elapsed time: **2s**

This is an example of buck converter control using the built-in library of PSpice. Comparator using the library can NOT adjust time step. It is required an appropriate maximum step size for each switching circuit in simulation settings. When maximum step size is not specified or too big, it gives an inaccurate analysis result because of the pulse width variation and missing some pulse. Smaller maximum step size brings more accurate result but longer analysis time.



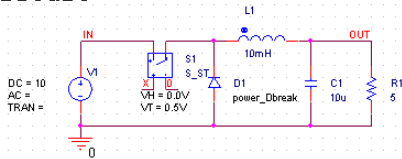
Maximum step size: **0.1us**
 Analysis result: **accurate**
 Analysis elapsed time: **29s**

Feature 2. Support for discrete-time modeling

PSpice

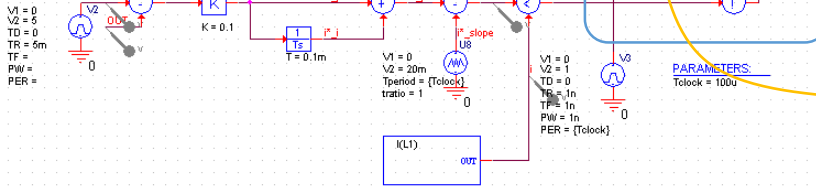
Buck Converter

Circuit



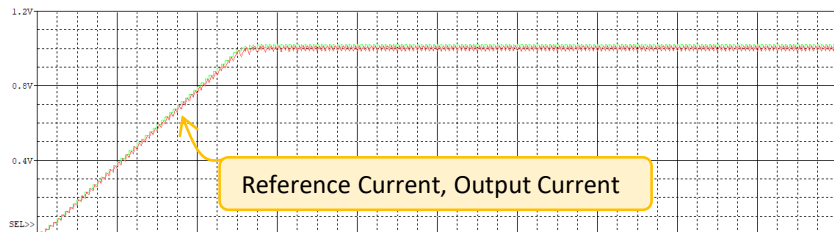
Current Mode Control

Controller



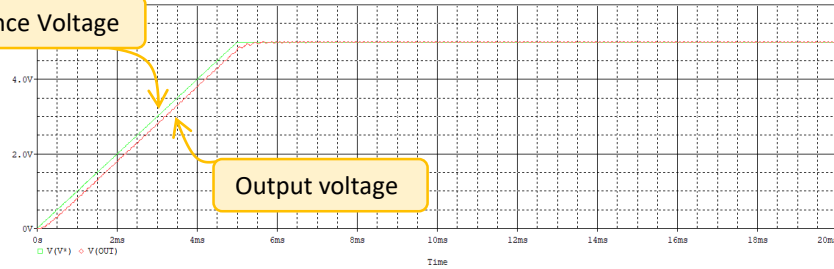
SR Flip-Flop implemented with Previous element

Previous element included in ControlBlock Library for PSpice outputs the value before 1 time step. This is the primitive element of discrete-time modeling.



Reference Current, Output Current

Reference Voltage



Output voltage

The libraries support discrete-time modeling such as latch and sample & hold. Previous element included in Discrete group of the library is the primitive element of discrete-time modeling. this element outputs the value before 1 time step. It allows to design a complex discrete-time modeling by combining Previous element with others.

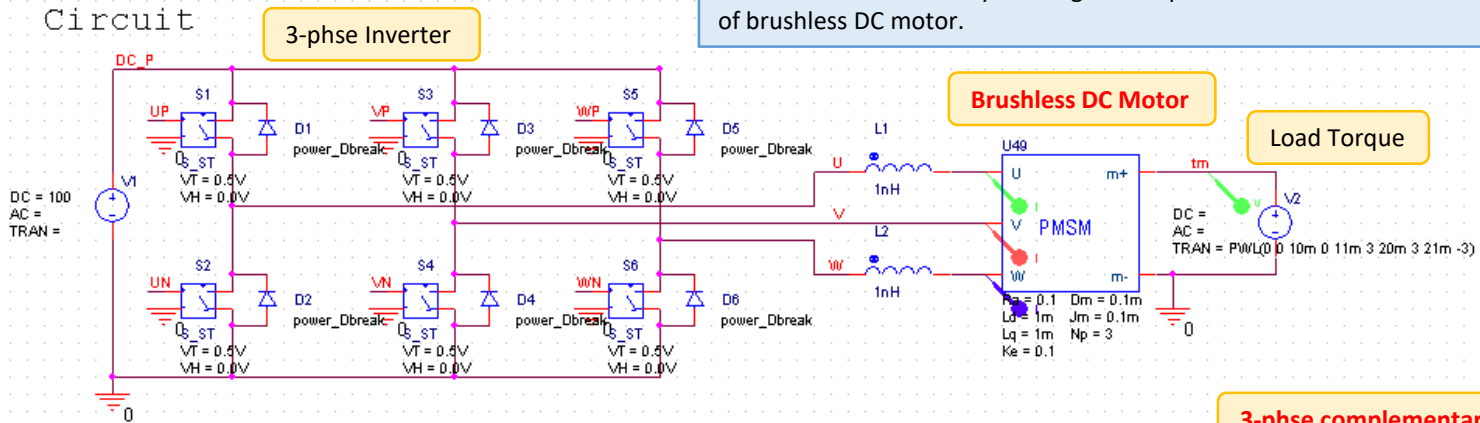
This is an example of buck converter using peak current mode control which has SR Flip-Flop implemented with Previous element.

PSpice has built-in digital elements (U elements), and SR Flip-Flop is provided as the one of U elements. U elements are analyzed as a digital signal system different from analog elements. If U elements are used correctly, it is possible to simulate fast. But the usability of U elements is unusual for users familiar with analog elements.

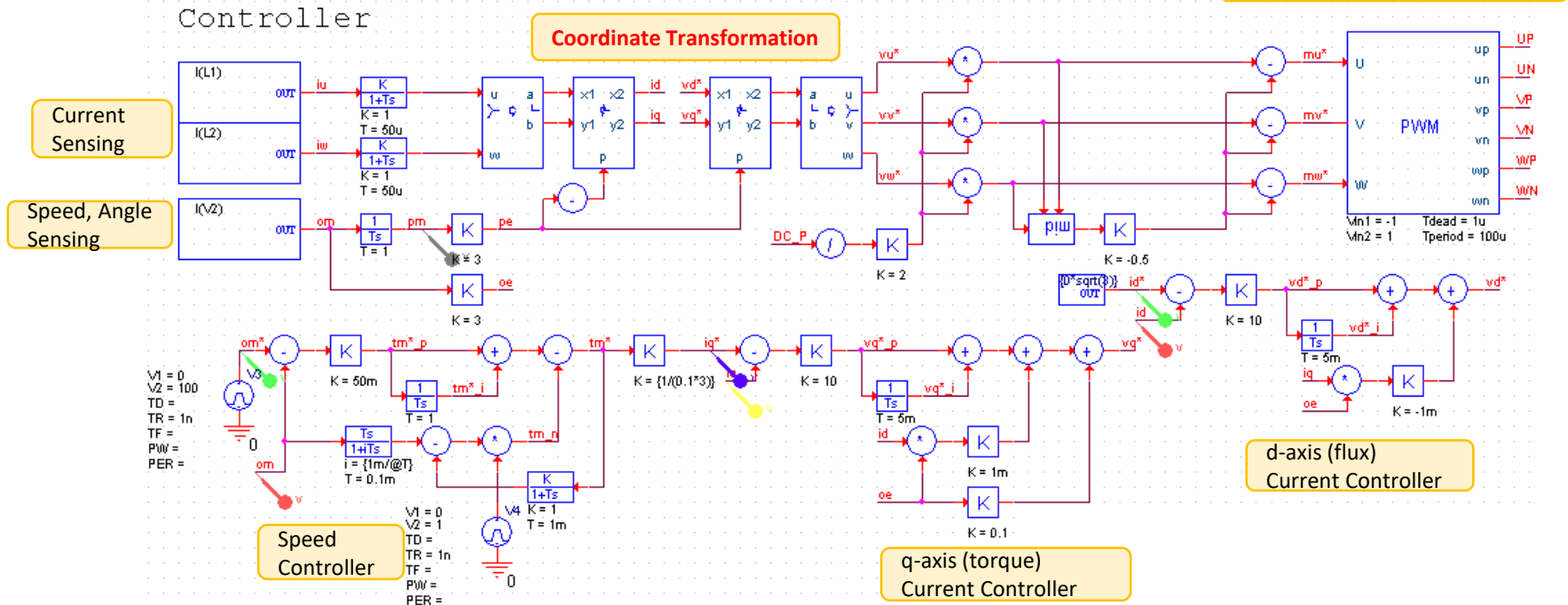
Feature 3. Motor models and motor control elements

The libraries make it easy to design a complicated controller such as vector control of brushless DC motor.

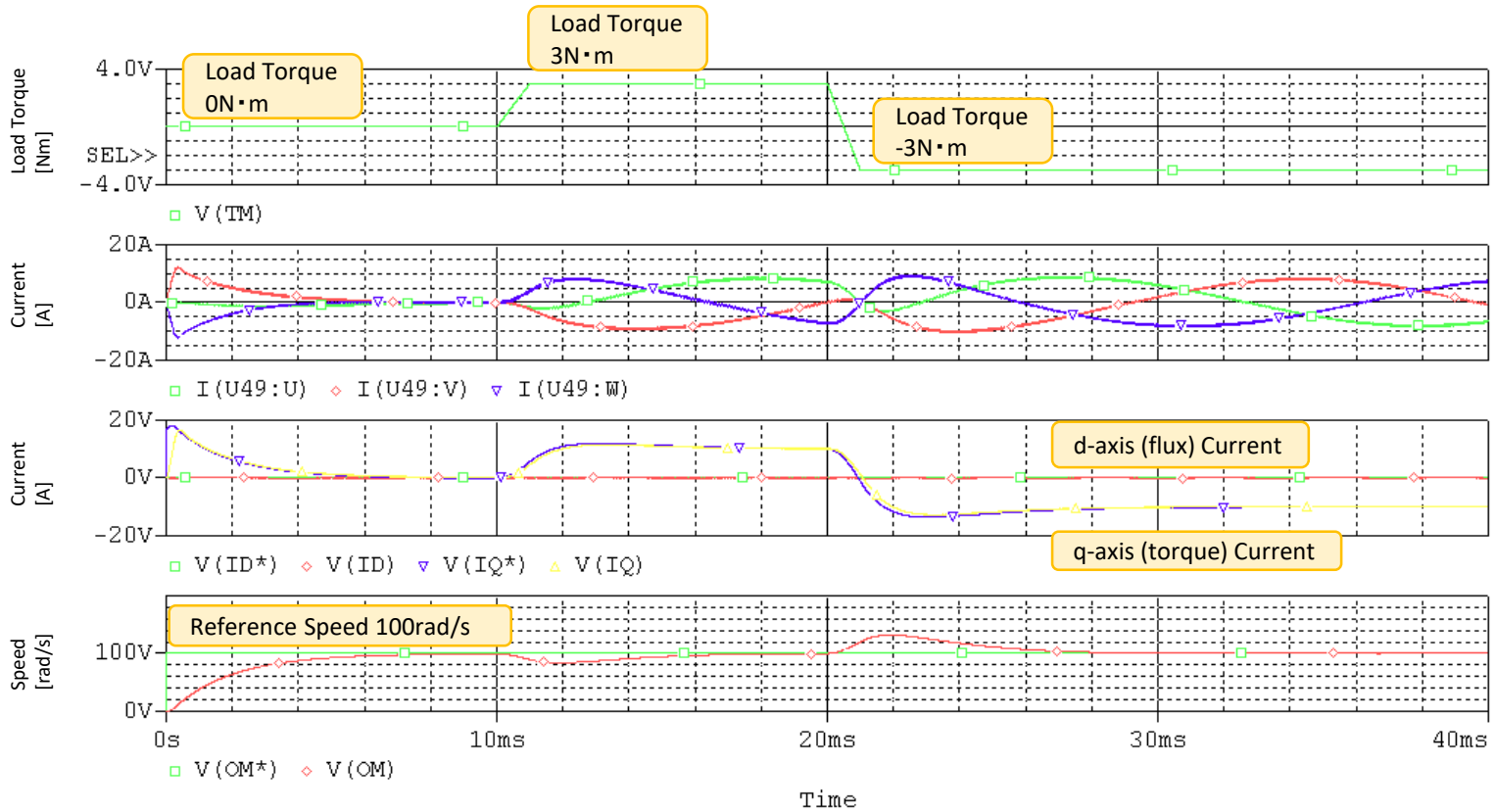
Circuit



Controller



Feature 3. Motor models and motor control elements



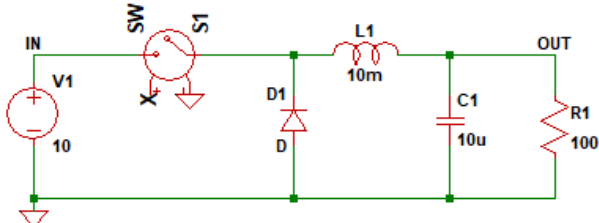
Examples

1. Buck Converter Control (DC-DCConverter/BuckConverter)
2. Boost Converter Control (DC-DCConverter/BoostConverter)
3. CCM PFC Control (AC-DCConverter/CCM-PFC)
4. CRM PFC Control (AC-DCConverter/CRM-PFC)
5. 3-Phase Inverter Control (DC-ACConverter/3PhaseInverter)
6. DC Motor Speed Control (MotorDrive/DCMotorSpeedControl)
7. Brushless DC Motor Vector Control (MotorDrive/PMSMVectorControl)
8. Brushless DC Motor 120 Degree Drive With Hall Sensors (MotorDirve/PMSM120DegreeDriveWithHallSensors)
9. Solar Cell MPPT Using Perturb & Observe Method (SolarCell/SolarCellMPPTUsingP&OMethod_Boost)

Example 1. Buck Converter Control

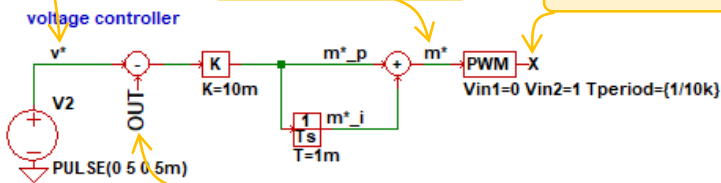
LTspice

Circuit



Reference Voltage

Controller

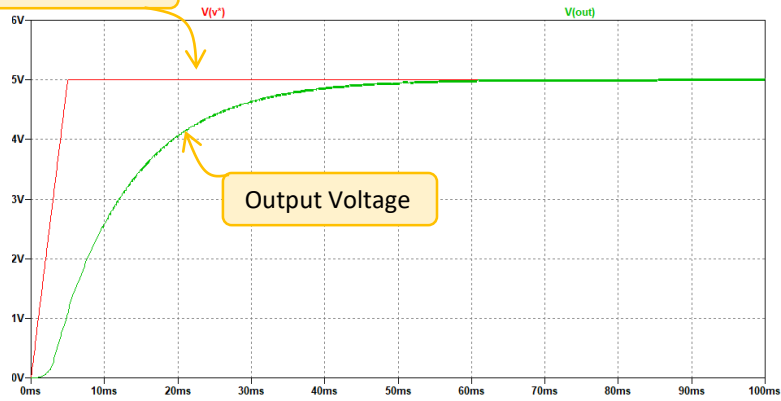


Modulation Ratio

Switching Pulse

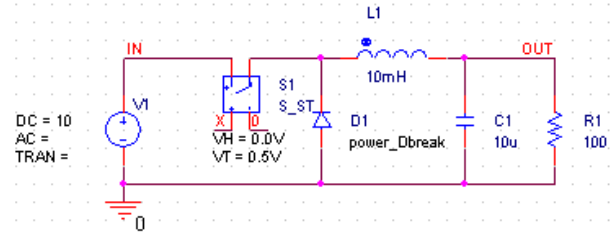
Output Voltage

Reference Voltage

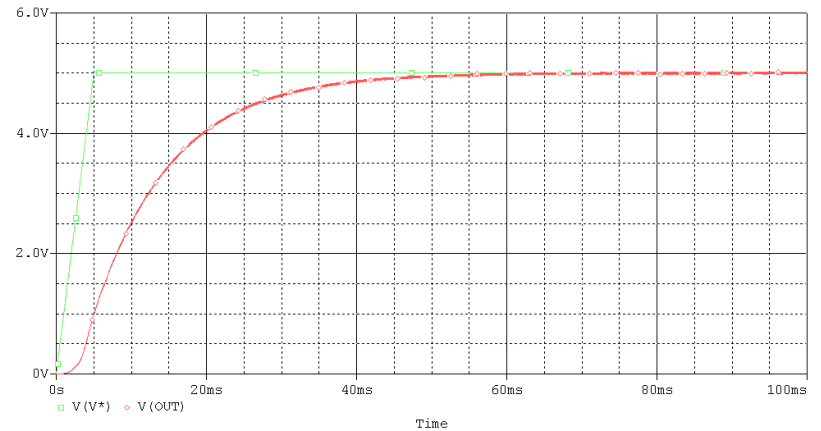
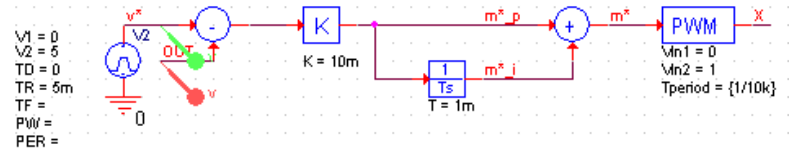


PSpice

Circuit



Controller

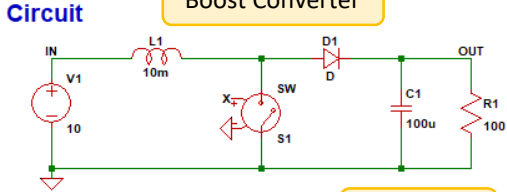


Example 2. Boost Converter Control

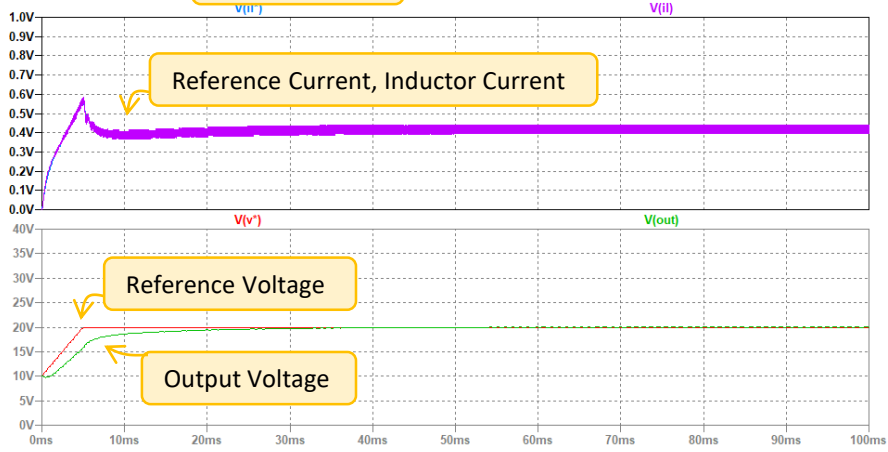
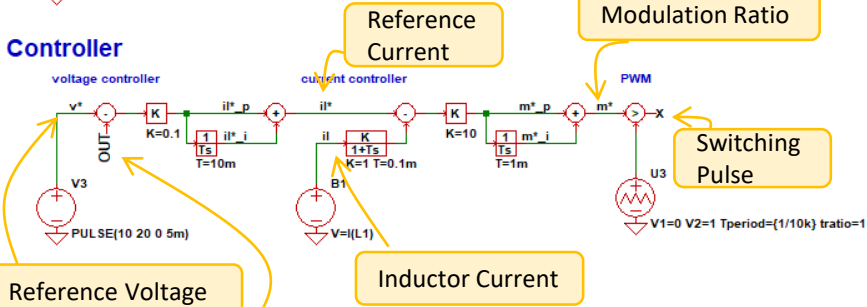
This is an example of boost converter which steps up voltage from 10V input to 20V output.

LTSpice

Boost Converter

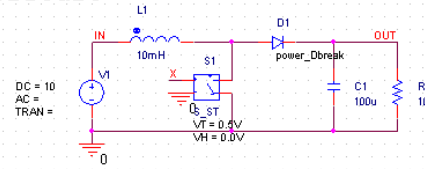


Controller

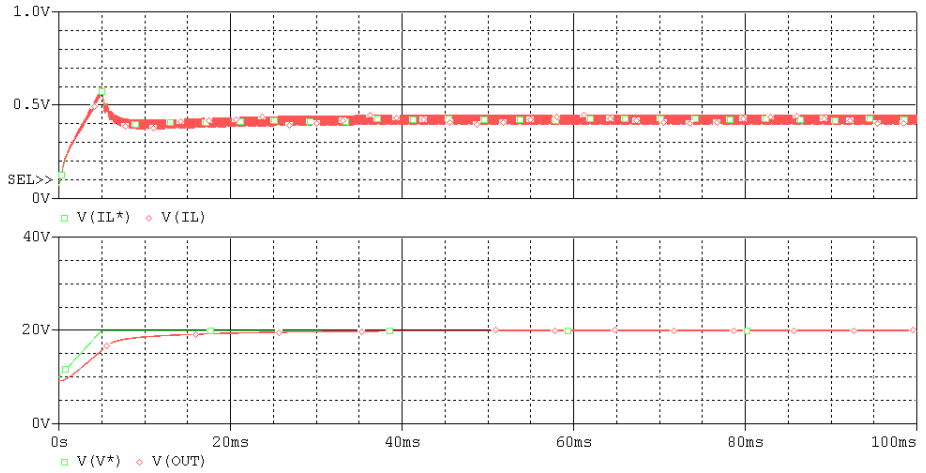
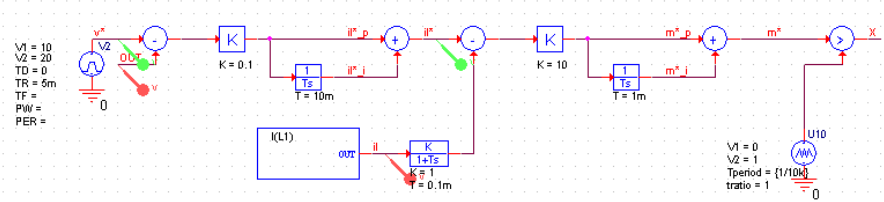


PSpice

Circuit

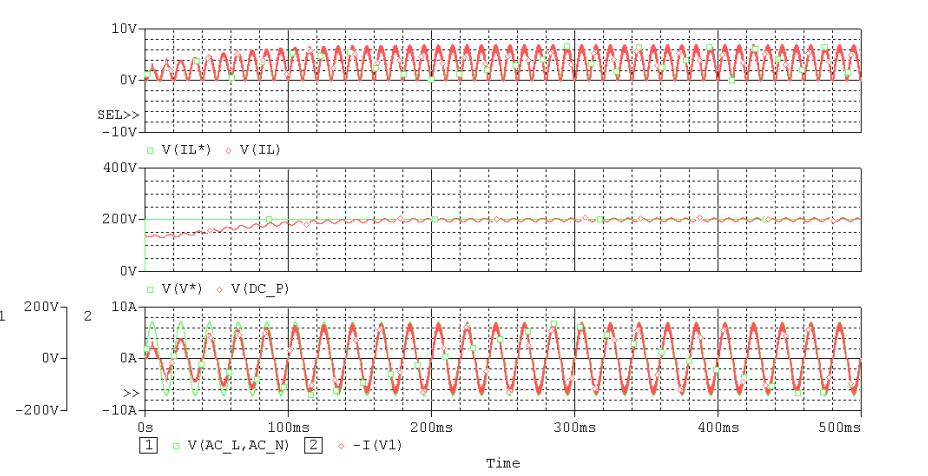
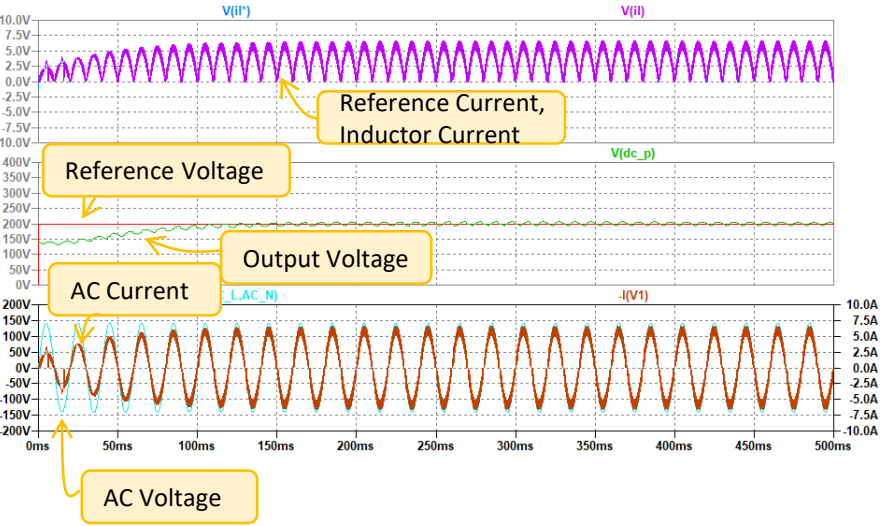
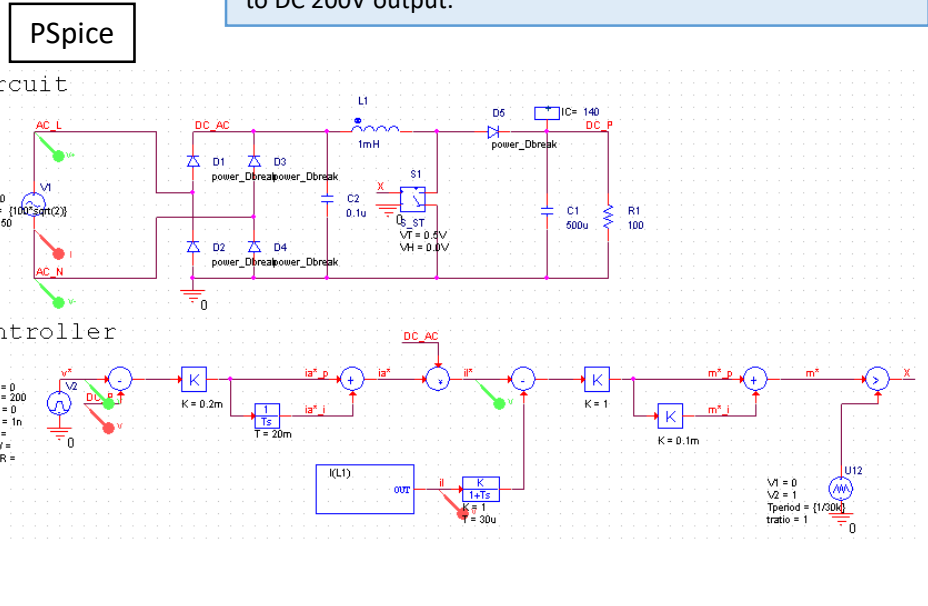
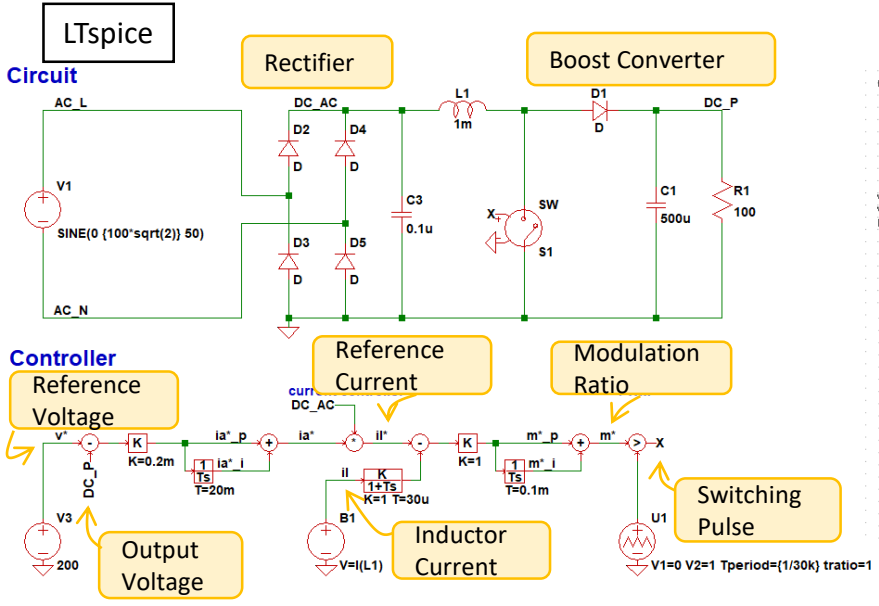


Controller



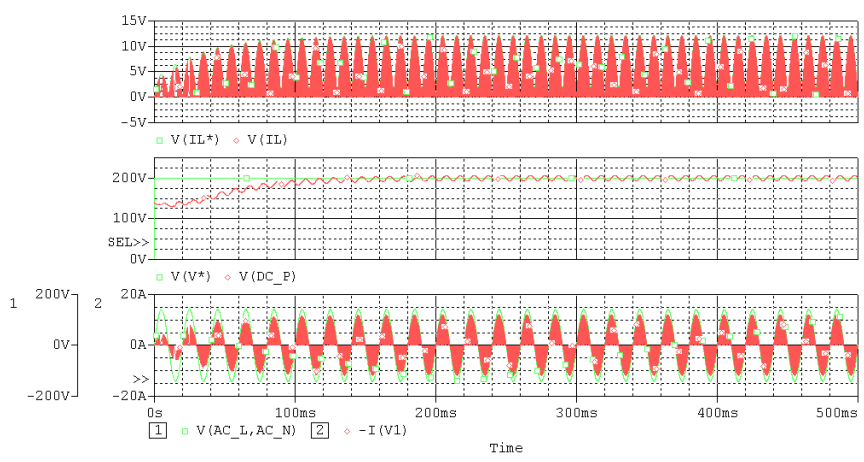
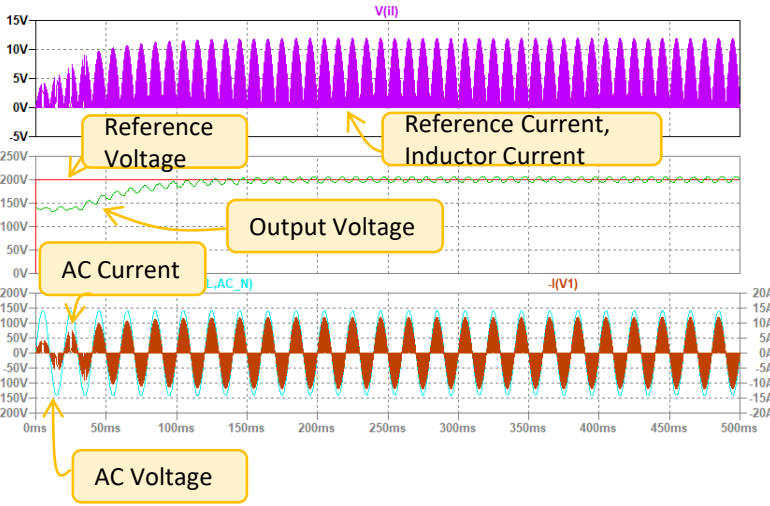
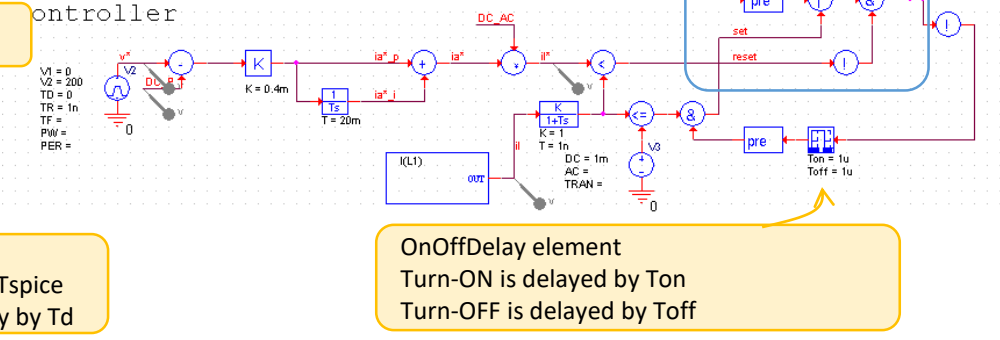
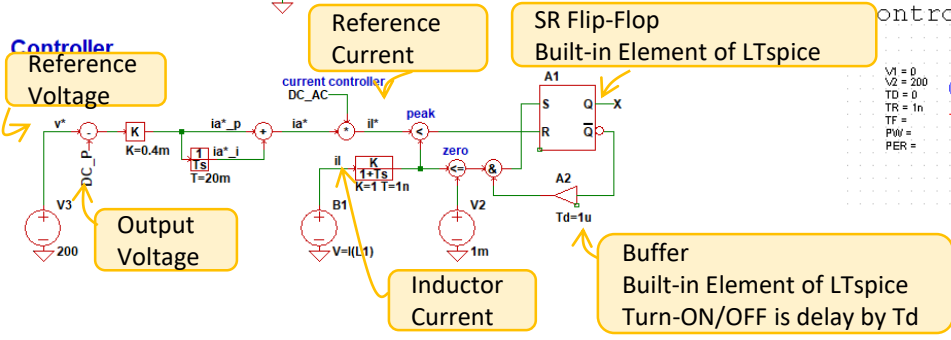
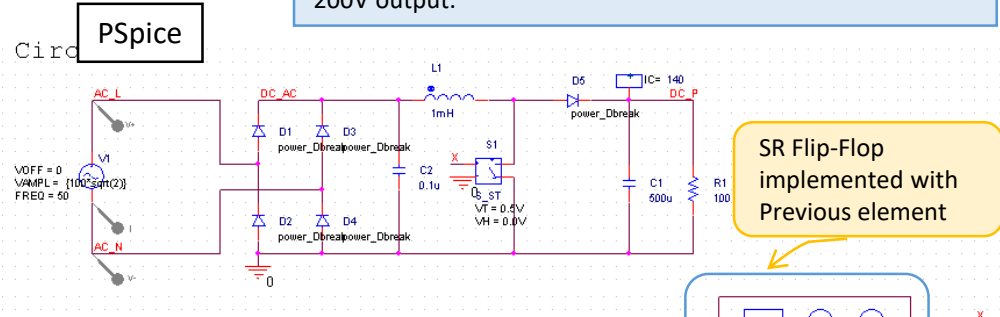
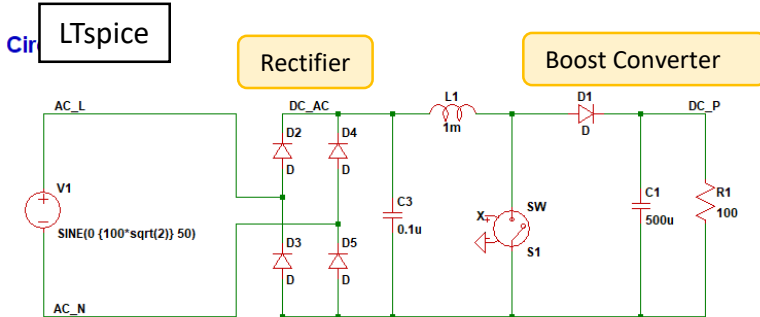
Example 3. CCM PFC Control

This is an example of Continuous Conduction Mode Power Factor Correction which controls voltage from AC 100V input to DC 200V output.



Example 4. CRM PFC Control

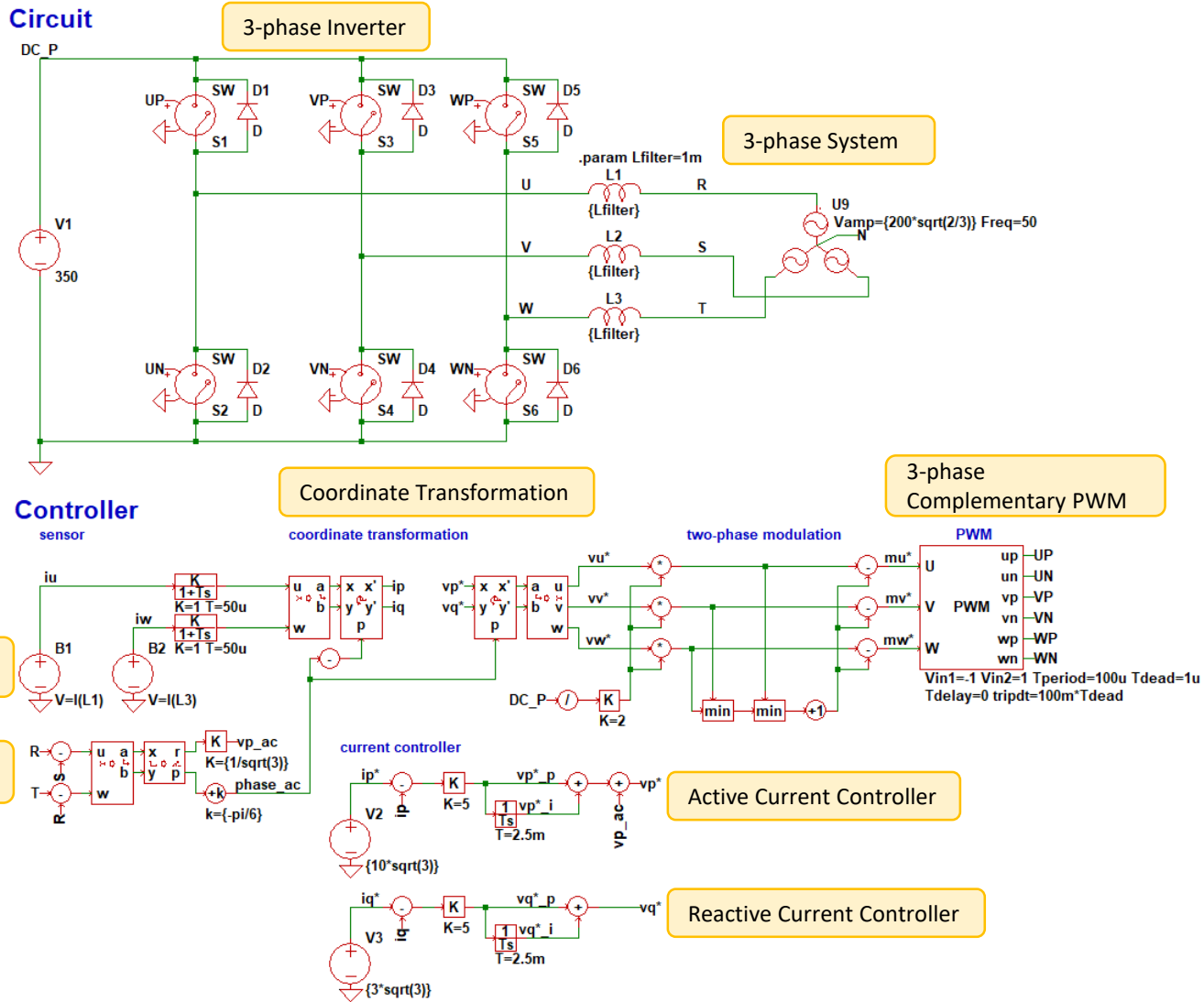
This is an example of Critical Conduction Mode Power Factor Correction which controls voltage from AC 100V input to DC 200V output.



Example 5. 3-Phase Inverter Control

This is an example of 3-phase inverter which controls active current to $10\sqrt{3}$ A and reactive current to $3\sqrt{3}$ A.

LTspice

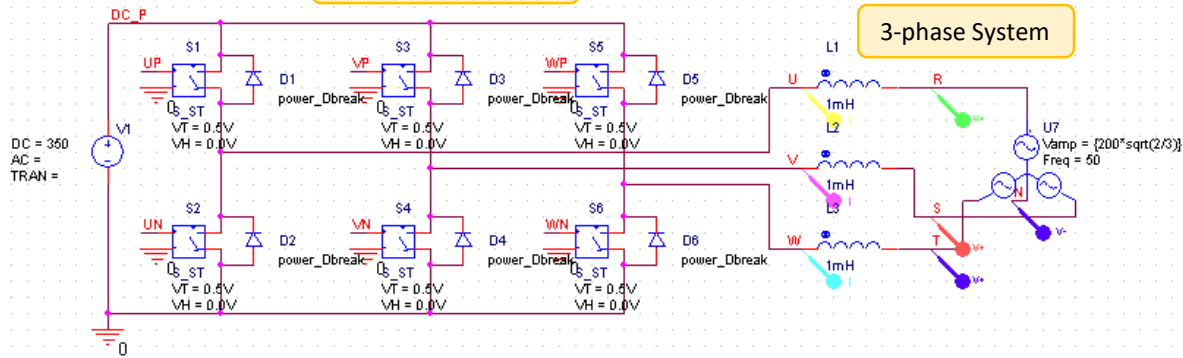


Example 5. 3-Phase Inverter Control

This is an example of 3-phase inverter which controls active current to $10\sqrt{3}$ A and reactive current to $3\sqrt{3}$ A.

PSpice

Circuit

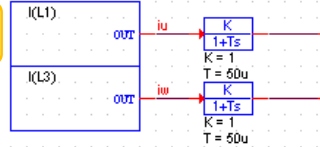


Controller

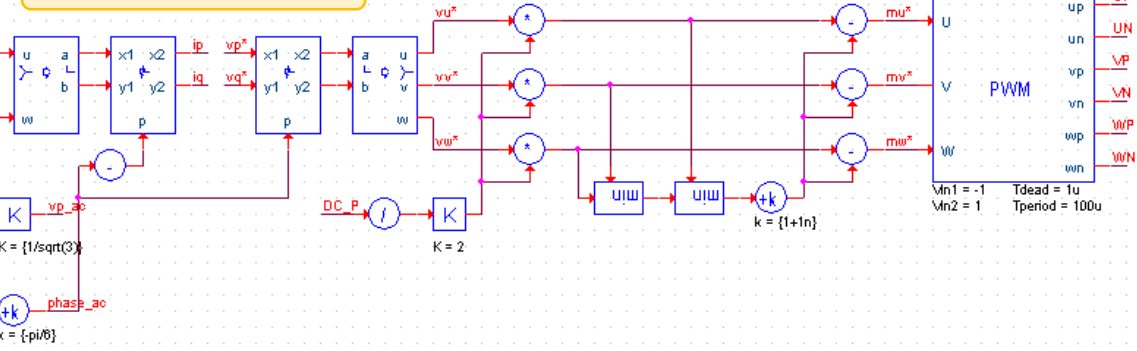
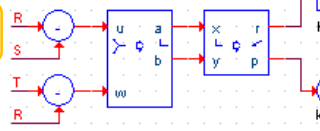
Coordinate Transformation

3-phase Complementary PWM

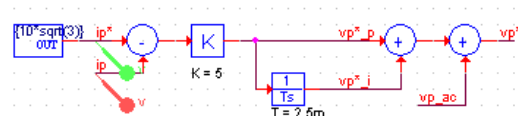
Output Current Sensing



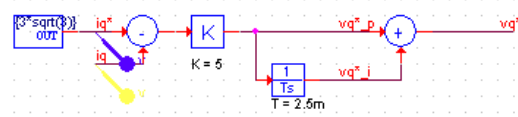
System Voltage Sensing



Active Current Controller



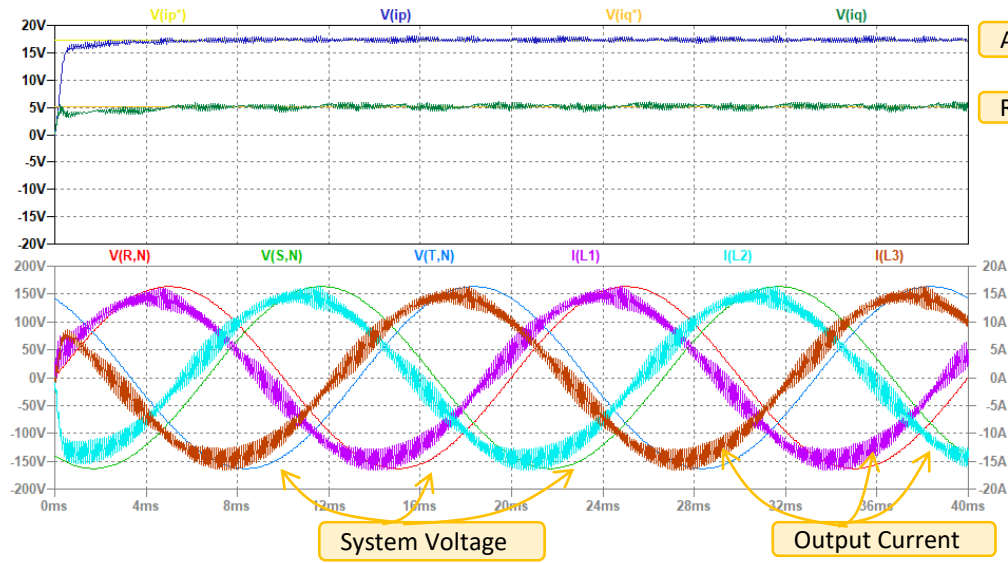
Reactive Current Controller



Example 5. 3-Phase Inverter Control

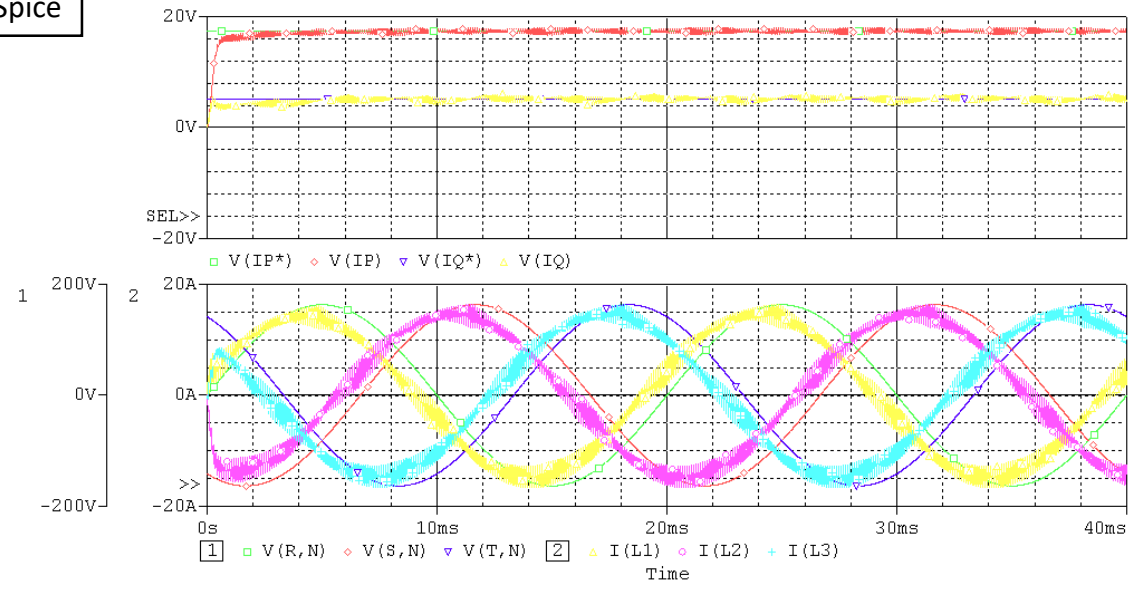
This is an example of 3-phase inverter which controls active current to $10\sqrt{3}$ A and reactive current to $3\sqrt{3}$ A.

LTspice



Active Current
Reactive Current

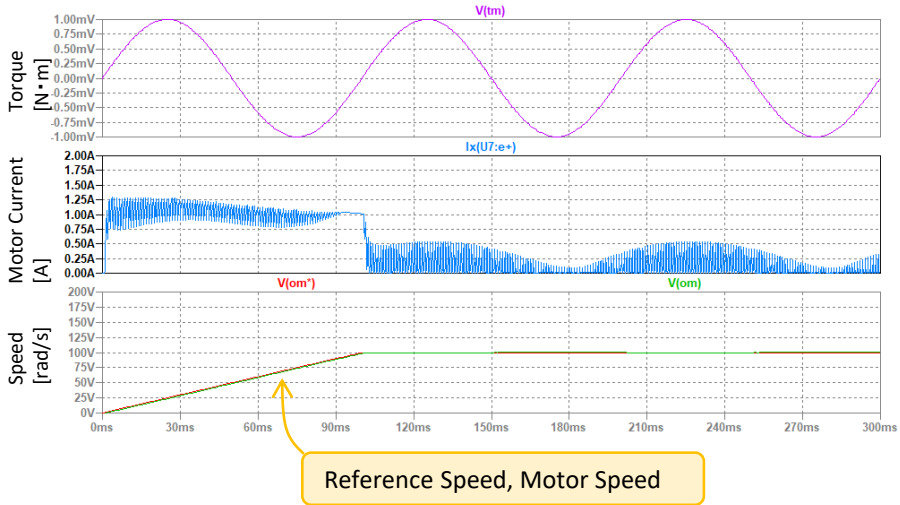
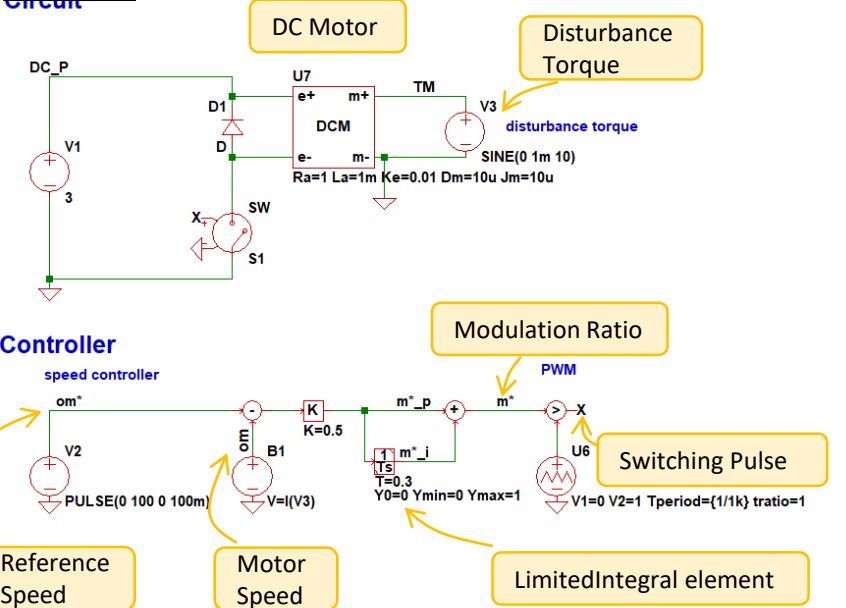
PSpice



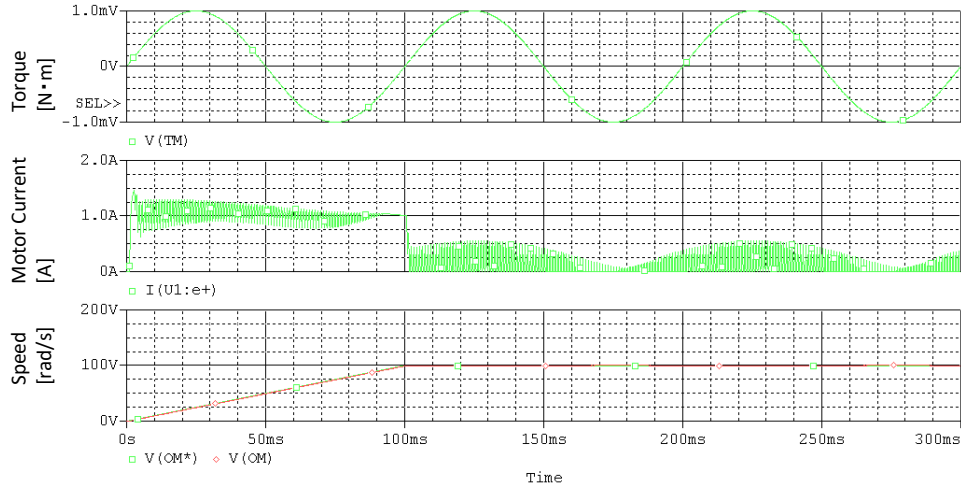
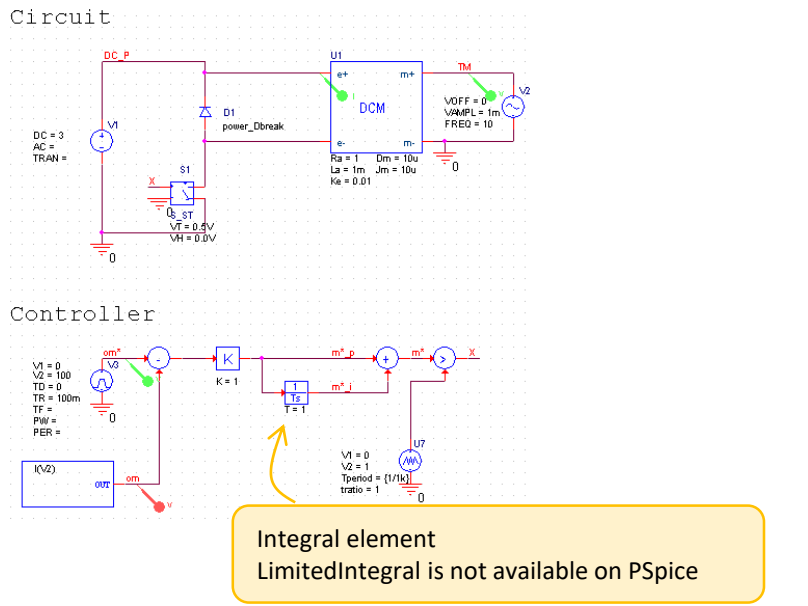
Example 6. DC Motor Speed Control

This is an example of DC motor drive which controls motor speed to 100 rad/s.

LTspice



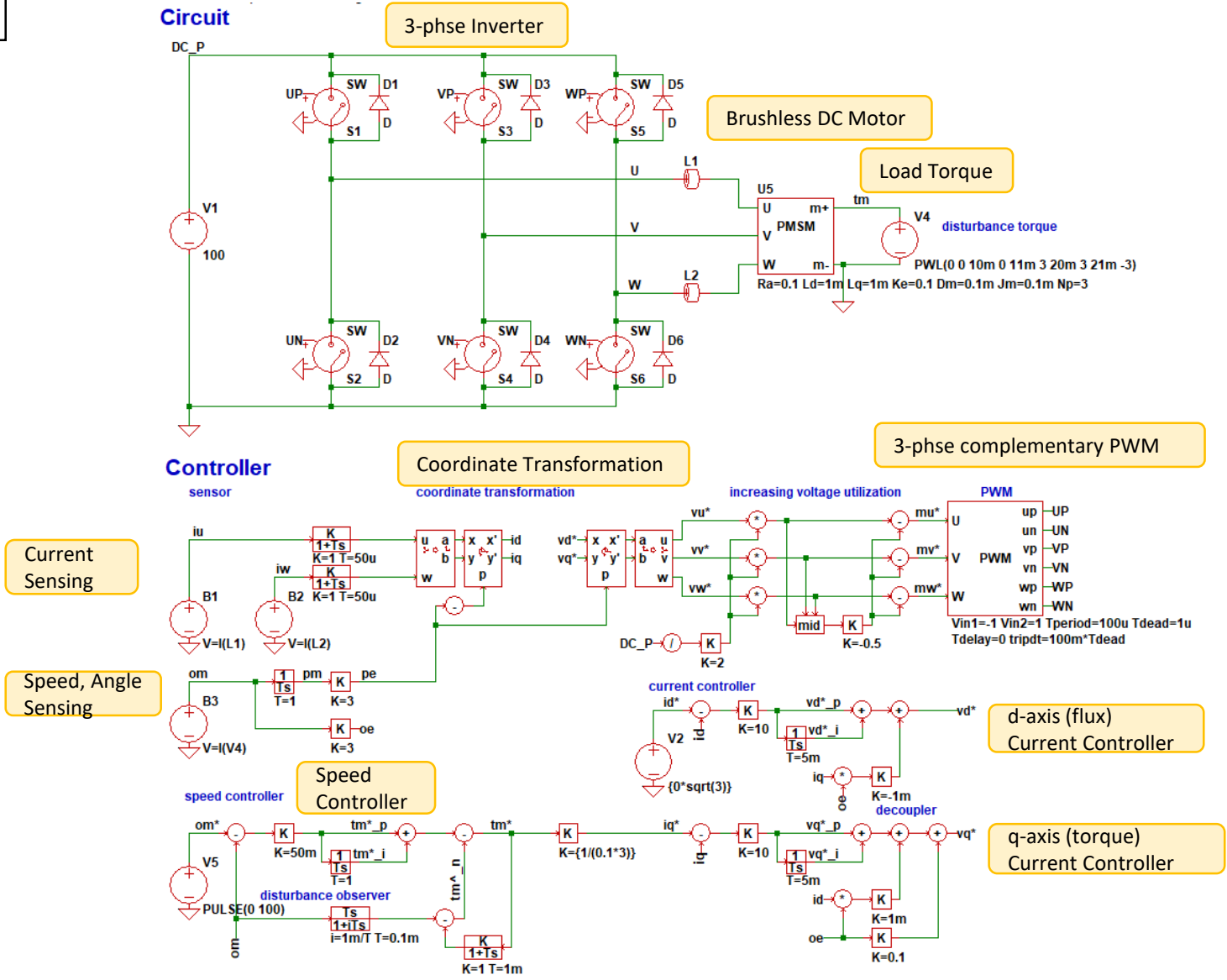
PSpice



Example 7. Brushless DC Motor Vector Control

This is an example of brushless DC motor vector control which controls motor speed to 100 rad/s.

LTspice

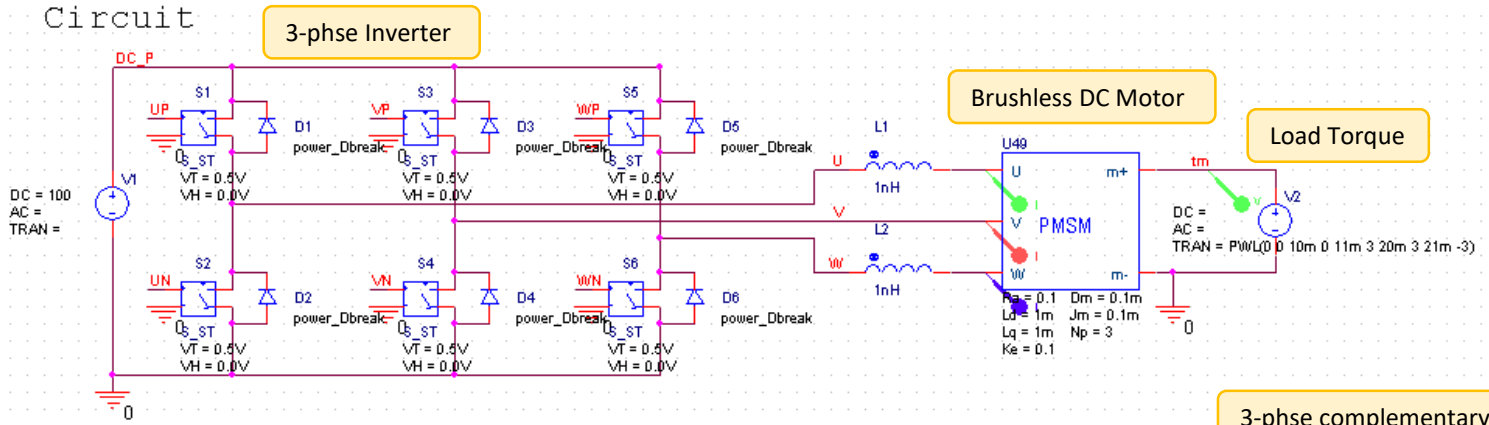


Example 7. Brushless DC Motor Vector Control

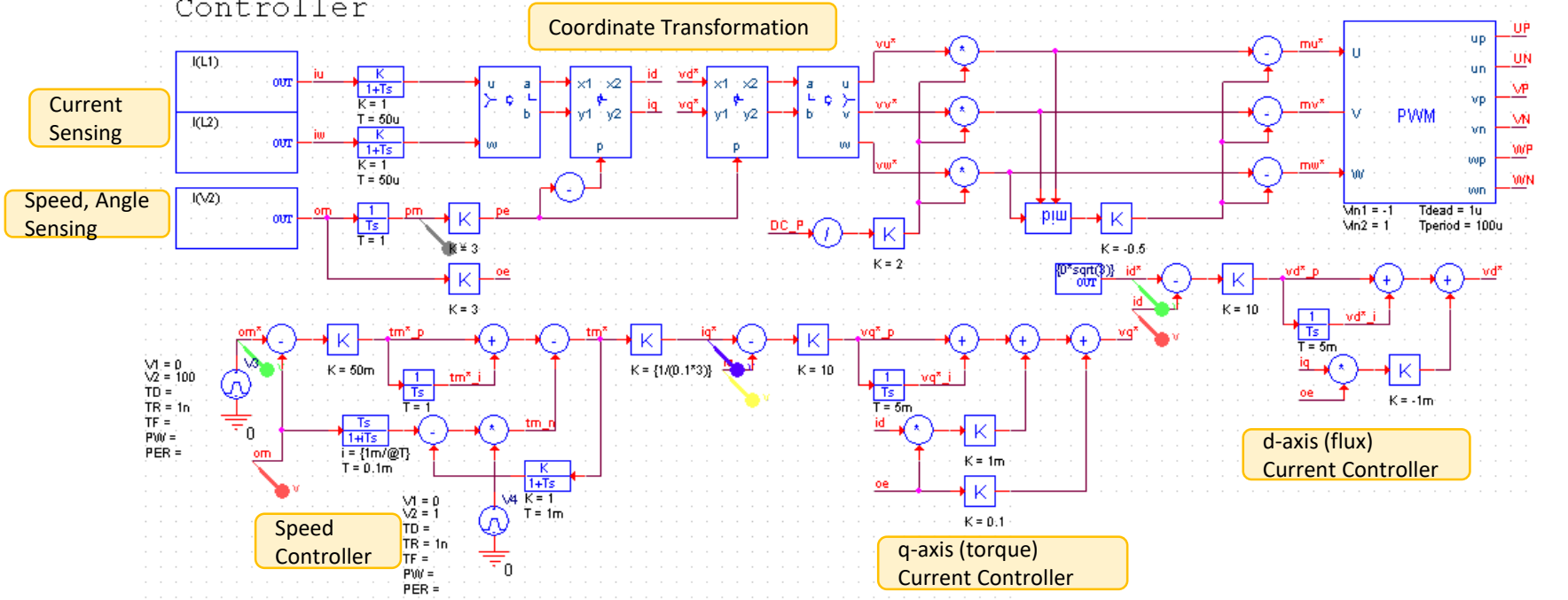
This is an example of brushless DC motor vector control which controls motor speed to 100 rad/s.

PSpice

Circuit



Controller



3-phase complementary PWM

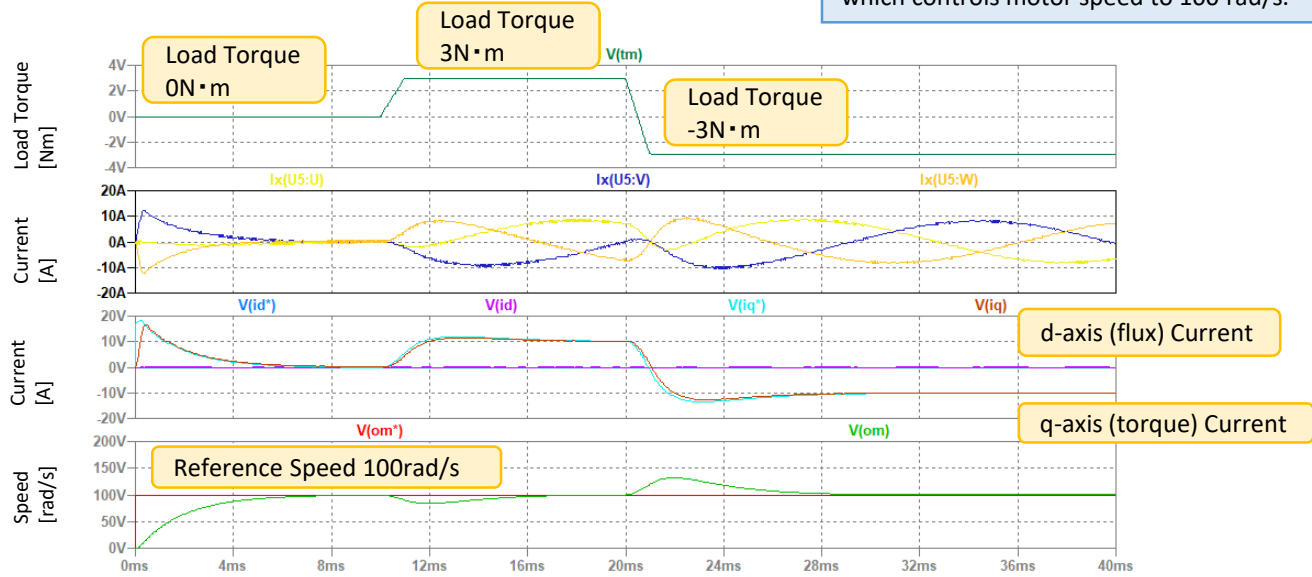
d-axis (flux) Current Controller

q-axis (torque) Current Controller

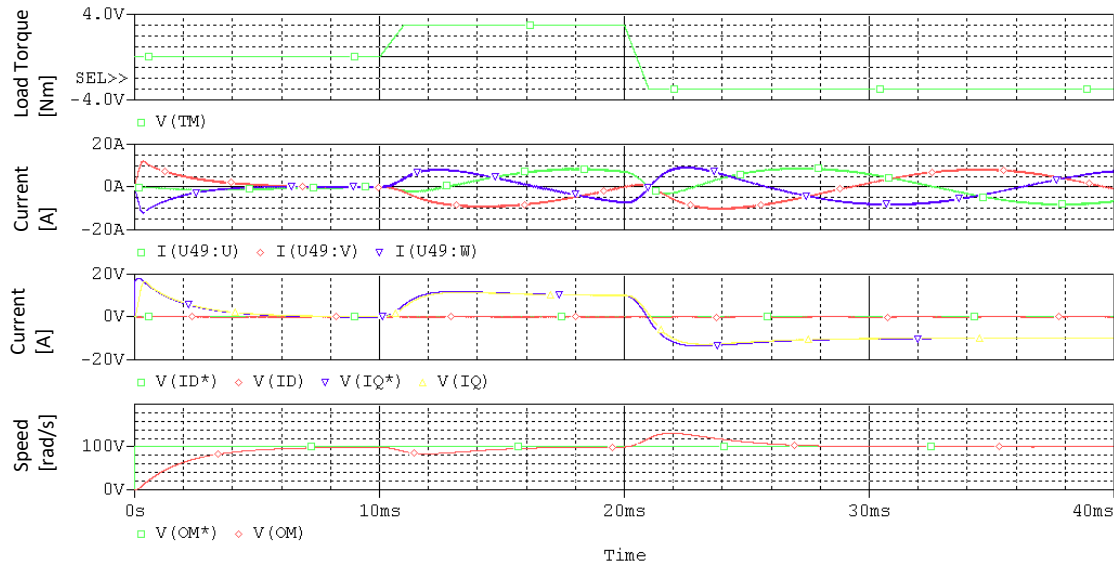
Example 7. Brushless DC Motor Vector Control

This is an example of brushless DC motor vector control which controls motor speed to 100 rad/s.

LTspice



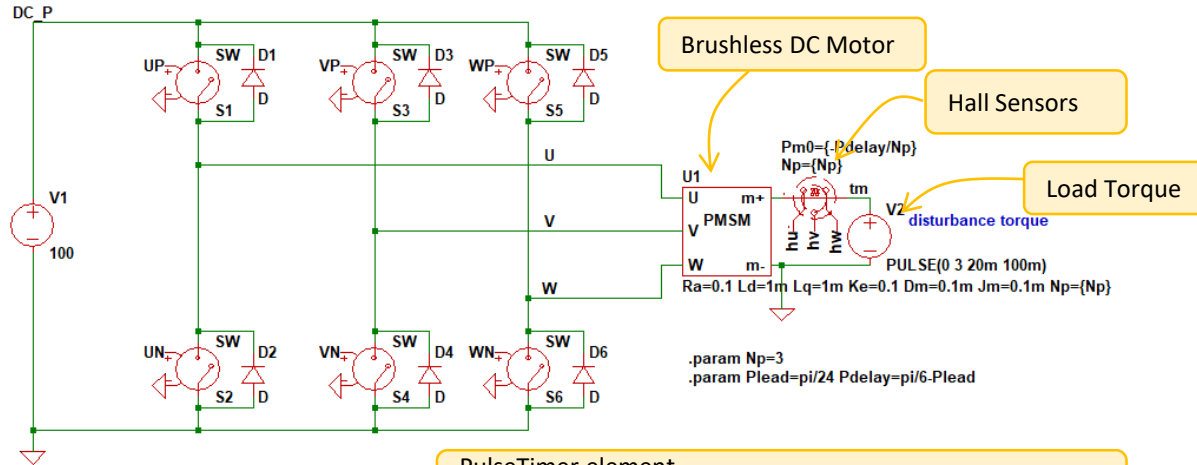
PSpice



Example 8. Brushless DC Motor 120 Degree Drive With Hall Sensors

LTspice

Circuit



This is an example of brushless DC motor 120 degree drive with hall sensors which controls motor speed to 100 rad/s.

Controller

speed calculator

Hall Sensor Signals

PulseTimer element
This is used for time measurement between signal changes.

Estimated Speed

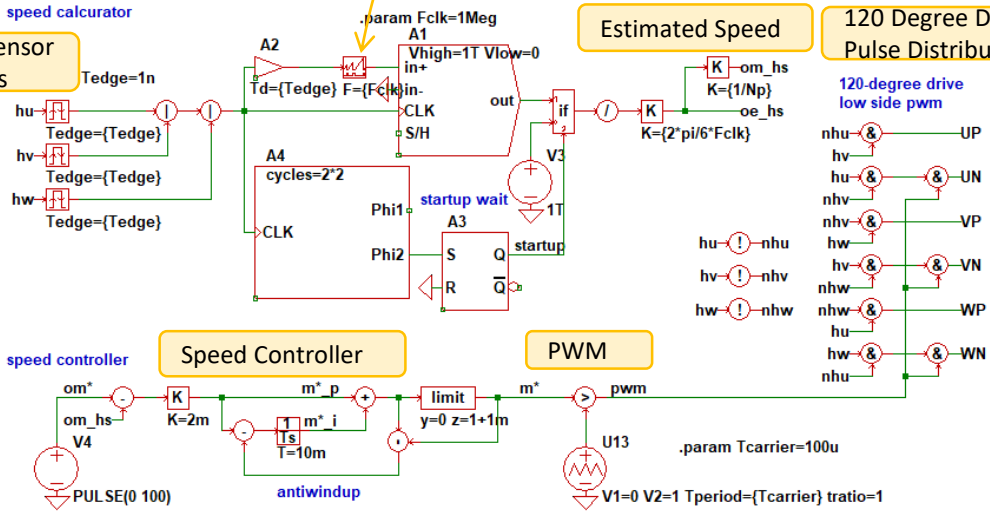
120 Degree Drive Pulse Distributor

120-degree drive low side pwm

speed controller

Speed Controller

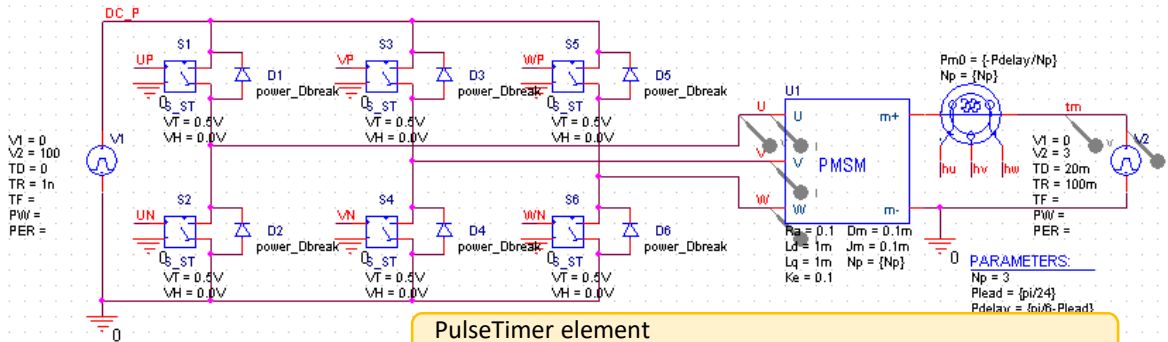
PWM



Example 8. Brushless DC Motor 120 Degree Drive With Hall Sensors

PSpice

Circuit



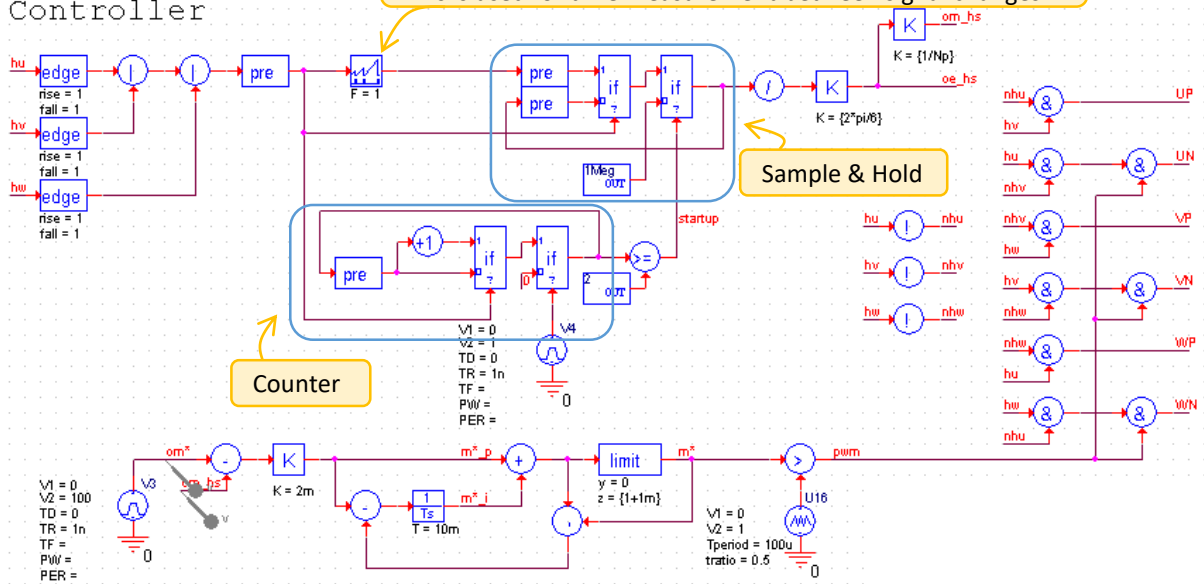
This is an example of brushless DC motor 120 degree drive with hall sensors which controls motor speed to 100 rad/s.

Controller

PulseTimer element
This is used for time measurement between signal changes.

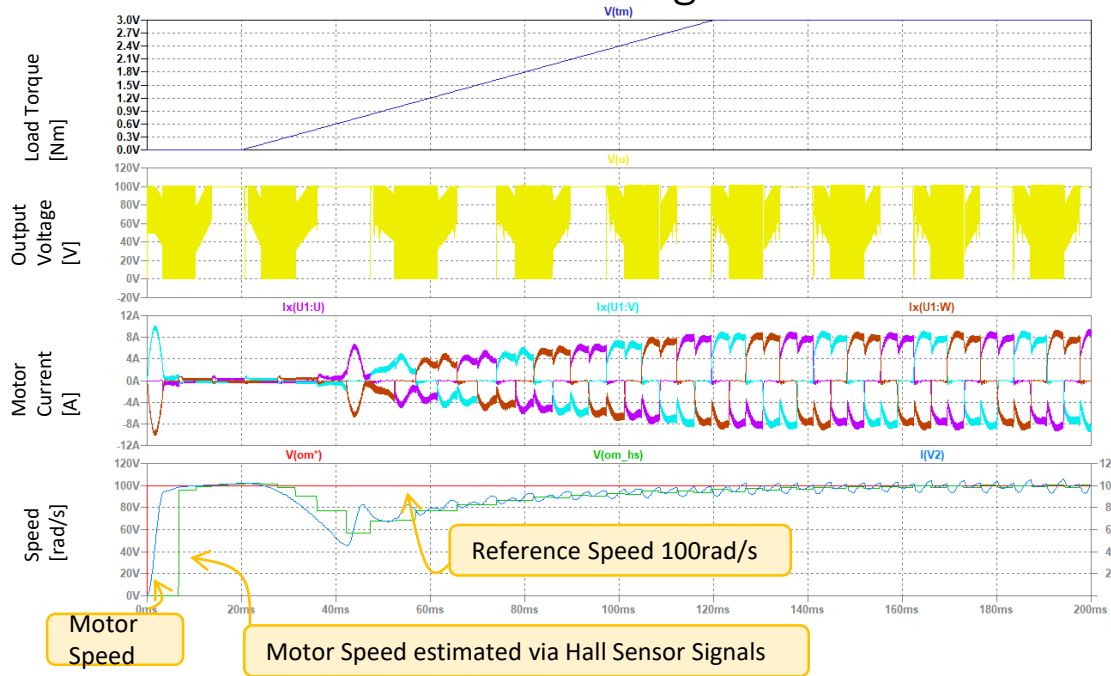
Sample & Hold

Counter



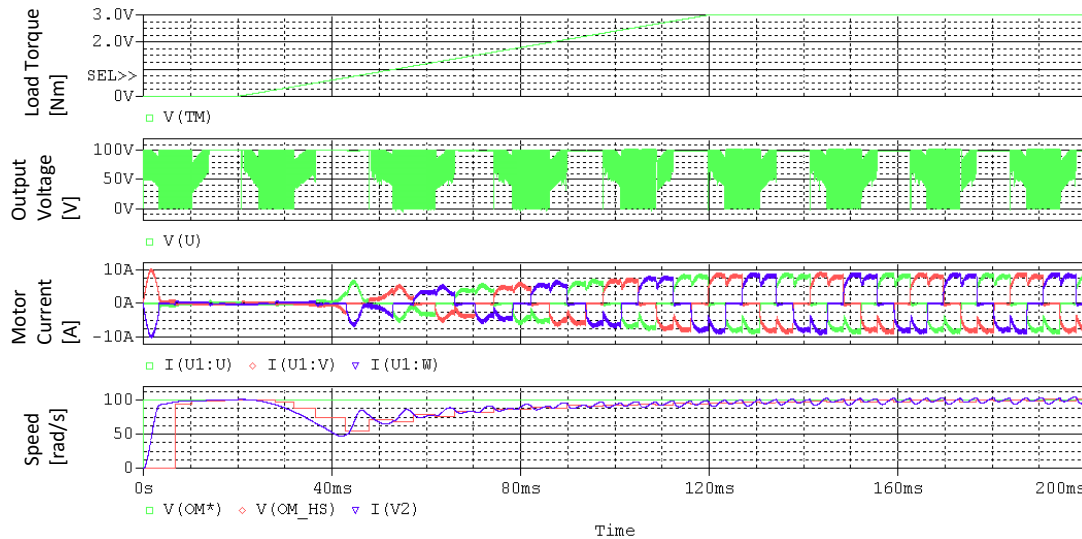
Example 8. Brushless DC Motor 120 Degree Drive With Hall Sensors

LTSpice



This is an example of brushless DC motor 120 degree drive with hall sensors which controls motor speed to 100 rad/s.

PSPice



Example 9. Solar Cell MPPT Using Perturb & Observe Method

This is an example of maximum power point tracking of solar cells using perturb & observe method under conditions where the irradiance changes from 1000W/m² ⇔ 200W/m².

