

PLECS

*DEMO MODEL*

## Brushless DC Machine

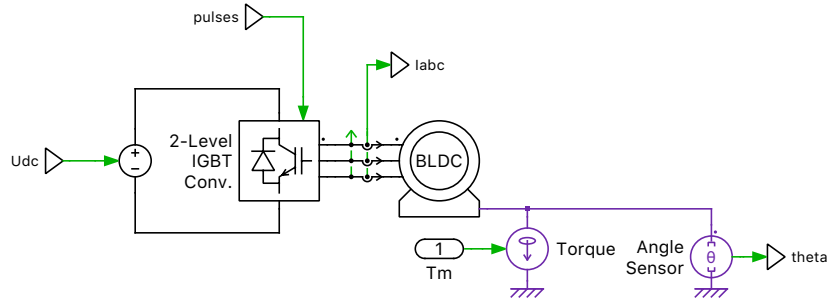
Last updated in PLECS 4.3.1

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# 1 Overview

This demonstration shows an inverter-fed, current-controlled brushless DC (BLDC) machine. The machine is initially sped up to a steady-state speed, and the shape on the back electromotive force (EMF) is observed.



**Figure 1: Brushless DC machine circuit**

## 2 Model

An ideal 300  $V_{DC}$  source and a 2-level, 6-switch inverter are used to drive a BLDC machine. The BLDC machine is a type of permanent magnet synchronous machine (PMSM) where the back EMF of the machine has a trapezoidal shape, which is suited for a “two phases ON” control. The 2-pole BLDC machine experiences a constant load torque of 3 Nm. The back EMF of the machine is modeled as the sum of the first six odd-order sinusoidal Fourier series. A more detailed description about the BLDC machine can be found here.

## 3 Control

The rotor position of the BLDC is measured using an ideal Angle Sensor to realize a Hall-effect type commutation pattern. Additionally, a three-phase ammeter is used to measure the phase currents of the BLDC. The rotor position and the stator phase currents are fed back into the current controller. The controller uses the rotor position to determine the three-phase reference currents, which are shaped in a trapezoidal fashion with two phases conducting (ON) and one phase floating (OFF). These are then compared to their corresponding measured phase currents and an error signal is generated. This error signal is then used to determine the gating signal for the IGBTs on each leg of the inverter.

## 4 Simulation

Run the simulation with the model as provided to view the steady-state waveforms. The BLDC machine is set to have an initial speed of 300 rad/s. The machine is initially sped up, and after 0.166 seconds reaches a steady-state speed of 365.4 rad/s. The amplitude of the back EMF increases gradually with the speed of the machine before reaching a steady-state value of 127.6  $V_{rms}$ .

Next, change the load torque applied on the BLDC machine to 3.8 Nm. Additionally, change the initial speed of the machine to 340 rad/s. Re-run the simulation. For this operating condition, notice the effect of commutation on the phase currents. As the energy is transferred from one phase to the next, the interaction of the three phase currents leads to a drop in the machine torque.

## Revision History:

PLECS 4.3.1      First release

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### *PLECS Demo Model*

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