PLECS

DEMO MODEL

Boosted Motor Drive

Last updated in PLECS 4.3.1

1   Overview

This demonstration illustrates a speed-controlled synchronous machine connected to a battery pack via a boost converter stage that precedes the active front end. The machine is being accelerated and decelerated and is running in both motoring and generating modes.

Note   This model contains model initialization commands that are accessible from:

PLECS Standalone: The menu **Simulation + Simulation Parameters... + Initializations**

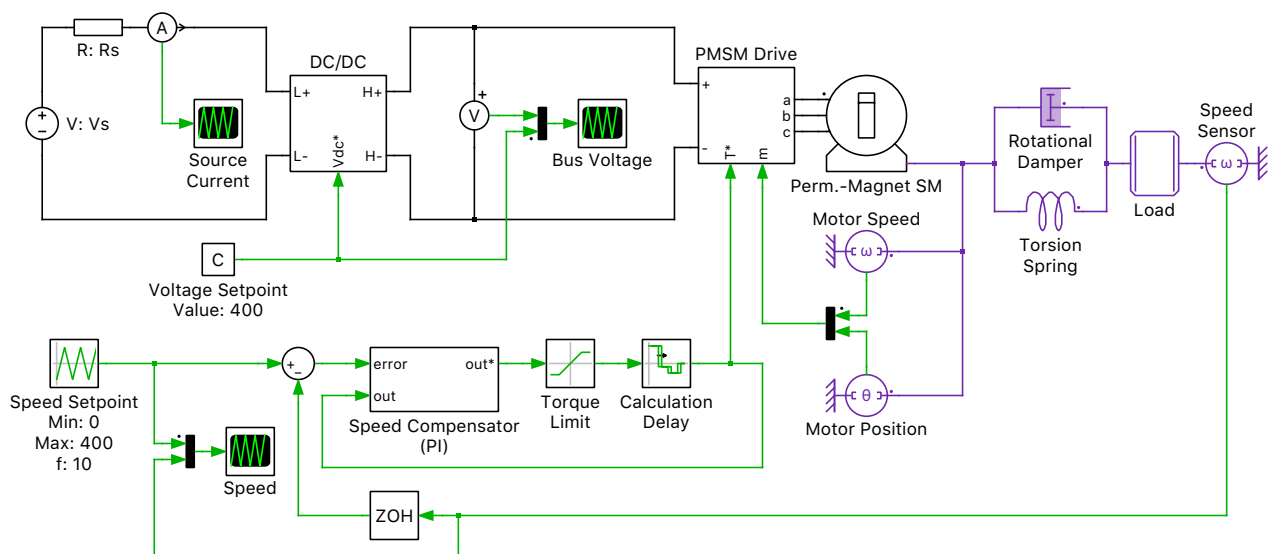*PLECS Blockset:*   Right click in the **Simulink model window + Model Properties + Callbacks + InitFcn***

Figure 1: Boosted motor drive circuit

2   Model

2.1   Power circuit and control modules

The circuit includes a simplified battery modeled as an ideal DC source with output impedance that feeds a step up converter stage and an inverter stage to drive a permanent magnet synchronous machine (PMSM). The load speed is measured and fed back into an outer speed loop. The speed compensator generates a torque set point which is then provided as a reference signal used for the calculation of the quadrature current set point for the inverter controller.

2.2   DC/DC Converter

A boost converter is connected on the front end of the drive to step up the 200 V battery to a 400 V DC-link. The boost stage is controlled with an outer voltage regulator, which generates a current set point for the DC-link current (high-side current). The current regulator in this controller is used to control the inductor current (low-side current). Thus the high-side current set point must first be transformed into a low-side current set point. The transformation is based on the approximation that

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Figure 2: DC/DC Converter

the input power is equal to the output power. The derived low-side current set point is fed into a current regulator that is used to generate a voltage set point for the output of the boost stage. This set point value and the measured DC-link voltage are fed into a modulator, which sets the duty cycle for the symmetrical PWM generator. These gating signals control the IGBT pair, and a small dead time is also included to prevent the shorting of the DC bus.

2.3 DC/AC Converter

Figure 3: DC/AC Converter

The DC-link is connected to a 2-level inverter which drives the PMSM. The torque set point generated by the outer speed loop is converted to a quadrature axis current set point (I_q*). The direct axis current set point is set to 0. The dq-current set points are fed into a digital synchronous frame regulator which calculates a desired $\alpha\beta$ voltage vector. This vector is fed into a space vector modulator to gener-

ate the switching signals for the IGBT inverter. Dead time is again included for protection of the devices.

2.4 Machine and Mechanical Load

The PMSM machine parameters correspond to a Baldor brushless servo motor (BSM90N-175A). An external inertia is included to represent a load. The shaft stiffness and damping are modeled using a torsion spring and a rotational damper, respectively.

3 Simulation

The simulation demonstrates the acceleration and deceleration of the PMSM. Run the simulation with the model as provided and observe how well the machine speed follows the commanded triangular waveform commands. During the simulation the bi-directional converter transfers energy from the battery to the PMSM while in the motoring operation. In the generation phase the generated energy is transferred from the PMSM to the battery. Initial values for the capacitor voltages are already provided so there will not be a transient in the current and voltage waveforms at the start of the simulation. One can also look at the DC voltage regulation and current regulation for both converters using the Scopes provided in the their respective subsystems.

Revision History:

PLECS 4.3.1   First release

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PLECS Demo Model