Simulink Powertrain Blockset Model

Progress and Documentation

HyTech Racing

Georgia Institute of Technology

Zekun Li

For detailed references and help, click the **help** button located at the bottom right of each parameter window in Simulink

This progress and documentation guide is generally organized as follows: a general description of the overarching system; a general description of any subsystems; a list of parameters grouped by tab and their status for subsystem blocks. Each subsection contains a raw “percentage parameterized” value suitable only for a rough indicator of the level of completion of the modl. Each subsection contains an appendix with relevant data, figures, and sources (collectively “resources”) used for parameterization so as to develop a robust, traceable, and replicable model. Each resource is labeled as A# and corresponds only to the relevant system the appendix is located in.

1. **Electric Plant**

The electric plant portion of the model includes the **battery** and the **motor**.

**Battery (Datasheet battery)**

The battery model is implemented base off discharge characteristics at different temperatures. It is most likely that the battery parameters are for a single cell. To generate parameter data: [Generate Parameter Data for Datasheet Battery Block](https://www.mathworks.com/help/autoblks/ug/generate-parameter-data-for-datasheet-battery-block.html)

Percentage parameterized: 0%

Parameters

1. Rated capacity at nominal temperature, BattChargeMax [Ah]: Not parameterized
2. Open circuit voltage table data, Em [V]: A 1-D lookup table of voltages at specific discharge capacity breakpoints plotted against iii (see below); Not parameterized
3. Open circuit voltage breakpoints 1, CapLUTBp: Discharge capacity breakpoints used to plot ii; Not parameterized
4. Internal Resistance table data, RInt [Ohms]: A 2-D lookup table of internal resistance at specific temperatures (v) and states of charge (vi); Not parameterized
5. Battery temperature breakpoints 1, BattTempBp: Battery temperature breakpoints used to plot iv; Not parameterized
6. Battery capacity breakpoints 2, CapSOCBp: battery capacity breakpoints used to plot iv; Not parameterized
7. Number of cells in series, Ns: Not parameterized
8. Number of cells in parallel: Not parameterized
9. Initial battery capacity, BattCapInit [Ah]: Not parameterized

**Motor**

There are two variants of the motor: **MotGenEvMapped**, a representation of the motor as a map between maximum torque (Nm) and maximum power (W), and **MotGenEvDynamic**, a mathematical model of the **motor controller**, **inverter**, and **motor**. The current model uses **MotGenEvDynamic**.

Percentage parameterized: 76%

**Interior PM Controller**

A representation of a motor controller for an interior permanent magnet motor.

Block Options

1. Control Type: Torque Control

Motor Parameters

1. Stator resistance, Rs [Ohm]: 0.012, Parameterized, A1
2. D-axis inductance, Ld [H]: 0.000125, Parameterized, A1
3. Q-axis inductance, Lq [H]: 0.00013, Parameterized, A1
4. Permanent magnet flux, lambda\_pm [Wb]: 0.0393, Parameterized, A1
5. Number of pole pairs, PolePairs: 10, Parameterized, A1

Id and Iq Calculation

The Id and Iq Calculation involves a set of derived parameters calculated by pressing the “Calculate MPTA Table Data” button. Only the first two parameters are actually entered by hand.

Parameters

1. Maximum torque, T\_max [N.m]: the maximum torque of the motor, currently set at 100 as a rough average of peak and continuous torque; 100, Roughly parameterized, A1
2. MTPA table breakpoints: the number of breakpoints to use in the derived parameters; 10, Parameterized

Current Controller

Correct information could not be found for any of the parameters in this section.

Parameters

1. Bandwidth of the current regulator, EV\_current [Hz]: Not parameterized
2. Sample time for the torque control, Tst [s]: Not parameterized

Electrical Losses

Parameters

1. Parameterize losses by: Tabulated efficiency data, Parameterized
2. Vector of speeds (w) for tabulated efficiency, w\_eff\_bp [rad/s]: See model, Parameterized
3. Vector of torques (T) for tabulated efficiency, T\_eff\_bp [Nm]: See model, Parameterized
4. Corresponding efficiency, efficiency\_table [%]: roughly parameterized by visually inspecting the efficiency map found in A1; See model, Roughly parameterized, A1

**Interior PMSM**

A representation of an interior permanent magnet synchronous motor. Many parameters are common with the Motor Parameters of the **Interior PM Controller**.

Percentage Parameterized: 100%

Block Options

1. Mechanical input configuration: Speed
2. Simulation Type: Continuous

Parameters

1. Number of pole pairs (P): 10, Parameterized, A1
2. Stator resistance per phase (Rs): 0.012, Parameterized, A1
3. Stator d-axis and q-axis inductance (Ldq): [0.000125 0.00013], Parameterized, A1
4. Permanent flux linkage constant (lambda\_pm): 0.0393, Parameterized, A1

Initial Values

1. Initial d-axis and q-axis current (idq0): [0 0], Parameterized
2. Initial rotor mechanical position (theta\_init): 0, Parameterized

**Three-Phase Voltage Source Inverter**

A representation of a three-phase voltage source inverter.

Percentage parameterized: 75%

Block Options

1. Input inverter temperature: unchecked
2. Enable memory optimized 2D LUT: unchecked

Electrical Model

1. Switching voltage function: Commanded phase voltage, Parameterized
2. Vector of speeds (w) for tabulated losses, w\_eff\_bp [rad/s]: See model, Parameterized
3. Vector of torques (T) for tabulated losses, T\_eff\_bp [Nm]: See model, Parameterized
4. Corresponding power loss, ploss\_table [W]: Current value is a non-default placeholder and is inaccurate; Not parameterized

**Motor Appendix**

A1. [EMRAX 208 Techincal Data Table](https://emrax.com/wp-content/uploads/2020/03/emrax_208_technical_data_table_graphs_5.4.pdf); high voltage column