Michigan Tech MEEM/EE 4295: Introduction to Propulsion Systems for Hybrid Electric Drive Vehicles

HW_6
Topics: Electric Drive Model Based Design (Simulink)

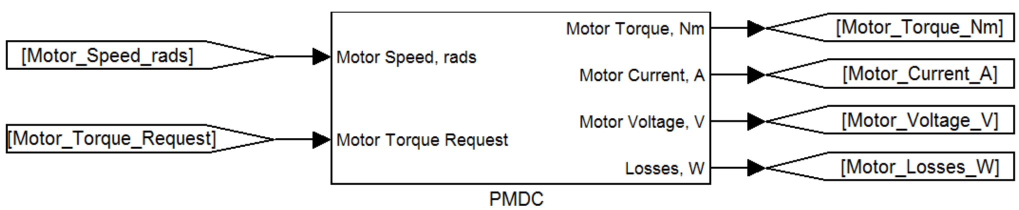
Posted: October 25th, 2012
Due Date: November 7th, 2012

Model Based Design Exercise

In HW-5, you created subsystems in Simulink for driver input, torque limits, transmission & drivetrain, IC engine, brakes and basic e-motor. For HW-6, you will start with your model from HW-5 and replace the "Electric Motor System" with more detailed and accurate electric drive line models including:

1) Permanent Magnet DC machine Subsystem
2) Power Electronics Subsystem
3) Battery Subsystem

Permanent Magnet DC (PMDC) Machine Subsystem



Note PMDC model

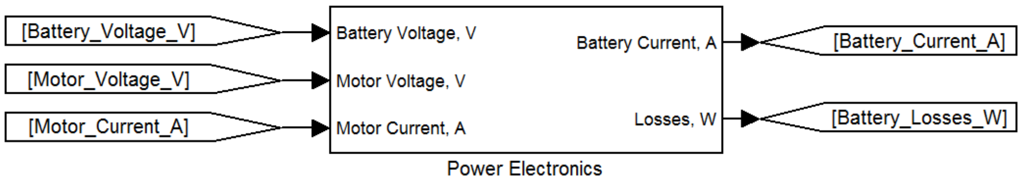
A modern electric drive system would utilize an induction or PMAC (brushless dc) machine. However, the model of a PMDC machine operates very much like the PMAC at the terminals of the machine. Therefore, our simplified model should be sufficiently accurate.

For HW-6, use the E-Motor maximum torque curve for the UQM motor from HW-4. This machine has a torque constant of 0.94 Nm/A. For HW-6, provide a torque request and the E-Motor speed to the E-Motor Subsystem. The E-Motor Subsystem will determine the available torque and provide UP TO the torque requested, motor voltage, current and losses. You may add an output flag to indicate the ratio of the requested torque/max torque at that speed.

Use the provided lookup table to get efficiency of the machine. The efficiency can be used to calculate the motor voltage (this is the terminal voltage to the machine v_a).

a) The PMDC Motor Torque Request is from the Driver Controller.
b) The PMDC Speed is from the Transmission and Drivetrain Subsystem.

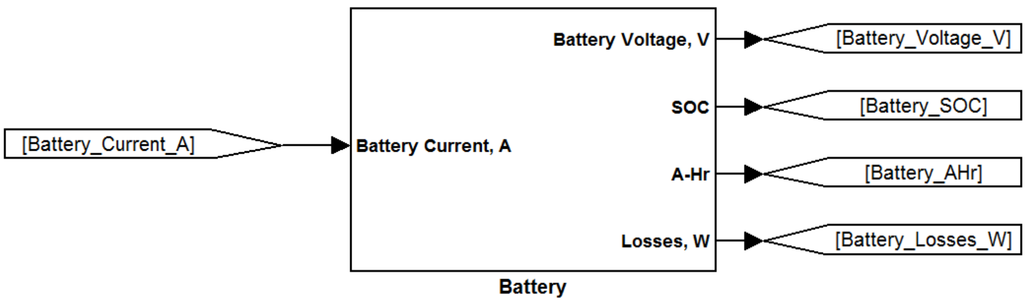
Power Electronics Subsystem



Note Power electronics model

The on state resistance of the power semiconductors is 0.02 Ω. You should use the average model of a two quadrant bidirectional buck converter (chopper).

Battery Subsystem



Note Power battery model

You should use the "Freedom Car" battery model presented in class. Your model should have a 300 V open circuit voltage, 20 A-Hr capacity and a 0.1 Ω internal resistance.

Output Requirements

1) You should use the two drive cycles from HW-5.

2) Use your Simulink model to:

    a) Control your electric vehicle over a drive cycle. Note that it is now a "real hybrid," and recovers energy through regeneration of the electrical machine and stores it the battery. To blend the torque from the IC Engine and the E-Motor, just allow each to provide 50% of the requested torque (if possible). A better method to blend the torque from the two drive systems will be derived for use in later HW's.
    b) Determine the regenerative torque. The E-Motor may only recover 85% of the capacity of the E-Motor. Some of the torque will go to the friction brakes.
    c) Plot the motor voltage and current for the drive cycle.
    d) Plot the battery voltage and current for the drive cycle.
    e) Plot the battery SOC drive cycle.
    f) Plot the losses for the motor, power electronics and battery for the drive cycle.
    g) Label ALL of the scopes with UNITS.
    h) Use variables in the Simulink models, initialize the variables with Matlab. This really will make development of the HVM simpler.