**Application: Battery Electric Vehicle (BEV) Power Loss Model and Torque-Speed (TS) Model Questions**

***Part 1:*** Develop a power loss EV mode. You will need to generate a battery model, motor model, and driveline model in order to create a simple electric vehicle. The driver should generate an accelerator pedal position and have it output to the motor model, as well as a brake force being output to the driveline in order to match an input drive cycle.  
  
**Power Loss Motor:** The motor model will be identical to the engine model created previously. The input to the model will be the APP from the driver model, while the output of the model will be the output power of the motor, and input electrical power to the battery. The model should interpret the APP as a command of the percentage of the maximum motor power. The losses of the motor should be characterized by the power loss equation.  
  
**Battery Model:** The battery model should have the input of electrical power output, and output the current SOC of the battery. The electrical power out should be equal to the motor power draw plus an accessory load. The following equation should be used to solve for the battery current with a known power:  
  
I = (Voc - sqrt(Voc^2 - 4RP))/2R  
  
The SOC of the battery can be calculated as the current energy of the battery divided by the maximum energy capacity of the battery. The rate of change of the energy in the pack can be calculated as Voc multiplied by the current Ibat.  
  
**Driveline Loss Model:** The same driveline model used in the conventional vehicle model (Module 3) can be used in this model.  
  
***Part 2:*** Develop a Torque-Speed EV model to compare to the power loss EV model  
  
**Motor T-S Model:** The motor model should have inputs of accelerator pedal position and motor speed, and outputs of output motor torque and input electrical power. The model should interpret the APP as a command of percentage of the maximum output torque at the current motor speed. The maximum torque at current speed can be derived from the motor peak torque and peak power. The losses for the motor can be calculated using the equation discussed in the previous lecture. Pin can also be calculated by finding the instantaneous power (Torque\*Motor Speed) and adding it to the calculated Ploss.  
  
**Driveline Model:** The driveline model should take as an input the motor torque, brake for, and vehicle speed and output the total tractive force and motor speed. The output tractive force should be calculated using:  
  
Ftr = (Tmot - Tloss)\*G\*Rw - Fb  
  
Where G is gearing, Rw is wheel radius, and Fb is brake force. The torque loss in the driveline should be a constant value and if the speed is non-zero, the sign of Tloss should match the sign of the vehicle speed. If the speed is zero, the sign of Tloss should match the sign of but not exceed Tmot in order to prevent the vehicle from moving backwards. The motor speed can be calculated from the vehicle speed using the tire radius and gear ratio.  
  
Use the following parameters for your vehicles, run the UDDS, HwFET, and US06 cycles and answer the questions that follow.  
  
Vehicle Parameters:  
Coefficient of Rolling Resistance (c\_rr): 0.01   
Coefficient of Drag \* Frontal area (CdAf): 0.76 m2   
Air Density (rho): 1.2 kg/m3   
Vehicle Mass (m): 2050 kg  
Inertial Mass (mi): 1.04\*m   
Road Grade (%): 0   
Gravitational Constant (g): 9.81 m/s2   
Accessory Load (AccyLoad): 0.60 kW  
Maximum Brake Force (BrakeF\_max): 10 kN  
  
Motor Model Parameters:  
Max Torque: 300 Nm  
Max Power: 125 kW  
C0 = 0.6 kW, C1 = 0.02, C2 = 0.0015 1/kW (Part 1)  
kc = 0.12, ki = 0.01, kw = 1.2e-5, C = 600 (Part 2)  
  
Battery Model Parameters:  
Maximum Energy Capacity: 18.8 kWh  
SOC initial: 95%  
SOC minimum: 15%  
Voc = 340 V, Rint = 0.08 ohm  
  
Driveline Parameters:  
Constant Spin-loss: 3.6 Nm  
Gear Ratio: 7.17  
Tire Radius: 0.324 m

Using the energy consumption obtained from running the UDDS cycle, estimate the range of the vehicle

|  |  |  |
| --- | --- | --- |
|  | 52 mi |  |
|  | 72 mi |  |

|  |  |  |
| --- | --- | --- |
|  | 32 mi |  |
|  | 102 mi | | |  |

For the HwFET cycle, find the total battery losses for the drive cycle.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | 14000 kJ | | |  |
|  | 1400 kJ |  |

|  |  |  |
| --- | --- | --- |
|  | 740 kJ |  |
|  | 140 kJ |  |

For the US06 cycle, find the total motor losses for the cycle.

|  |  |  |
| --- | --- | --- |
|  | 210 kJ |  |
|  | 2100 kJ | | |  |

|  |  |  |
| --- | --- | --- |
|  | 1100 kJ |  |
|  | 21000 kJ | | |  |

After running all of the drive cycles, what can you conclude about the losses vs. powertrain efficiency when comparing the US06 cycle to the other two cycles?

 