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ECE 438

2/28/19

Project 3

Part 1:

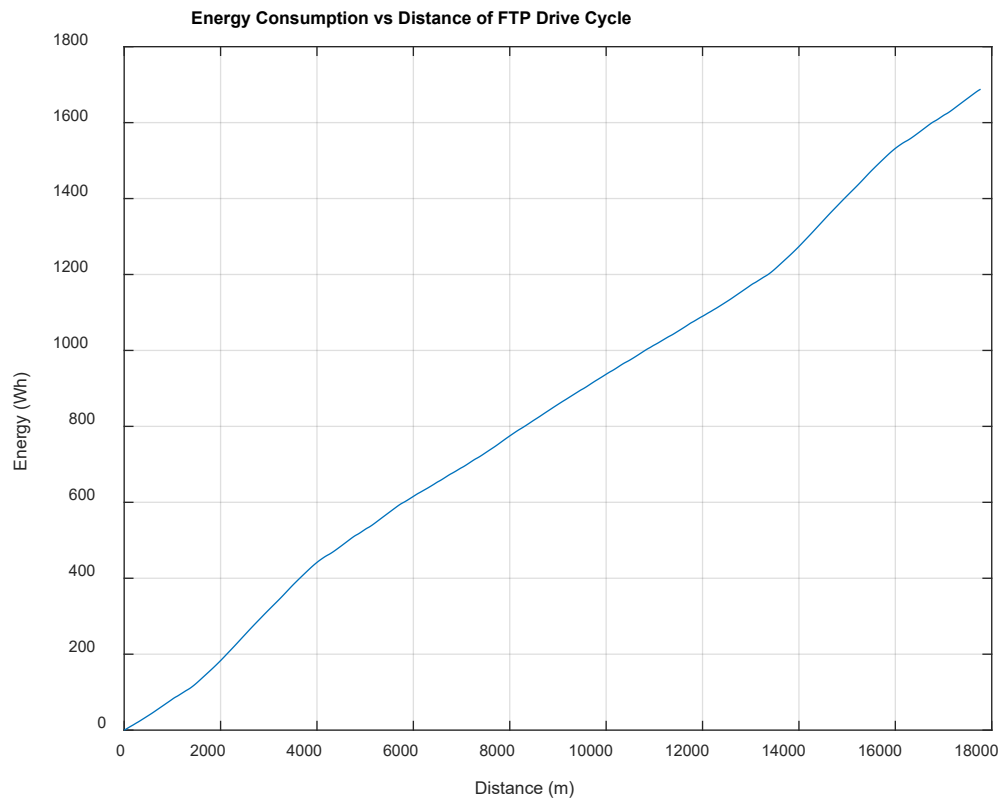


Figure 1: Energy Consumption vs Distance of FTP Drive Cycle

Design of battery:

Given:

- Batteries: 2.2Ah Li-ion with 3.8V nominal
- DC bus voltage: 400V
- BOL range: 200km

From Figure 1 above:

- Energy Consumption throughout FTP: 1687.917Wh

- Distance over FTP Drive Cycle: 17.77km

Calculations:

- $\frac{Wh}{km} \text{ average: } \frac{1687.917Wh}{17.77km} = 94.986 \frac{Wh}{km}$
- $\left(94.986 \frac{Wh}{km}\right)(200km) = 18997.26Wh$
- $I = \frac{P}{V} = \frac{18997.26Wh}{400V} = 47.493Ah$
- Series cells: $\frac{400V}{3.8V} = 105.263 \rightarrow 106 \text{ cells}$
- Parallel cells: $\frac{47.493Ah}{2.2Ah} = 21.588 \rightarrow 22 \text{ cells}$
- With 106 cells series and 22 cells parallel: 402.8V, 48.4Ah, 19495.52Wh

Part 2:

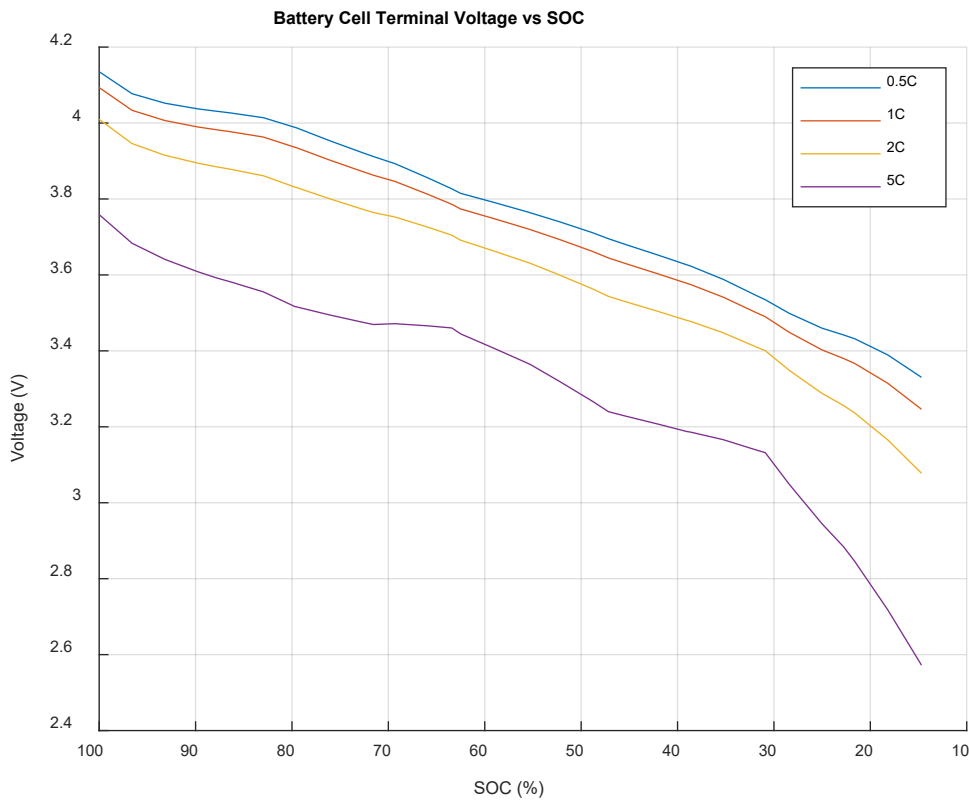


Figure 2: Battery Cell Terminal Voltage vs SOC

As shown above in Figure 2, drawing more current from the battery will result in a lower voltage.

Part 3:

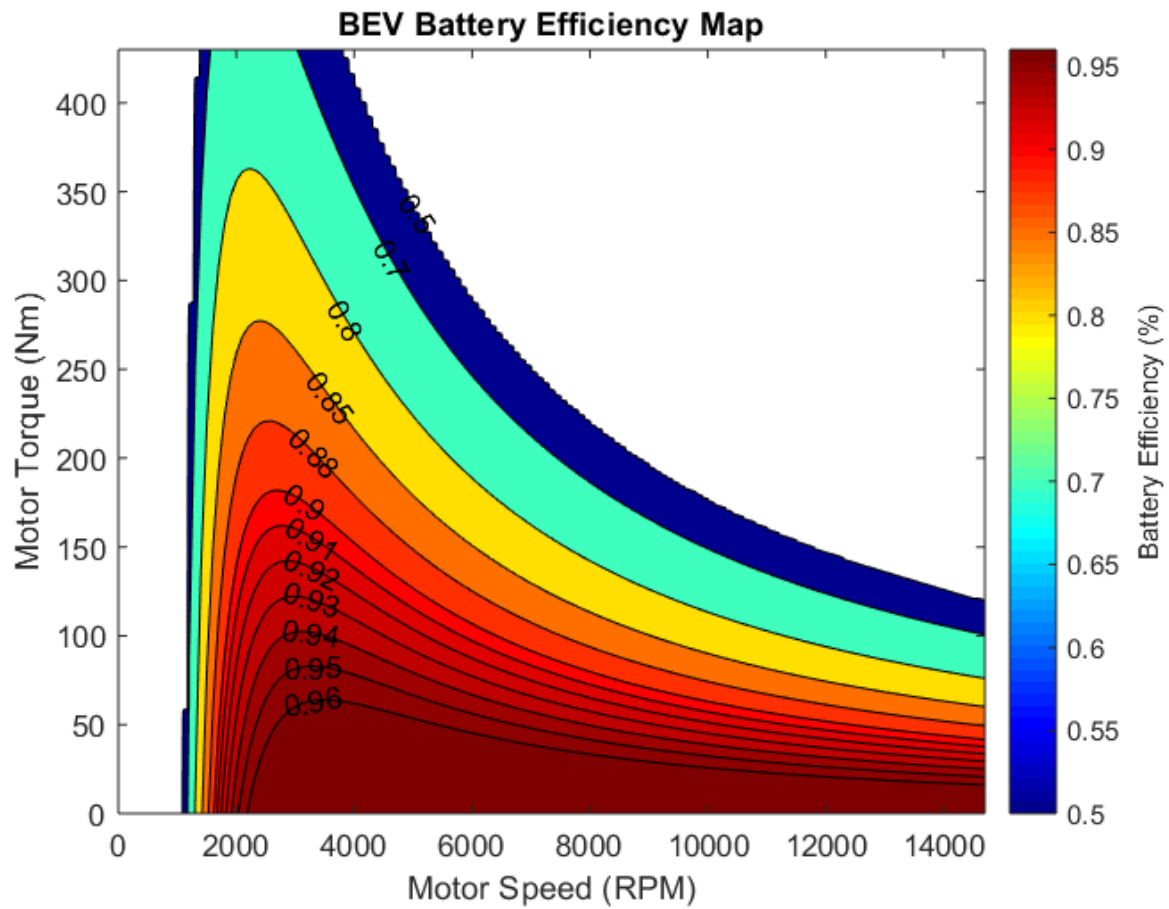


Figure 3: BEV Battery Efficiency Map

As shown in Figure 3 above, as torque decreases the battery efficiency rises because the current needed decreases. Also, at higher speeds the efficiency decreases because of the back EMF lowering the efficiency.

Part 4:

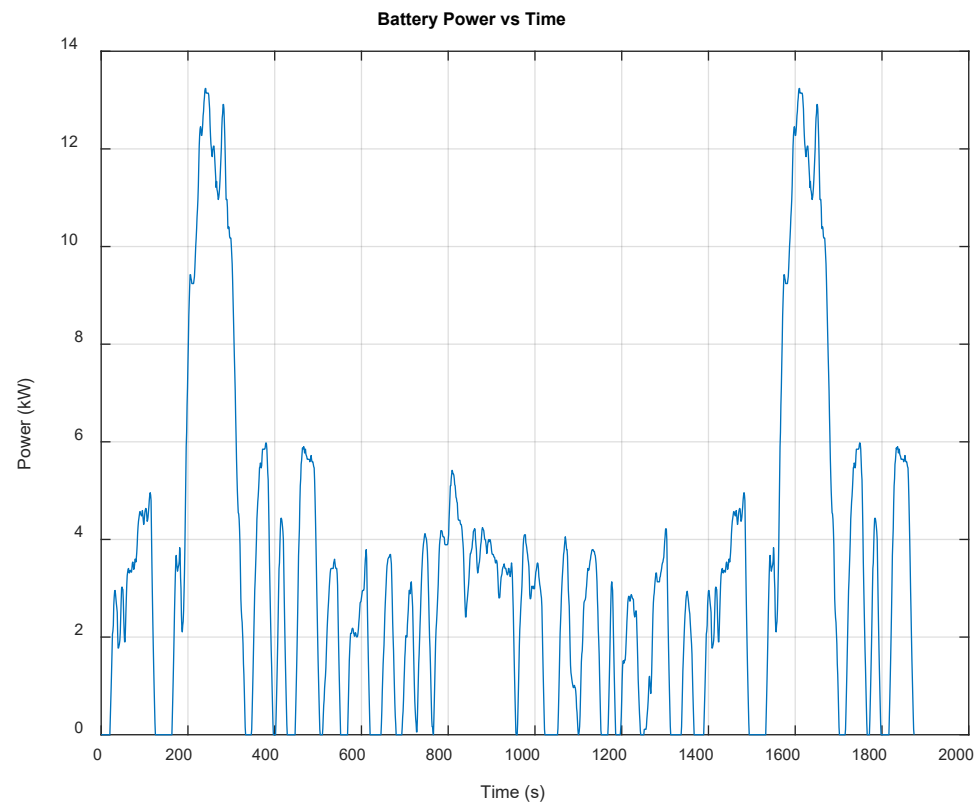


Figure 4: Battery Power vs Time

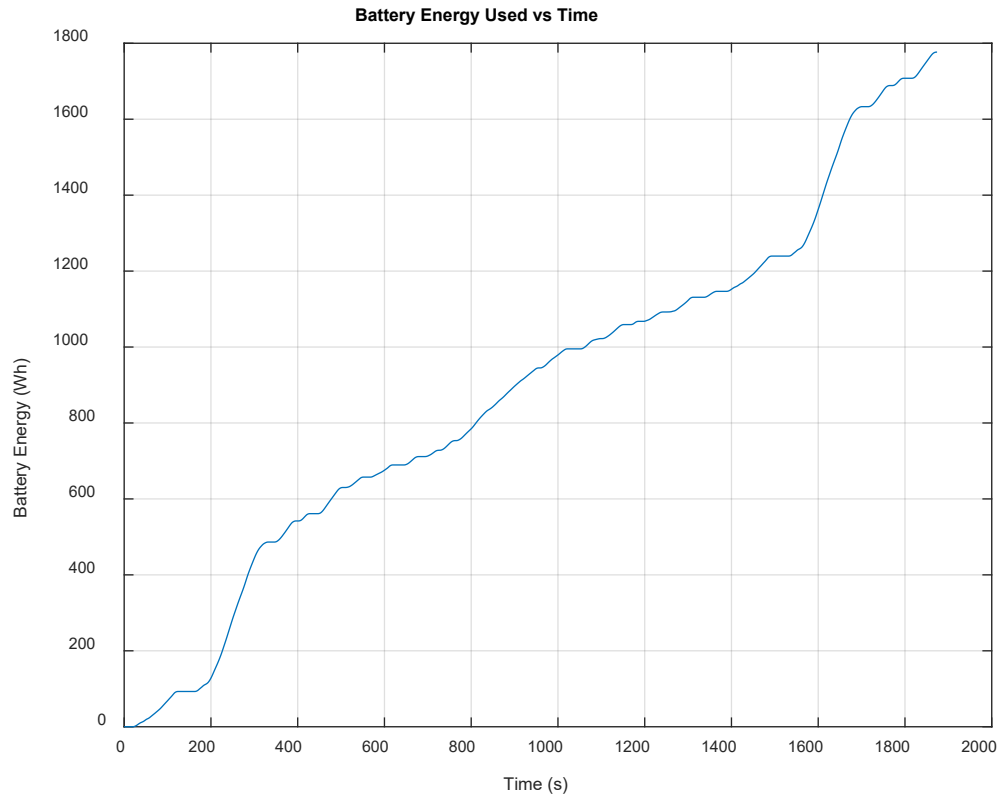


Figure 5: Battery Energy Used vs Time

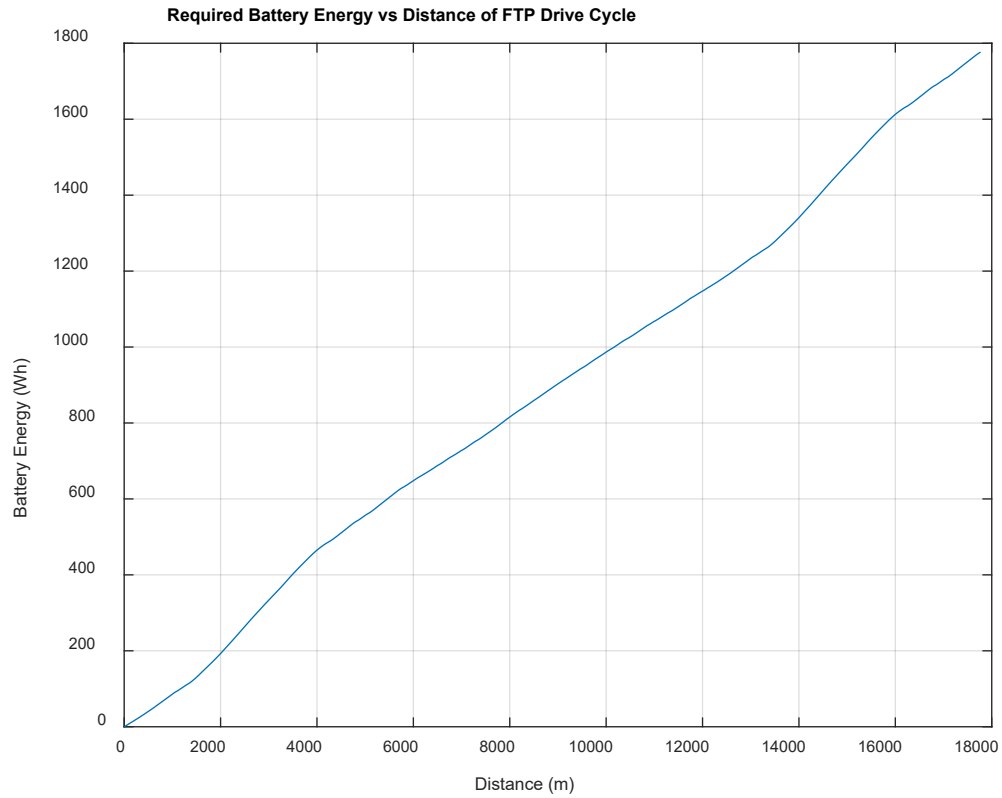


Figure 6: Required Battery Energy vs Distance of FTP Drive Cycle

New Vehicle Range:

Given:

- Battery: 106 cells series and 22 cells parallel for 402.8V, 48.4Ah, 19495.52Wh

From Figure 6 above:

- Total battery energy used throughout FTP: 1776.7Wh
- Distance over FTP Drive Cycle: 17.77km

Calculations:

- $\frac{Wh}{km}$ average: $\frac{1776.7Wh}{17.77km} = 99.983 \frac{Wh}{km}$
- Range (km): $\frac{19495.52Wh}{99.983 \frac{Wh}{km}} = 194.988km$

Part 5:

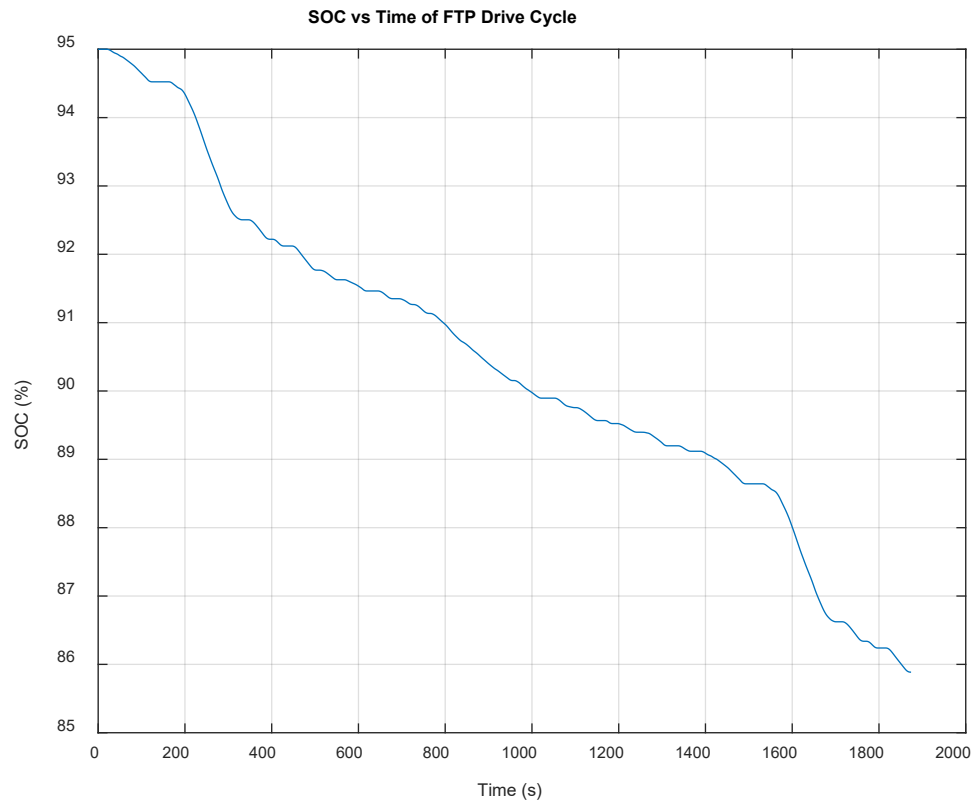


Figure 7: SOC vs Time of FTP Drive Cycle

Final SOC after starting at 95% and driving FTP Drive Cycle is 85.89% as shown above in Figure 7.

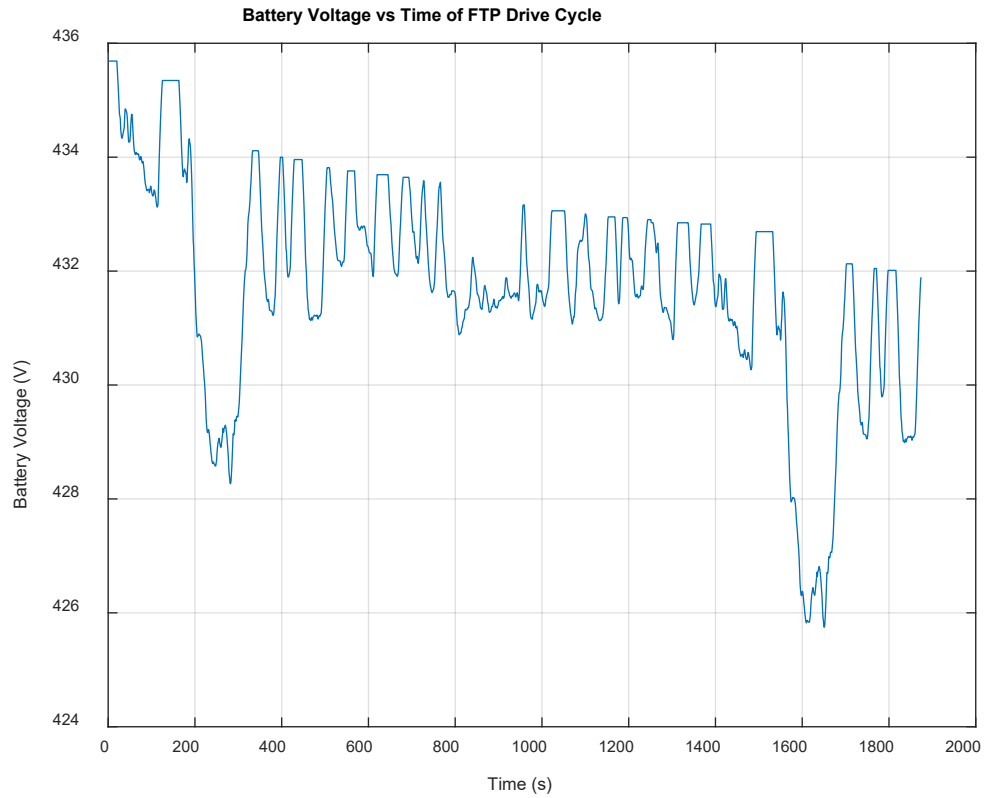


Figure 8: Battery Voltage vs Time of FTP Drive Cycle

As shown above in Figure 8, the battery voltage fluctuates based on the required current at each time step. The max voltage also trends downward because of the changing resistance based on the SOC at each time step.