Oregon State University
College of Engineering

ECE538

ELECTRIC AND HYBRIID VEHICLES

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PROJECT–02

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TANVIR ALAM SHIFAT
934371336

I. TASK 01: EFFICIENCY MAP PLOTTING

Motor's efficiency is subjected to vary based on variable speed and torque combination. In this step, 2020 Nissan Leaf's efficiency has been calculated and plotted in a 3-D plane using MATLAB's contour command. Vehicle's rated torque is 320Nm and torque values are considered for 0-320Nm with an increment of 1Nm. Rotor speed is swept from 0 to 10,000 RPM with an increment of 100 RPM in each stage. Efficiency computed for torque-speed combination has been plotted in Fig. 1.

Parameters for 2020 Nissan Leaf presented in TABLE 1.

TABLE 1: 2020 Nissan Leaf Parameters for Project 1.

Vehicle: 2020 Nissan Leaf; Vehicle Manufacturer Code: NSX; Test Vehicle ID: KWB115

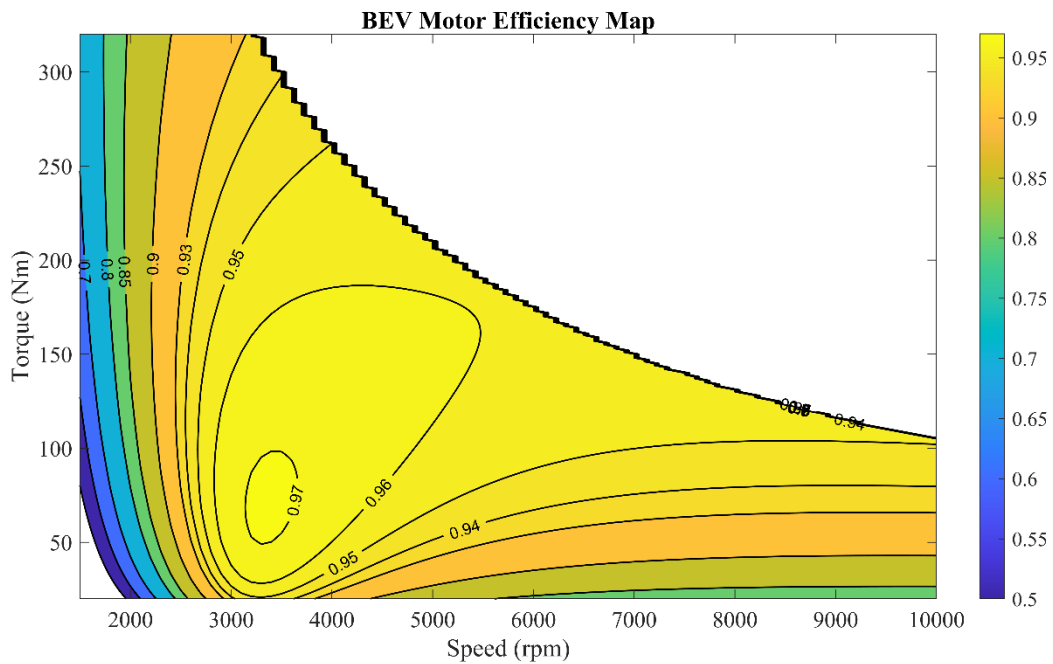| Parameter	Value	Parameter	Value
Rated power, P_{rated} [1]	110 kW	Gear ratio, n_g [1]	8.19
Wheel radius, r [2]	0.316 m	Max speed, v_{max} [3]	150 km/h
Rated torque, T_{rated} [3]	320 Nm	Parameter "A" [1]	25.89
Parameter "B" [1]	0.34490	Parameter "C" [1]	0.019450

Figure 1: Efficiency map.

II. TASK 02: TORQUE AND SPEED PROFILE OVER AN FTP DRIVE CYCLE:

In this stage, 2020 Nissan Leaf's motor speed and power is computed against time by taking into account the Federal Test Procedure (FTP) drive cycle data. It has a total of 1875s of data with four different segments. Details of the dataset can be found in [4].

Speeds in different stages are converted into RPM and plotted against time in Fig. 2. It is evident that the vehicle is accelerating during the rise of speed and decelerating during the fall of speed curve. Similarly, the torque produced by the motor is +ve, -ve, and zero for acceleration, deceleration, and standstill conditions, respectively. Motor torque is for the FTP drive cycle is shown in Fig. 3.
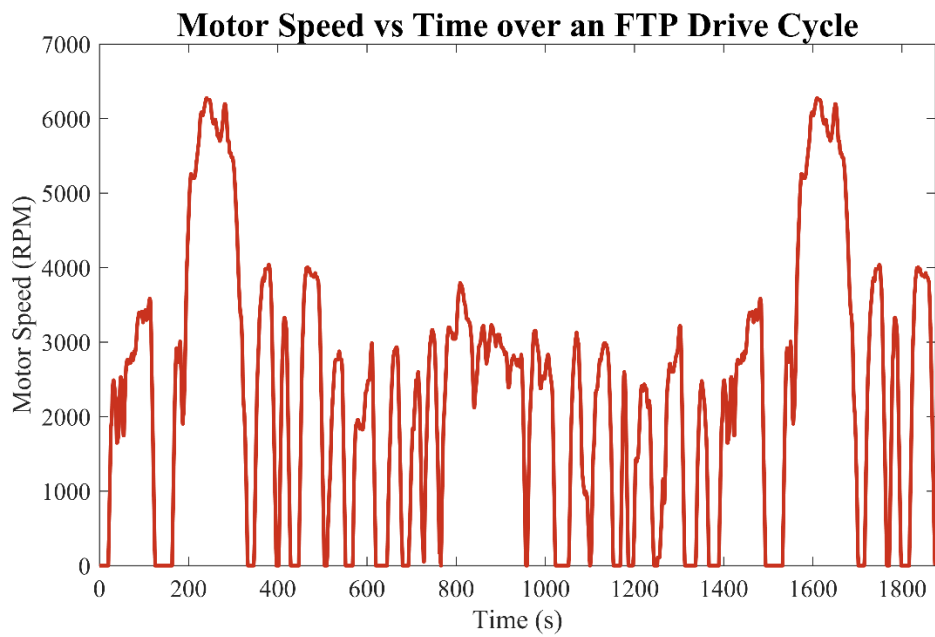

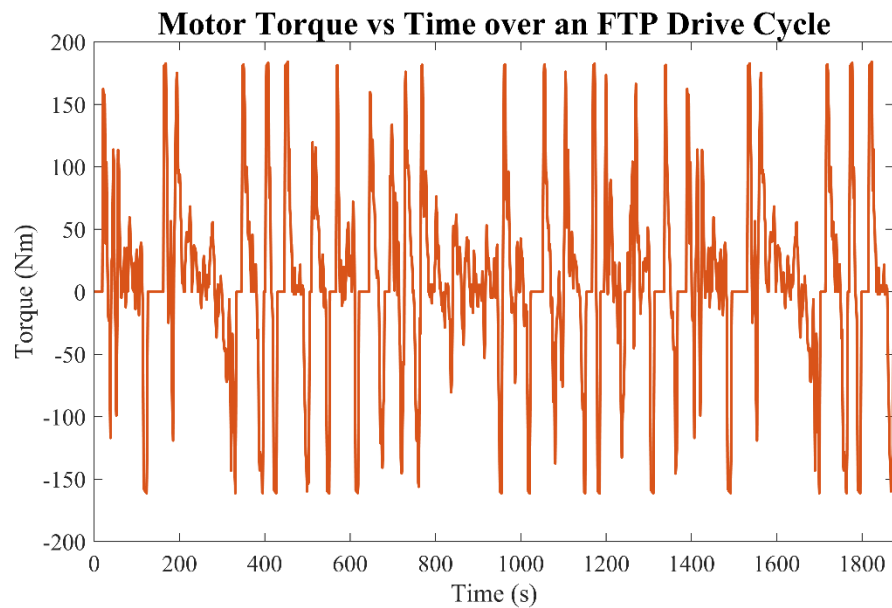Figure 2: Motor speed (RPM) vs time.

Figure 3: Motor speed (RPM) vs time.

III. TASK 03: POWER AND ENERGY PROFILE:

A range of RPM has been chosen from the FTP drive cycle data for the BEV motor. Some of these RPM values are over the rated RPM values which will require to consider the field weakening current to reduce the back emf voltage. This current is referred as the direct axis (d-axis) current, $I_{ph,d}$. Therefore, the total current is computed as the sum of $I_{ph,d}$ and $I_{ph,q}$ components. However, $I_{ph,d}=0$ when the motor speed is less than the rated speed. Thus, motor efficiency is determined by taking the ratio of P_{rrated} and P_{in}.

On the other hand, from the given FTP drive cycle speed, axle force and torque are determined by following equations:

$$F_{axle} = A + Bv + Cv^2$$

$$T_{axle} = F_{axle} \times r + J\frac{d\omega}{dt}$$

Where A, B, and C are the coast-down coefficients. 'r' is the wheel radius.

Also, the rotor speed is determined for different acceleration profiles by using the following equations.

For acceleration:

$$T_{shaft} = \frac{T_{axle}}{n_g \times \eta_g}$$

For deceleration/regeneration:

$$T_{shaft} = \frac{T_{axle} \times \eta_g}{n_g}$$

Where, n_g is the gear ratio and η_g is the efficiency.

Later, for each torque-speed pair, the efficiency is found from the efficiency map and the input power is computed by dividing the output power, P_{out} by the corresponding efficiency number. Motor input power, output power and the instantaneous efficiency are illustrated in Fig. 4.

Finally, the power is integrated over time to get the cumulative energy. Input energy and output energy over time are shown in Fig. 5.
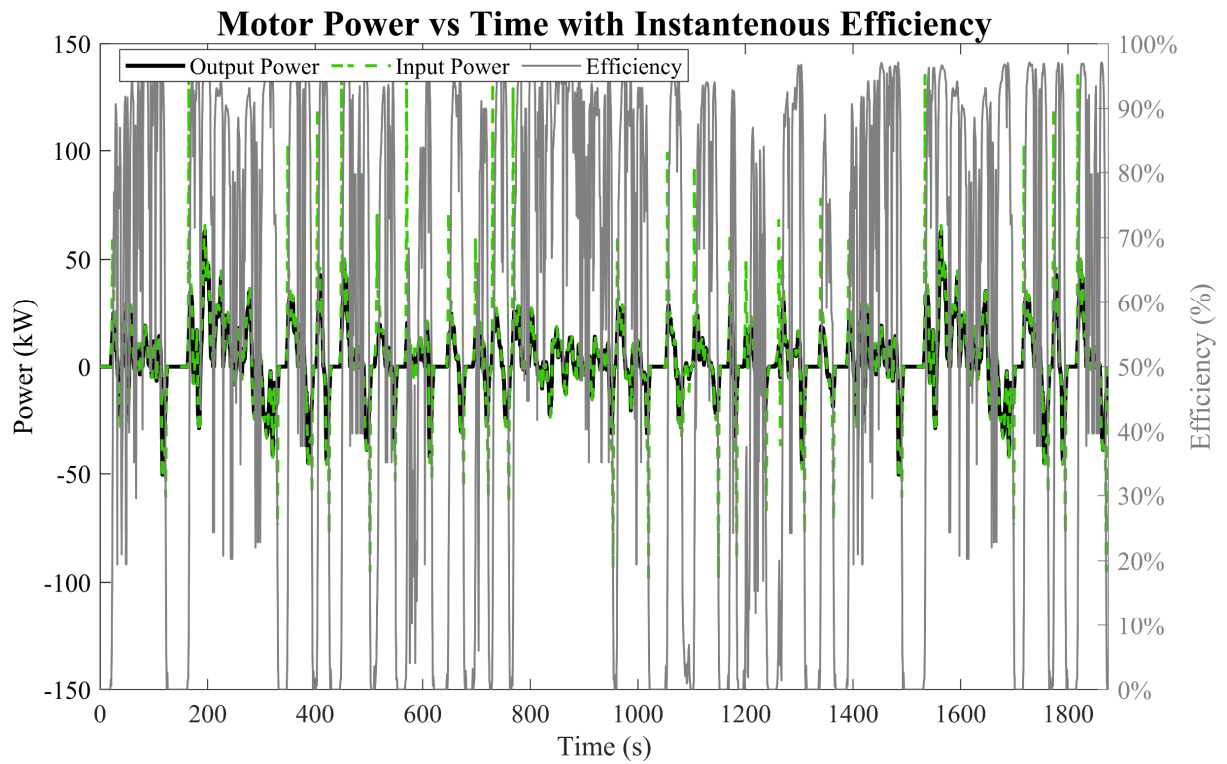
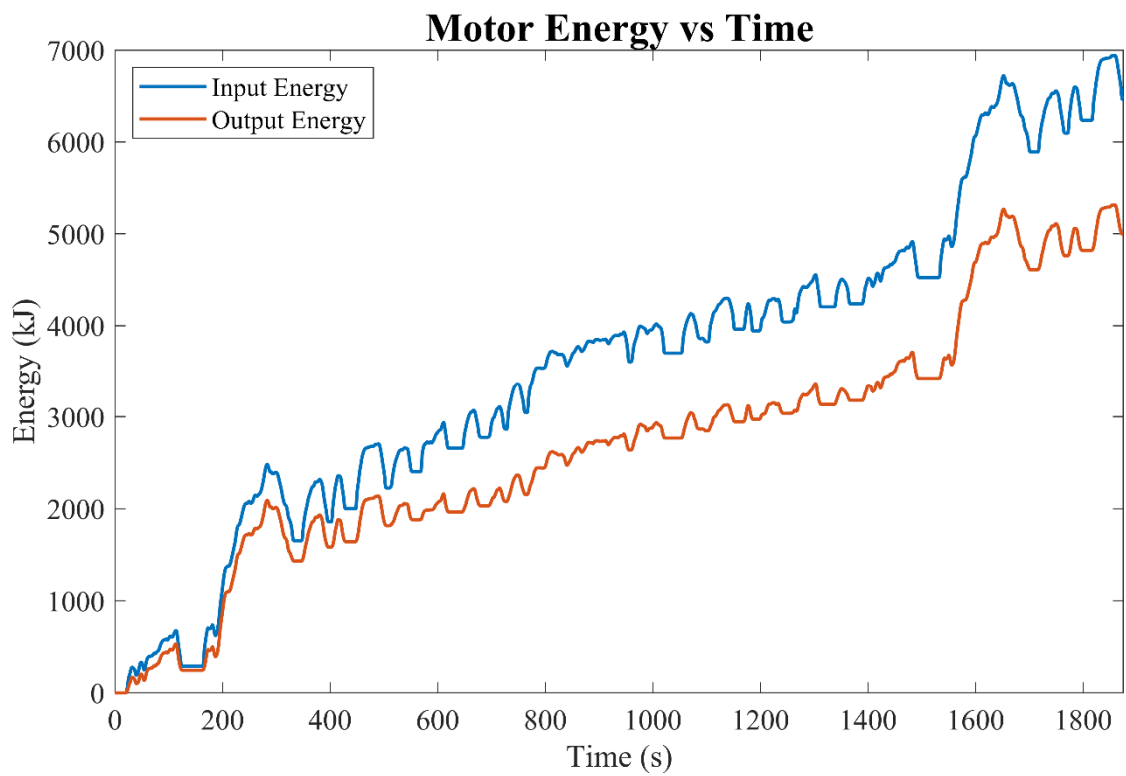Figure 4: Motor Power and instantaneous efficiency vs. time.

Figure 5: Motor speed (RPM) vs time.

REFERENCES

[1] EPA. [Online]. Available: https://www.epa.gov/compliance-and-fuel-economy-data. [Accessed: 13-Feb-2022].

[2] "Nissan Leaf Tire Sizes," tiresize.com. https://tiresize.com/tires/Nissan/Leaf/ (accessed Feb. 13, 2022).

[3] "2020 Nissan Leaf - driven @ top speed," Top Speed, 13-Aug-2020. [Online]. Available: https://www.topspeed.com/cars/nissan/2020-nissan-leaf-driven-ar189115.html. [Accessed: 13-Feb-2022].

[4] Dieselnet.com. 2022. Emission Test Cycles: FTP-75. [online] Available at: <https://dieselnet.com/standards/cycles/ftp75.php> [Accessed 13 February 2022].

[5] Hayes, John G., and G. Abas Goodarzi. "Electric powertrain: energy systems, power electronics and drives for hybrid, electric and fuel cell vehicles." (2018), pp 40-62.