2021

PE Assignment

EV simulation model

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1. Validation of acceleration specification using a basic EV simulation model

a) Acceleration time calculation:

$$p_{\bar{v}max} = p_{vmax} - p_r(v_f) = p_{vmax} - C_r M_v g v_f - \frac{1}{2} C_d \rho A_v V_f^3$$

$$p_{\bar{v}max} = 80000 - 0.01 * 1620 * 9.81 * 26.82 - \frac{1}{2} * 0.29 * 1.204 * 2.75 * (26.82)^3$$

$$= 66475.73911\ W$$

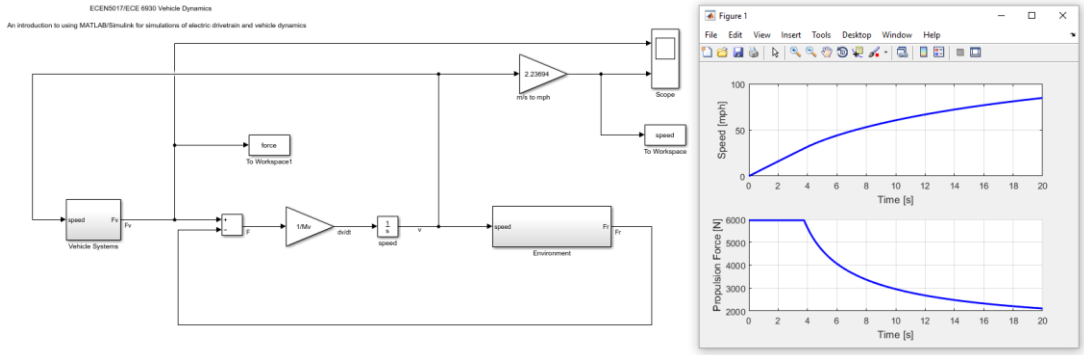
$$t_a = \frac{\frac{1}{2} M_v (v_f^2 + v_b^2)}{p_{\bar{v}max}} = \frac{\frac{1}{2} * 1620 * (26.82^2 + 13.411\text{^}2)}{66475.73911} = 10.95s$$

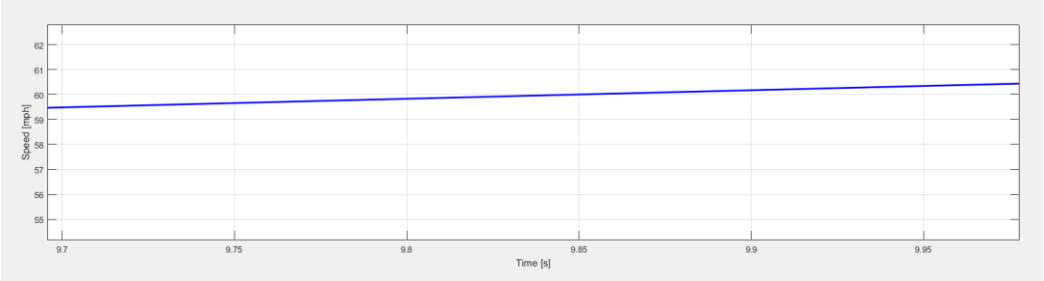
a) The total energy required from the battery to accelerate from 0 to 60 MPH:

$$Etot = \int_0^{ta} P_v = P_{avg} \frac{t_{trip}}{\eta} = \frac{1}{2} * 8 * \frac{10^4 (10.95 - 3.60 + 10.95)}{0.8} = \frac{640000}{3600000 * 0.8}$$

$$= 0.254\ kwh$$

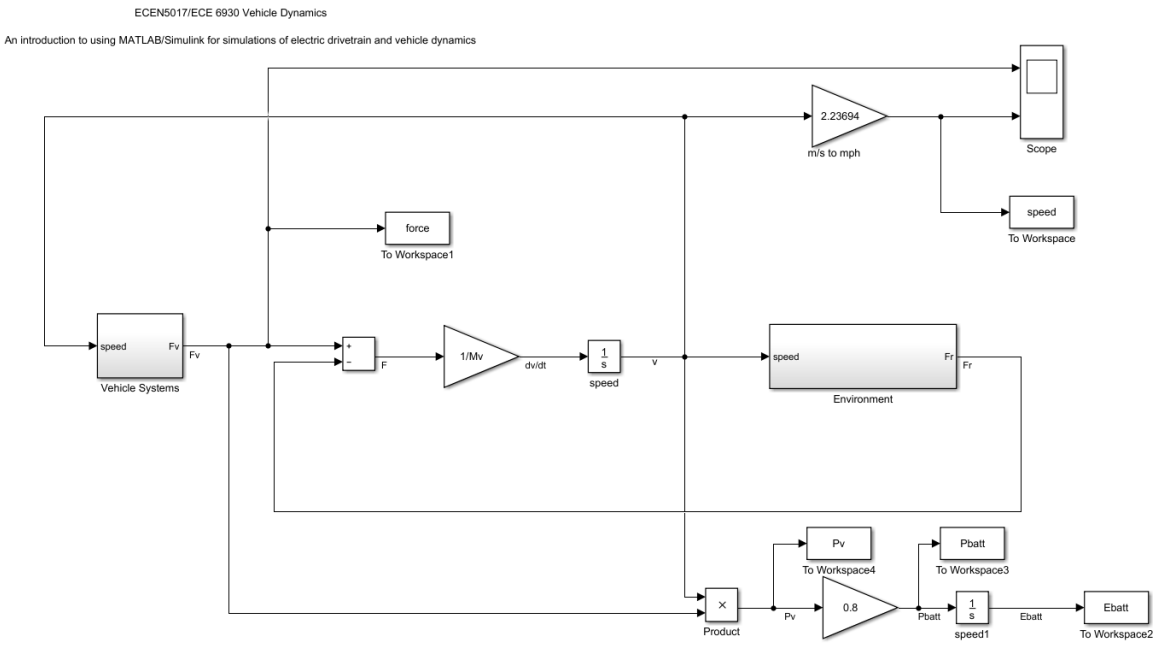
b) Simulation of the model in **VehicleDynamics2.mdl**





Form speed-time curve $t_a = 9.85\ s$

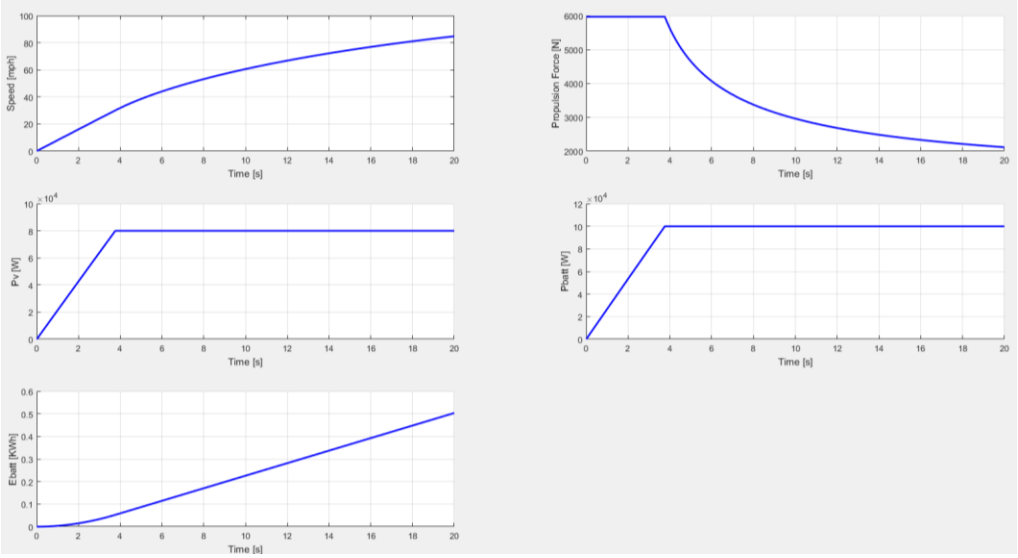
c) Modification of **VehicleDynamics2.mdl**

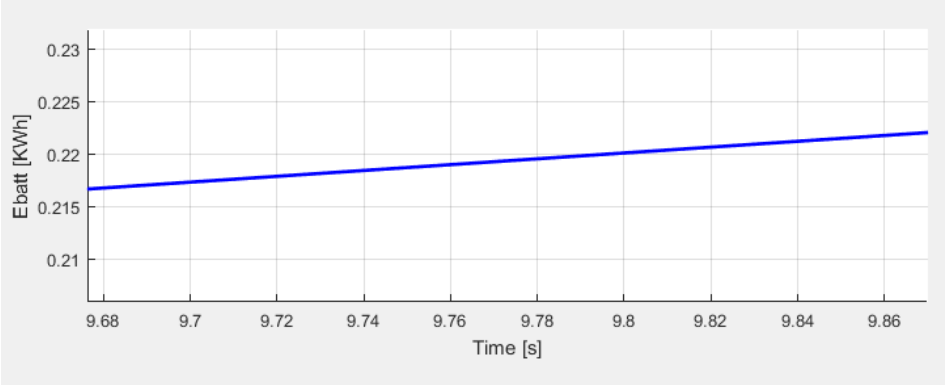


Modification the **PlotEVData.m** file

```
subplot(3,2,1);
plot(speed.time, speed.signals.values(:,1), 'b', 'LineWidth', 2);
ylabel('Speed [mph]');
xlabel('Time [s]');
grid on;

subplot(3,2,2);
hold on;
plot(force.time, force.signals.values(:,1), 'b', 'LineWidth', 2);
ylabel('Propulsion Force [N]');
xlabel('Time [s]');
grid on;

subplot(3,2,3);
hold on;
plot(Pv.time, Pv.data(:,1), 'b', 'LineWidth', 2);
ylabel('Pv [W]');
xlabel('Time [s]');
grid on;

subplot(3,2,4);
hold on;
plot(Pbatt.time, Pbatt.data(:,1), 'b', 'LineWidth', 2);
ylabel('Pbatt [W]');
xlabel('Time [s]');
grid on;

subplot(3,2,5);
hold on;
plot(Ebatt.time, Ebatt.data(:,1), 'b', 'LineWidth', 2);
ylabel('Ebatt [Wh]');
xlabel('Time [s]');
grid on;
```

Simulation Results:





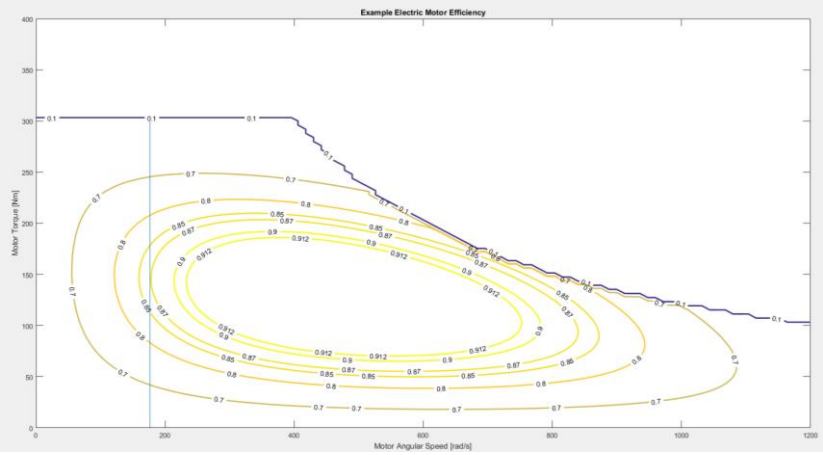
From the previous results $E_{batt} = 0.222\ kwh$

2. System Simulation of Leaf-Sized Electric Vehicle

a) Vehicle speed = 20 mph = 8.94 m/s

$$w_v = \frac{v}{r_w} = \frac{8.94}{0.4} = 22.5\ rad/s$$
$$w_e = g_{ratio} * w_v = 7.94 * 22.5 = 178.7\ rad/s$$
$$\eta_m = 87\%$$

From the contour line curve:



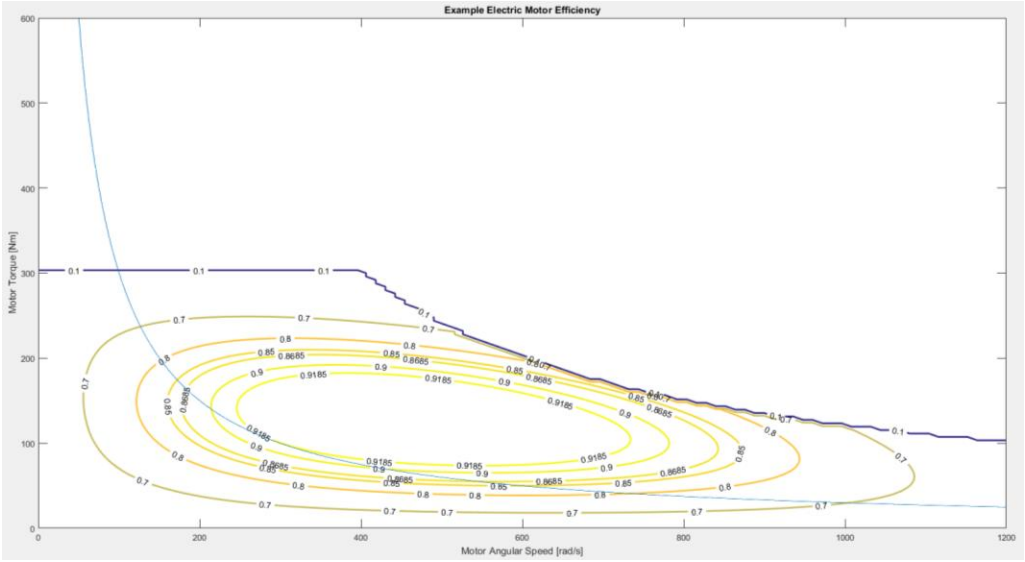
$$\eta = 0.865 = 0.87$$

$$T_e = 144\ N.m$$
$$T_v = Te * g_{ratio} = 144 * 7.94 = 1143.36\ N.m$$
$$F_r = C_r M_v g + \frac{1}{2} C_d \rho A_v V^2 = 0.01 * 1620 * 9.81 + 0.5 * 0.29\ * 1.204\ * 2.75 * 8.94^2$$
$$= 197.3\ N$$
$$P_r = Fr * v = 1763.862\ w$$
$$\eta_{tw} = \eta_{DC-DC}\ \eta_{inv}\ \eta_m\ \eta_{transimission} = 0.98 * 0.95 * 0.87 * 1 = 0.81$$
$$\eta_{tw} = \frac{P_v}{P_{bat}} = 0.81$$
$$P_{batt} = 31.54\ kw$$

$$P_v = W_e T_e = 178.5 * 144 = 25704\ W = 25.704\ W$$

$$P_v - P_r = \frac{M_v v dv}{dt}$$
$$\frac{dv}{dt} = \frac{P_v - P_r}{M_v\ v} = \frac{25.704 - 1763.862}{1620 * 8.94} = 1.65\ m/s^2$$

b) $v = 20\,mph \quad P_v = 30\,kw \quad w_v = 22.5$

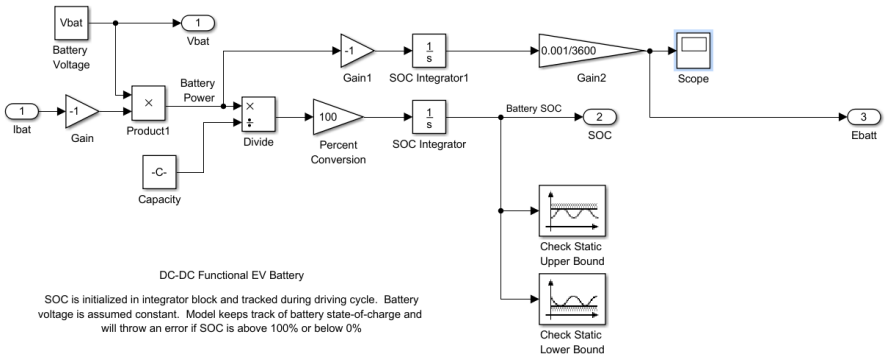


From the curve:

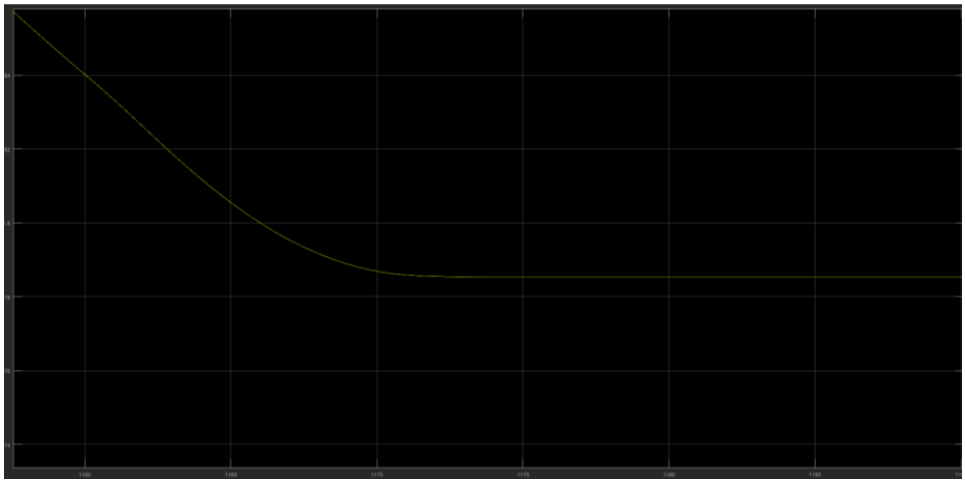
$$\eta = 0.9185$$
$$T_e = 102\ N.m$$

$$F_v = \frac{P_v}{v} = \frac{30000}{8.94} = 3355.7\ N$$
$$T_v = F_v * r_w = 1342.28\ N.m$$
$$g_{ratio} = \frac{T_v}{T_e} = \frac{1342.28}{102} = 13.15$$

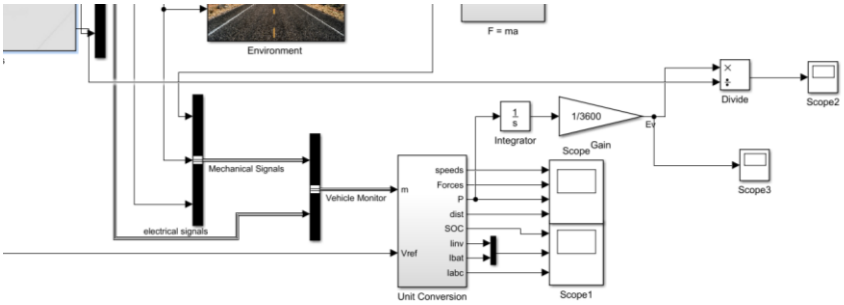
c) **At $g_{ratio} = 7.94$**
power integration to get Ebatt:



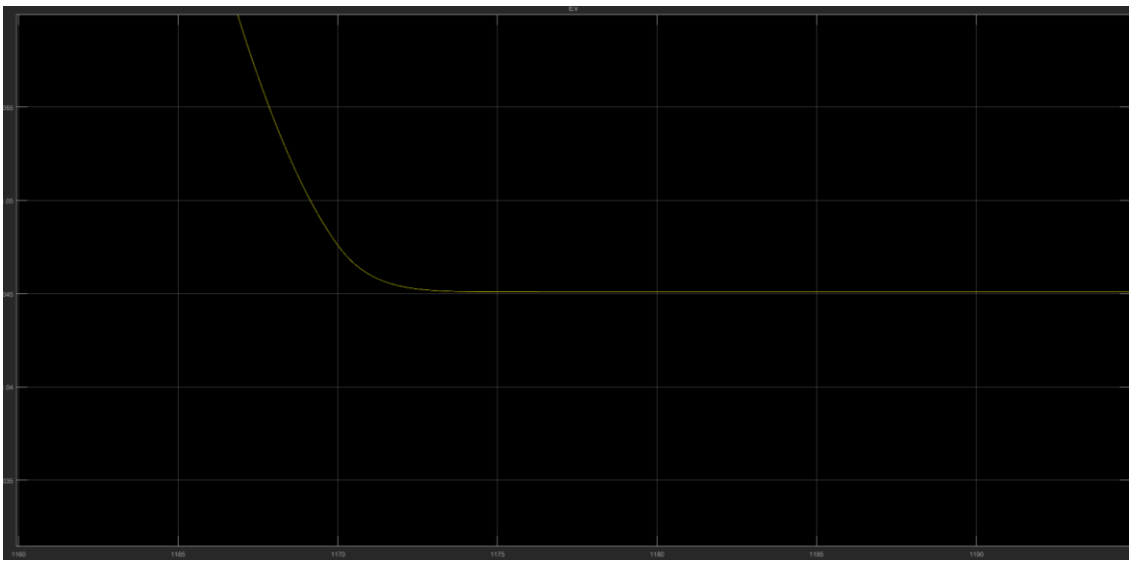
The results Ebatt = 1.7 kwh



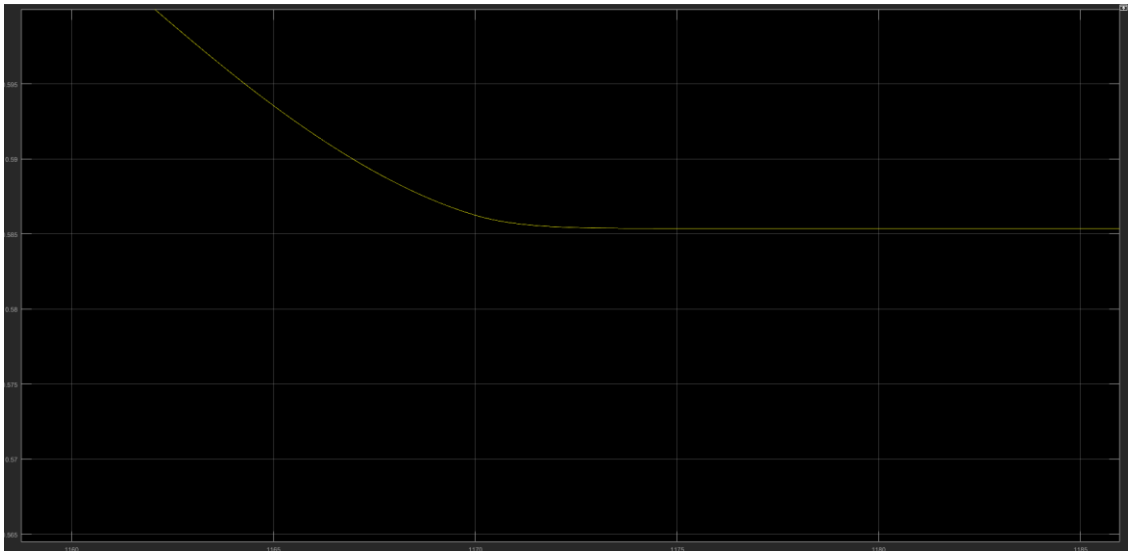
Power integration to get Ev:



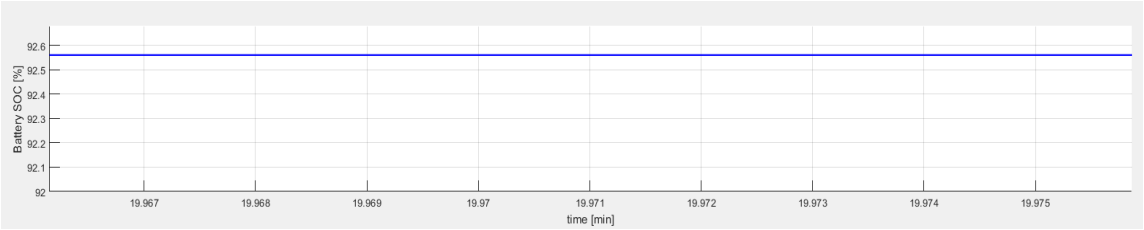
The results Ev = 1.045 kwh



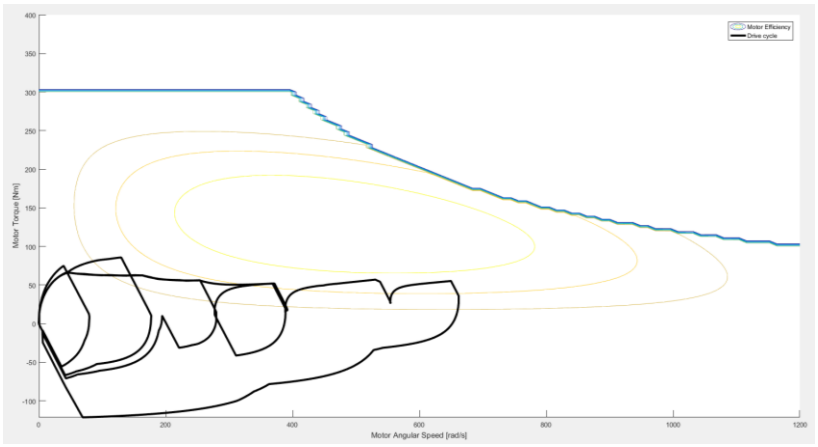
The Efficiency $\eta = 58.5\%$

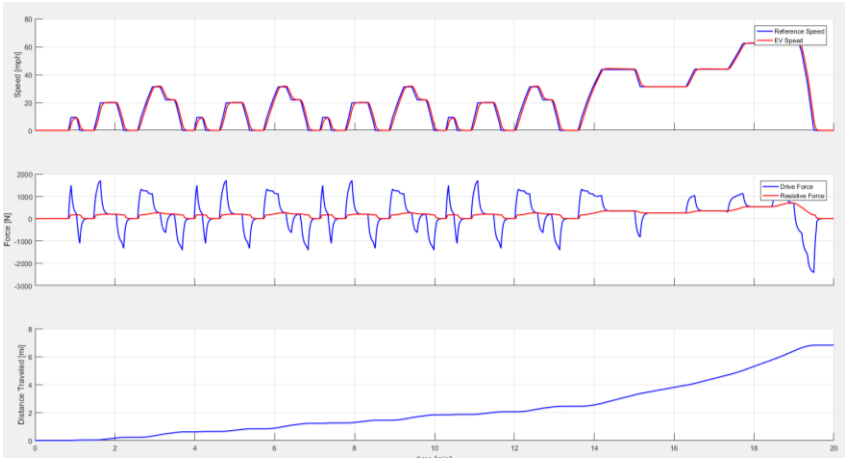


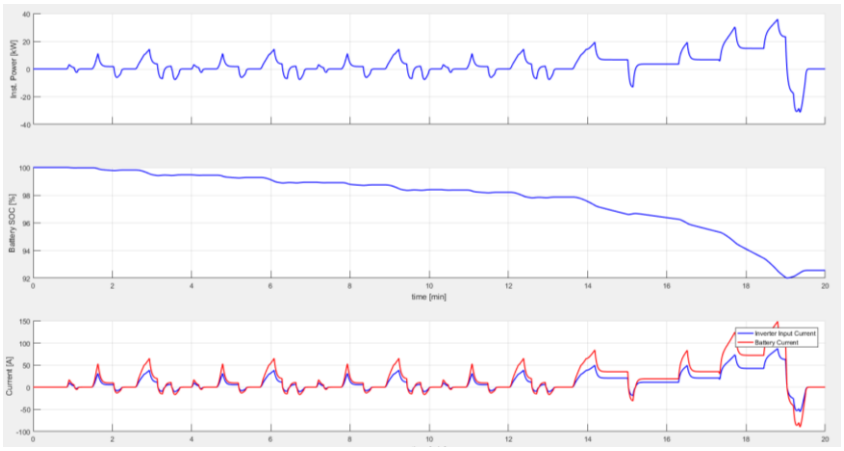
battery state of charge (SOC) at the end of the cycle = %92.6



$$MPGe = 33.7 * \frac{Distance}{Ebatt} = 33.7 * \frac{6.8}{1.7} = 134.8\ MPGe$$

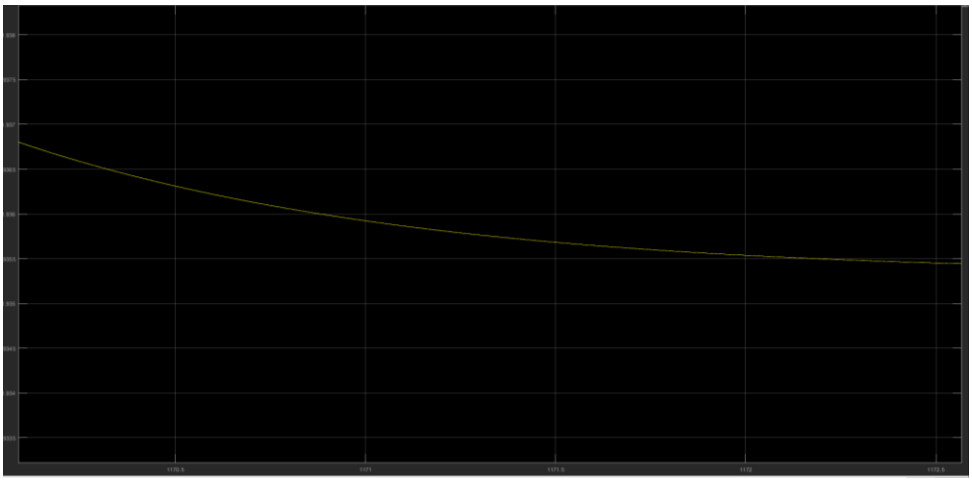

Motor Efficiency
Drive cycle
Motor Torque [Nm]
Motor Angular Speed [rad/s]


Reference Speed
EV Speed
Speed [mph]
Drive Force
Resistive Force
Force [N]
Distance Traveled [mi]

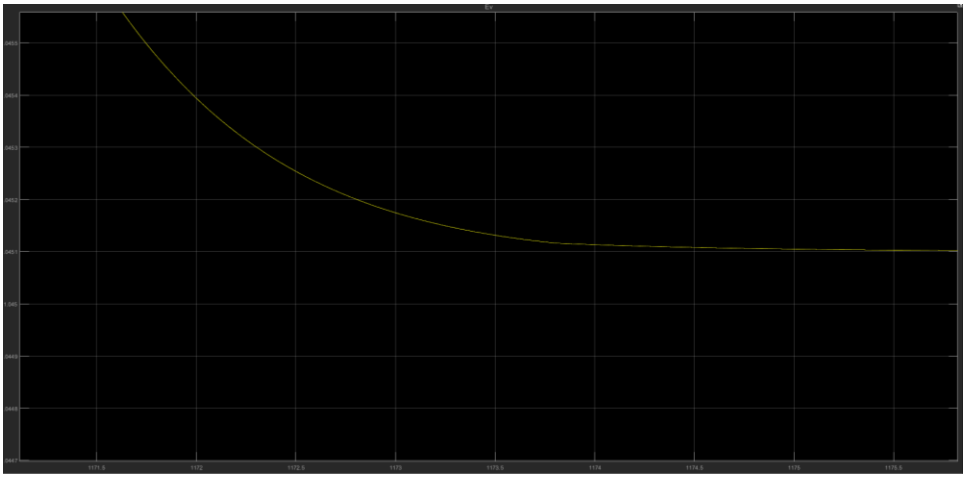

Inst. Power [kW]
Battery SOC [%]
time [min]
Inverter Input Current
Battery Current
Current [A]

At $g_{ratio} = 13.15$

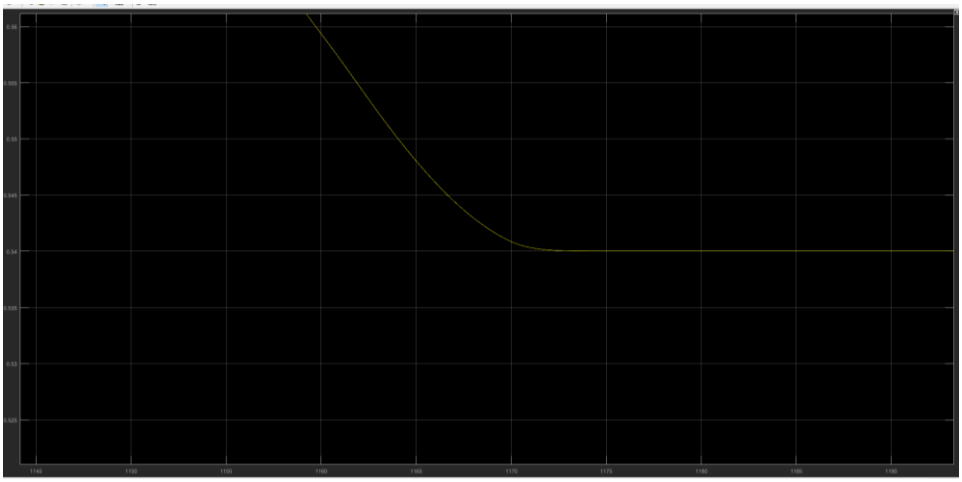
The result Ebatt = 1.935 kwh



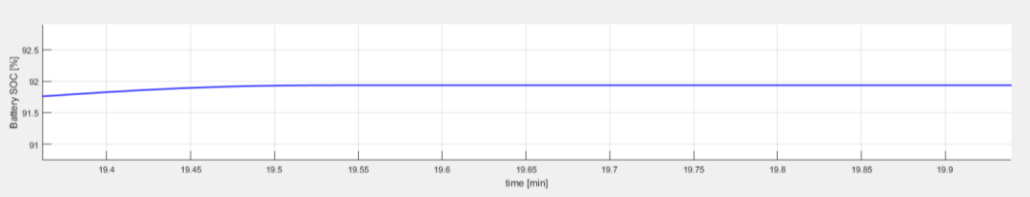
The result Ev = 1.045 kwh



The Efficiency $\eta = 54\%$



battery state of charge (SOC) at the end of the cycle = %92



$$MPGe = 33.7 * \frac{Distance}{Ebatt} = 33.7 * \frac{6.8}{1.935} = 118.4289\ MPGe$$