	CAIRO UNIVERSITY		FACULTY OF ENGINEERING
4th Year			
Course: Electrical Power Systems (3) (EPE4010)			

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Assignment no.: HW1 - HW2

Instructor: Dr. Mohamed Rabah

Date: 26/12/2023

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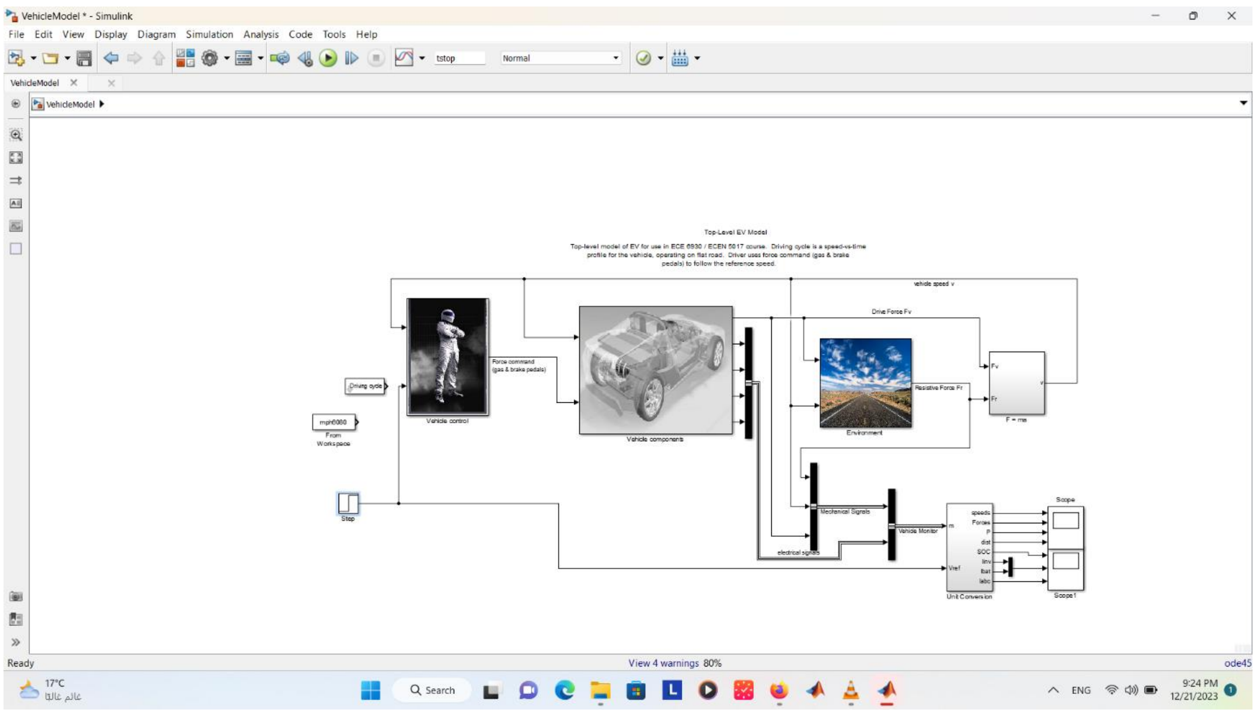
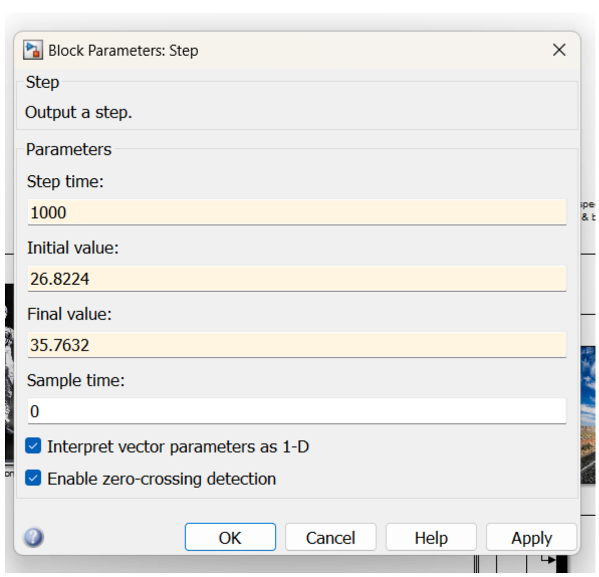
HW1

Acceleration time from 60mph – 80mph:

System Modification:

Modification of the input drive cycle to step input changes from 60mph (26.82 m/s) to 80mph (35.76 m/s) to test the response of the model and the acceleration time needed to reach 80mph.





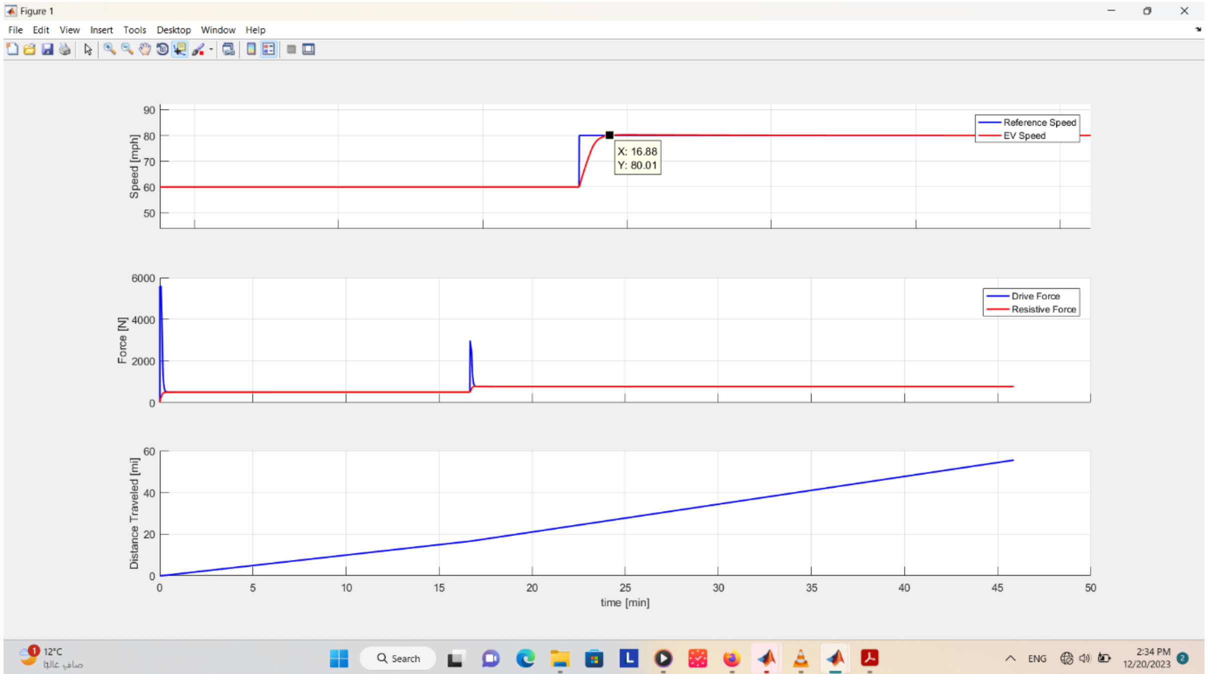
Initiation model:

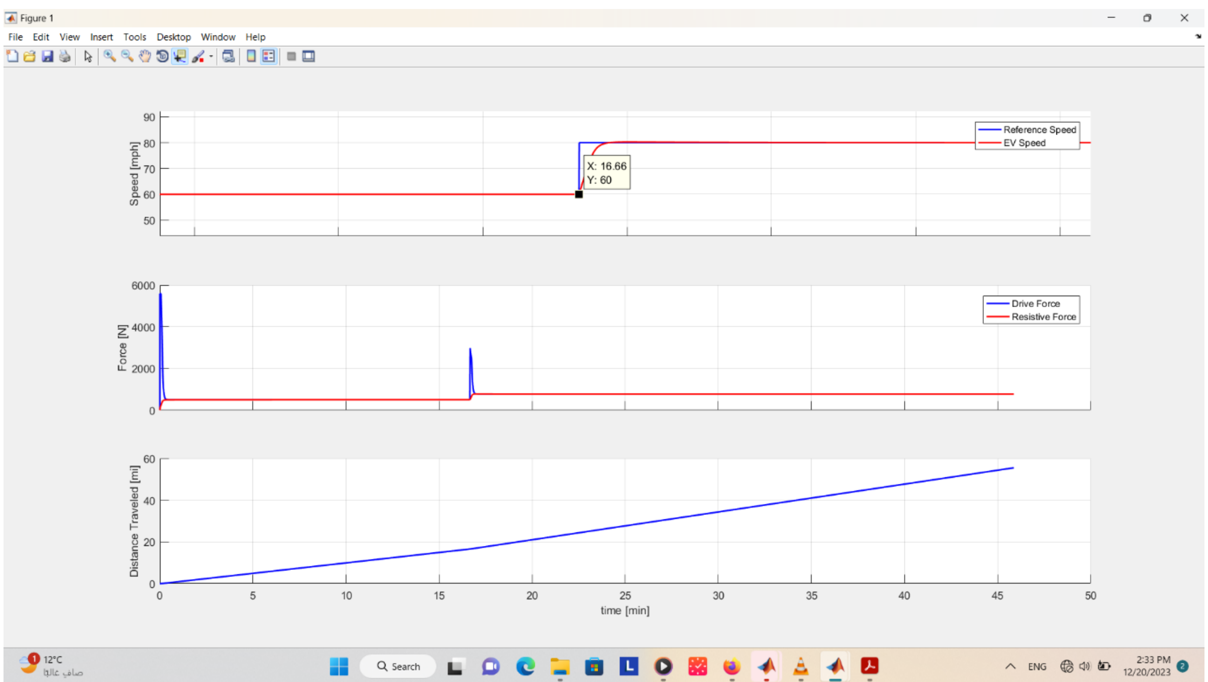
Editor - D:\CUFE Courses\Electric_Vehicles\EVModel\test\EVModel\InitiateModel.m

InitiateModel.m

```matlab

%% Battery Model Parameters
Capacity = 24e3*60*60;        % Battery pack capacity [J] = Wh*60*60
SOC_0 = 100;                 % Initial battery state of charge [%]
Vbat = 300;                  % battery pack nominal voltage [V]

%% Electric Motor Parameters
load MotorEff;               % Electric Motor Efficiency Data
Ke = 0.407;                  % Torque Constant [Nm/A]
Pe_max = 80e3;               % Maximum Motor Power [W]
Vbase = 32*0.44704;          % Base speed [m/s] = MPH * 0.44704
Te_max = Pe_max*rw/gratio/Vbase;     % Maximum motor torque [Nm]
Fv_max = Te_max*gratio/rw;     % Maximum vehicle tractive force [N]
VbaseMPH = Vbase/0.44704;    % Base speed [mph]

%% DC-DC Converter Parameters
eta_DC = .98;                % DC-DC Converter Efficiency (constant)
Vbus_ref = 500;              % DC Bus Voltage Reference (constant) [V]

%% Inverter Parameters
eta_inv = .95;               % Inverter Efficiency (constant)

%% Vehicle physical parameters
Mv = 1620; % Vehicle curb weight + 250 kg passenger and cargo
Cd = 0.29;                   % Coefficient of Drag
Cr = 0.01;                   % Coefficient of Friction
Av = 2.75;                   % Front area [m^2]
rho_air = 1.204;             % Air density [kg/m^3]

```

Results:



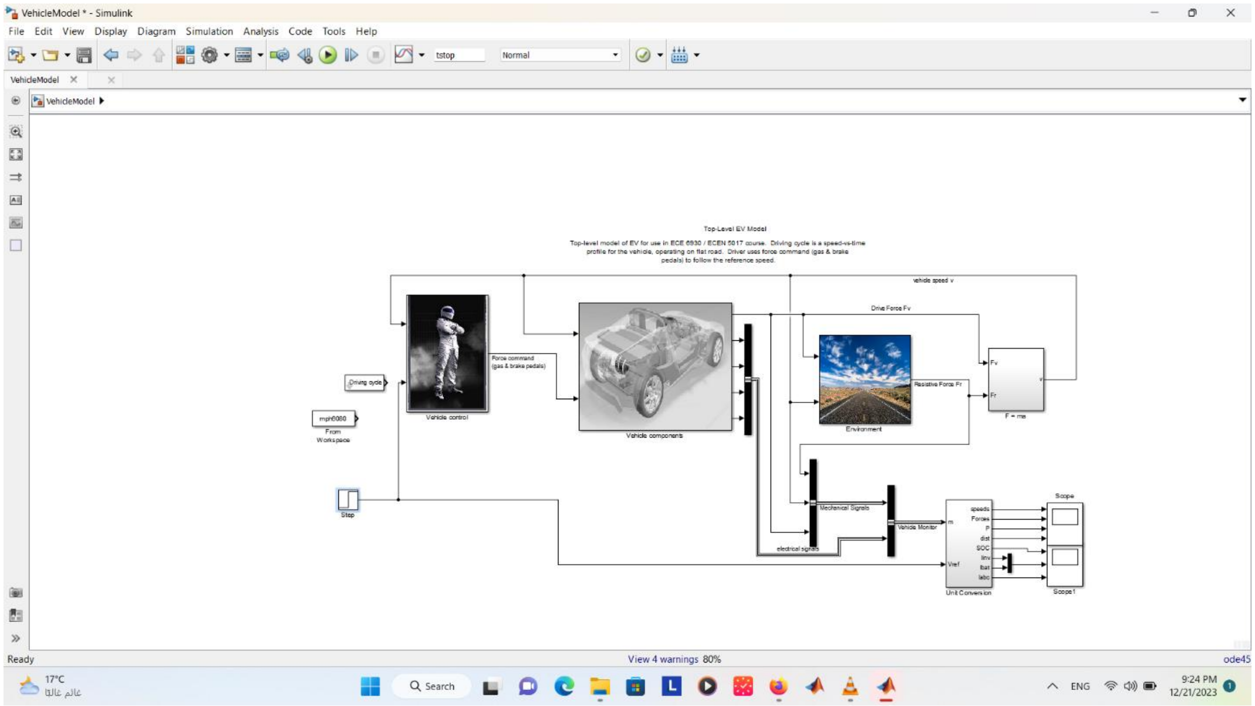


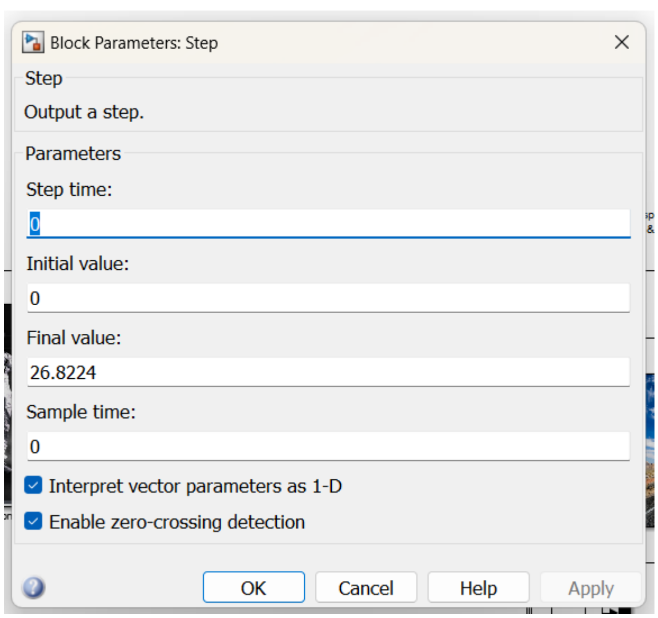
$T_a = (16.88 - 16.66) * 60 = 13.2$ sec

Acceleration time from 0 mph – 60mph:

System Modification:

Modification of the input drive cycle to step input changes from 0 mph (0 m/s) to 60mph (26.82 m/s) to test the response of the model and the acceleration time needed to reach 0 mph.





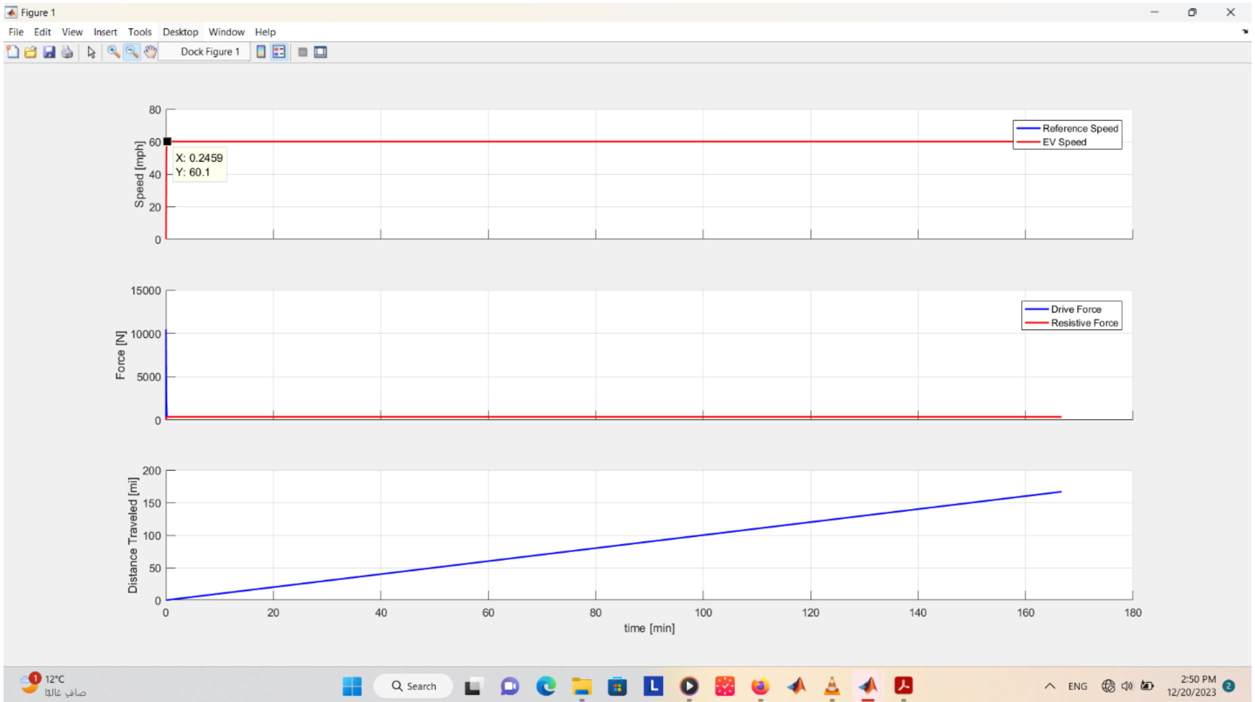
Initiation Model:

Editor - D:\CUFE Courses\Electric_Vehicles\EVModel\EVModel\InitiateModel.m

InitiateModel.m

```matlab

%% Battery Model Parameters
Capacity = 60e3*60*60;        % Battery pack capacity [J] = Wh*60*60
SOC_0 = 100;                 % Initial battery state of charge [%]
Vbat = 300;                  % battery pack nominal voltage [V]

%% Electric Motor Parameters
load MotorEff;               % Electric Motor Efficiency Data
Ke = 0.407;                  % Torque Constant [Nm/A]
Pe_max = 225e3;               % Maximum Motor Power [W]
Vbase = 48.21*0.44704;          % Base speed [m/s] = MPH * 0.44704
Te_max = Pe_max*rw/gratio/Vbase;     % Maximum motor torque [Nm]
Fv_max = Te_max*gratio/rw;    % Maximum vehicle tractive force [N]
VbaseMPH = Vbase/0.44704;    % Base speed [mph]

%% DC-DC Converter Parameters
eta_DC = .98;                % DC-DC Converter Efficiency (constant)
Vbus_ref = 500;              % DC Bus Voltage Reference (constant) [V]

%% Inverter Parameters
eta_inv = .95;               % Inverter Efficiency (constant)

%% Vehicle physical parameters
Mv = 1235; % Vehicle curb weight + 250 kg passenger and cargo
Cd = 0.23;                   % Coefficient of Drag
Cr = 0.013;                   % Coefficient of Friction
Av = 2;                   % Front area [m^2]
rho_air = 1.204;             % Air density [kg/m^3]

```

Results:



Ta = 0.2459 * 60 = 14.754 sec

HW2

Basic EV model development to validate acceleration specification.

Validation of acceleration specification using a basic EV simulation model

INITIAL CONDITIONS


```matlab
%% load driving cycles
thisPath = strrep(mfilename('fullpath'),mfilename,'');
addpath([thisPath 'images']);
addpath([thisPath 'drivingCycles']);
load eudc;                    % simulation time: 1200
load us06;                    % simulation time: 600
load udds;                    % simulation time: 1380
load hwy;                     % simulation time: 780
load mph60;                   % simulation time: 10000


%% Simulation Parameters
tstop = 1200;                   % simulation run time [sec]
tstep = .01;                  % maximum simulation step [sec]

%% Driver model parameters
Ti = 50;                      % integral time constant
Kv = 650;                     % proportional gain

%% Transmission Parameters
gratio = 7.94;                % Transmission reduction ratio

%% Wheel Parameters
rw = 0.4;                     % wheel radius [m]

%% Battery Model Parameters
Capacity = 24e3*60*60;         % Battery pack capacity [J] = Wh*60*60
SOC_0 = 100;                  % Initial battery state of charge [%]
Vbat = 300;                   % battery pack nominal voltage [V]

%% Electric Motor Parameters
load MotorEff;                % Electric Motor Efficiency Data
Ke = 0.407;                   % Torque Constant [Nm/A]
Pe_max = 80e3;                % Maximum Motor Power [W]
Vbase = 30*0.44704;           % Base speed [m/s] = MPH * 0.44704
Te_max = Pe_max*rw/gratio/Vbase;    % Maximum motor torque [Nm]
Fv_max = Te_max*gratio/rw;     % Maximum vehicle tractive force [N]
VbaseMPH = Vbase/0.44704;     % Base speed [mph]

%% DC-DC Converter Parameters
eta_DC = .98;                 % DC-DC Converter Efficiency (constant)
Vbus_ref = 500;               % DC Bus Voltage Reference (constant) [V]

%% Inverter Parameters
eta_inv = .95;                % Inverter Efficiency (constant)

%% Vehicle physical parameters
Mv = 1620; % Vehicle curb weight + 250 kg passenger and cargo
Cd = 0.29;                    % Coefficient of Drag
Cr = 0.01;                    % Coefficient of Friction
Av = 2.75;                    % Front area [m^2]
```

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```
rho_air = 1.204;            % Air density [kg/m^3]
```

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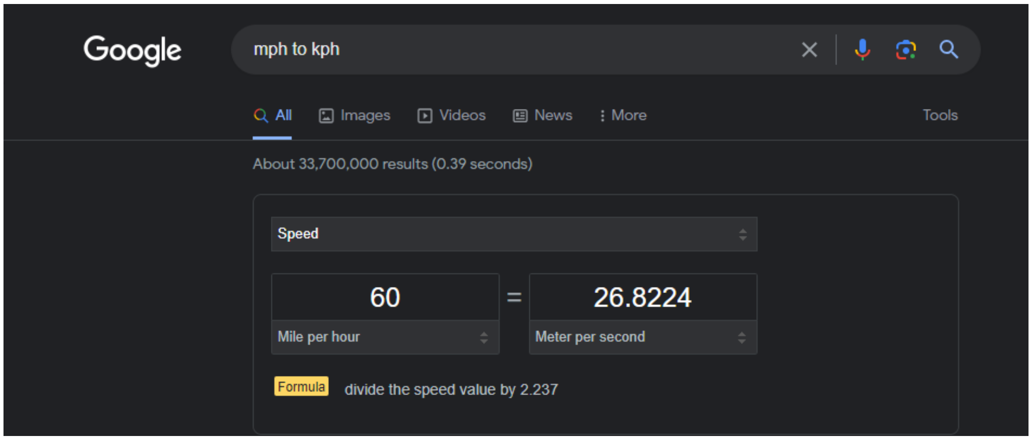
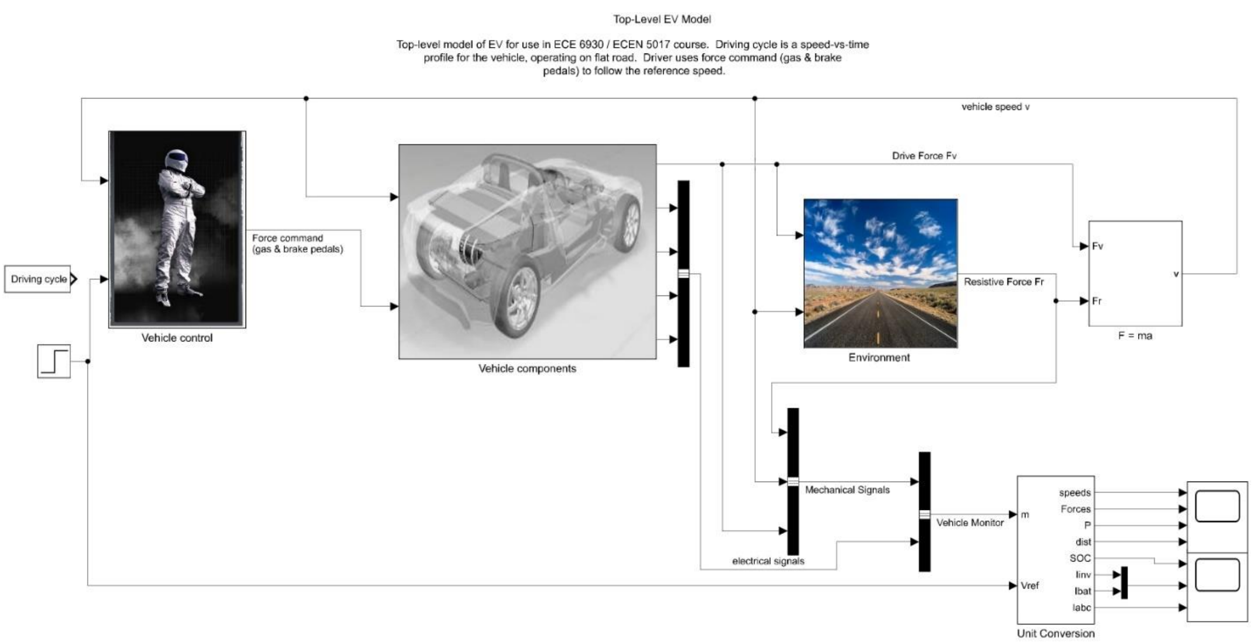
Verify the analytical results of (a) via simulation using the following steps:

N.B. 1: a) Solve the approximate accelerate time ta from 0 to 60 MPH.

N.B. 2: 60MPH = 26.8224 M/S.



Build the basic EV Simulink simulation model described in the "Intro to MATLAB/Simulink" supplementary lecture (posted online with the course lectures)



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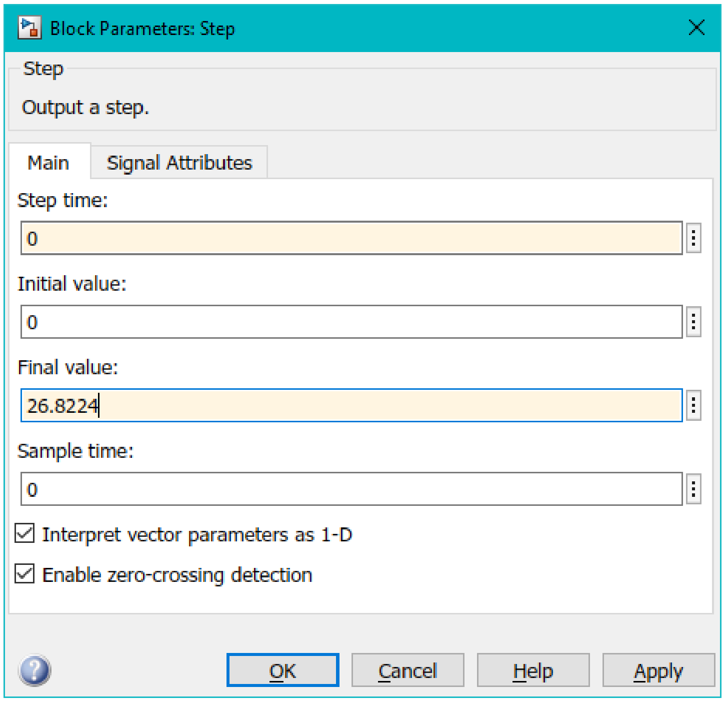
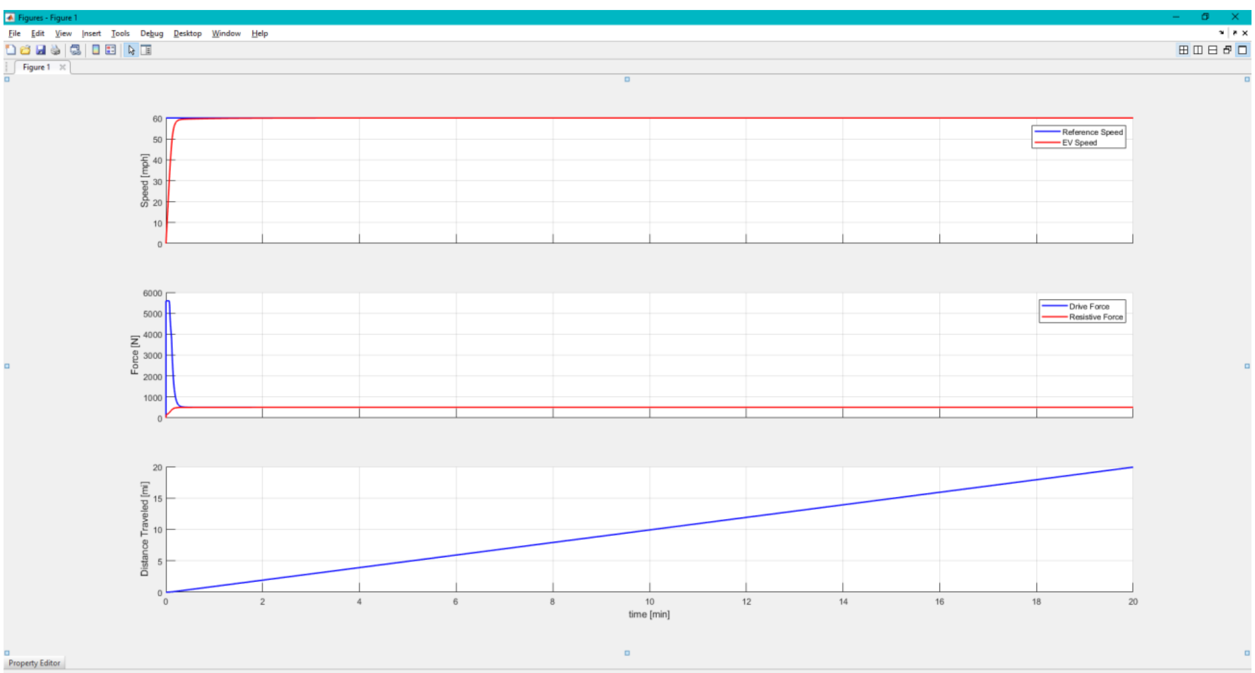
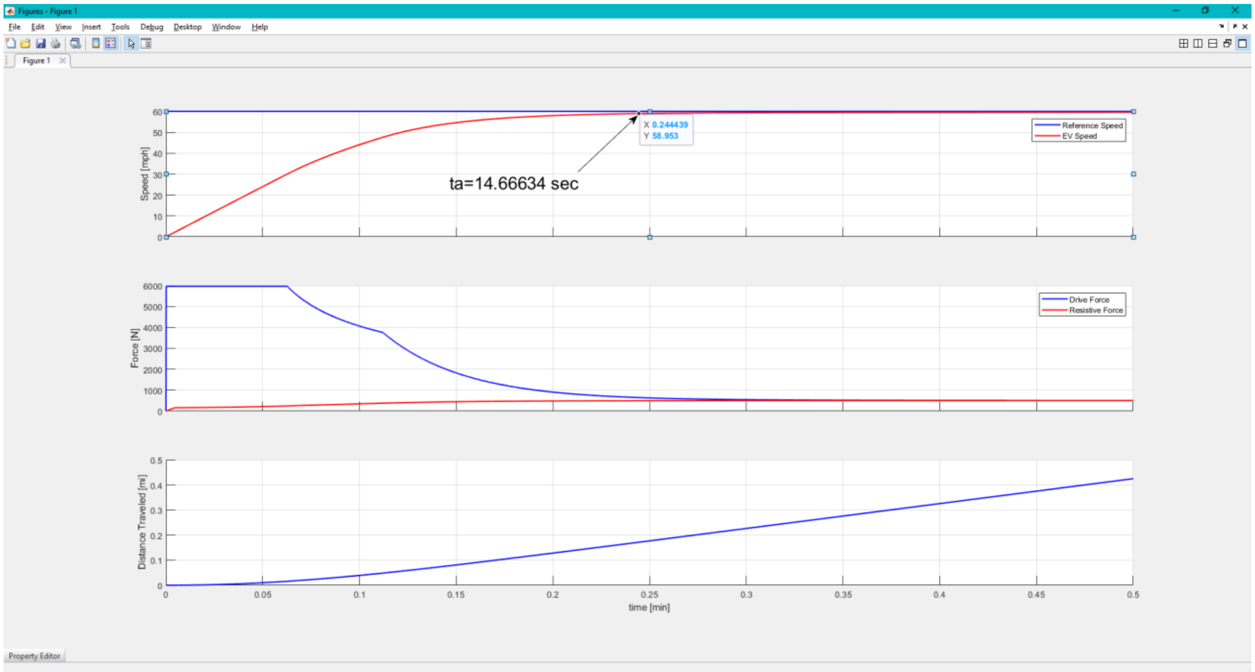


Simulate the model with the parameters above and show the resulting plot with speed v [mph] and tractive propulsion force Fv [N] and the solved acceleration time ta.

OUTPUTS OF THE SIMULATION (v, Fv, DISTANCE)

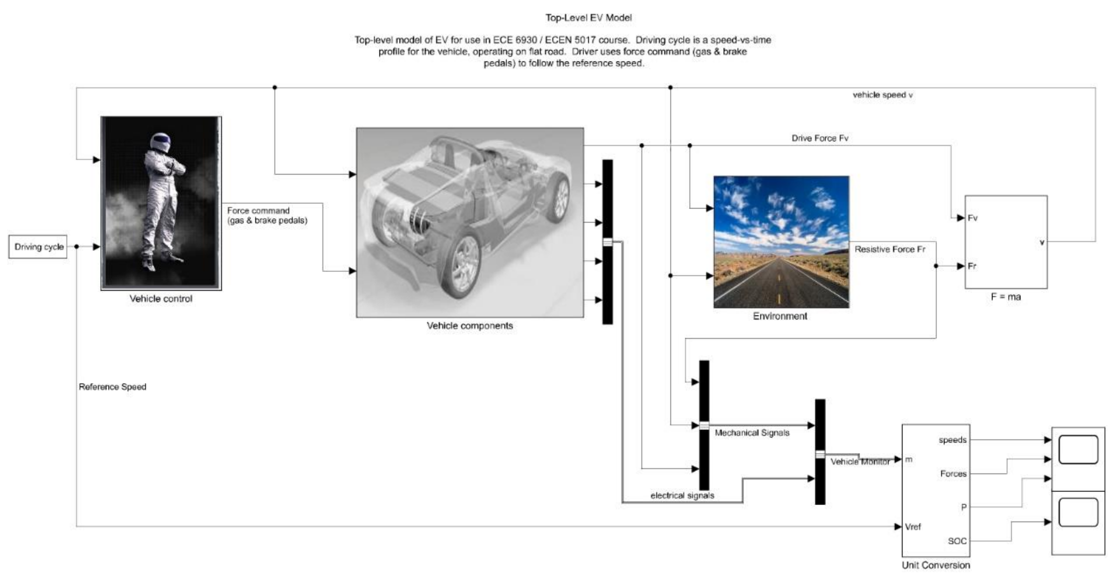


CLOSE VIEW OF THE OUTPUTS (t=0-0.5 min)



Verify the analytical results of (b) via simulation using the following steps

- Modify the basic EV model to include the following signals



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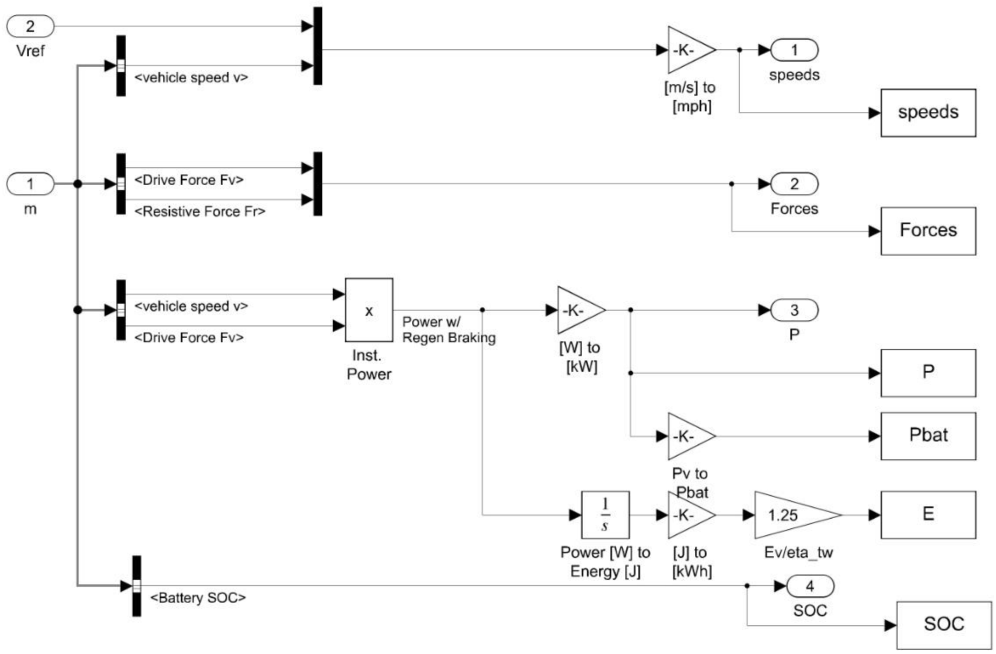

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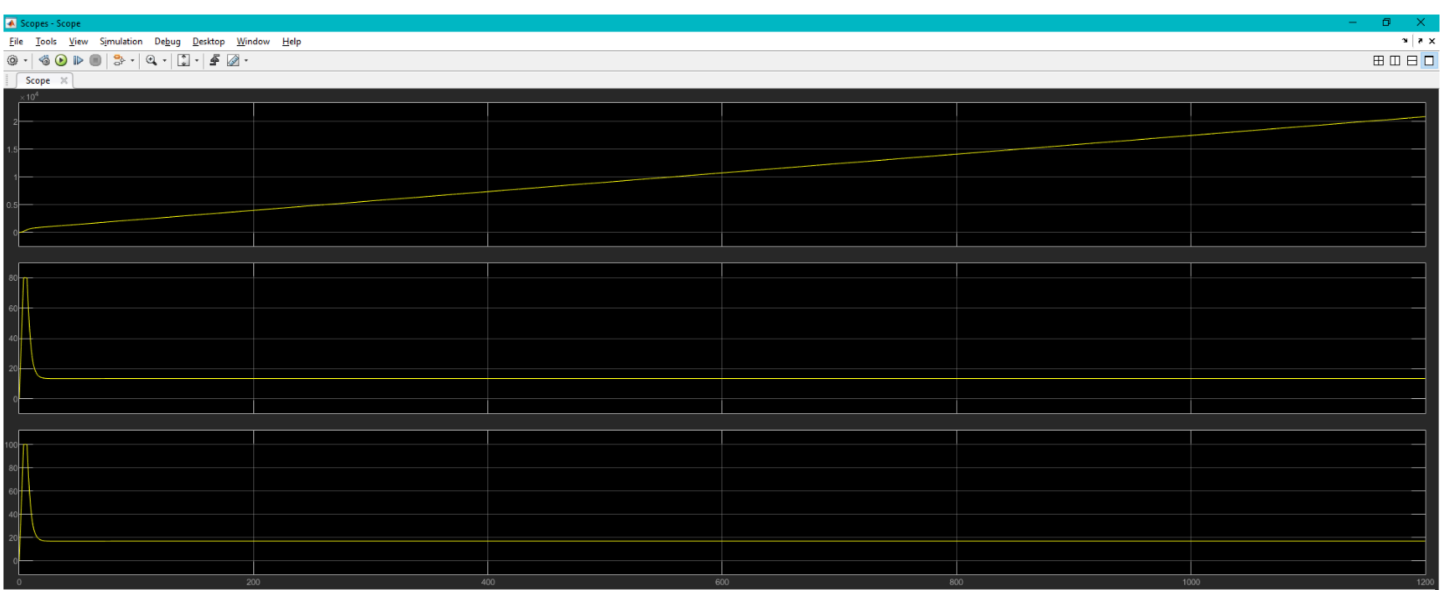
- Vehicle tractive power Pv
- Battery power, Pbatt = Pv / ηtw
- Total battery energy used, Ebatt (integral of battery power)



• Modify the PlotEVData.m file to add two additional subplots with the signals

23/12/23 07:10 C:\Users\user\Desktop\COURSE...\PlotEVData.m 1 of 1

```
figure(1);

subplot(3,1,1);
hold on;
plot(P.time/60, P.signals.values(:,1), 'b', 'LineWidth', 1.5);
ylabel('Inst. Power Pv [kW]');
set(gca, 'XTickLabel', []);
grid on;

subplot(3,1,2);
hold on;
plot(Pbat.time/60, Pbat.signals.values(:,1)/0.8, 'b', 'LineWidth', 1.5);
ylabel('Inst. Battery Power Pbat [kW]');
set(gca, 'XTickLabel', []);
grid on;

subplot(3,1,3);
hold on;
plot(E.time/60, E.time/60, 'b', 'LineWidth', 1.5);
ylabel('Consumed Battery Energy [kJ]');
xlabel('time [min]');
grid on;


figure(2);
plot(SOC.time/60, SOC.signals.values(:,1), 'b', 'LineWidth', 1.5);
ylabel('Battery SOC [%]');
xlabel('time [min]');
grid on;
```

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- Pv and Pbatt
- Ebatt

GRAPH 1: Pv GRAPH 2: Pbat GRAPH 3: Ebat

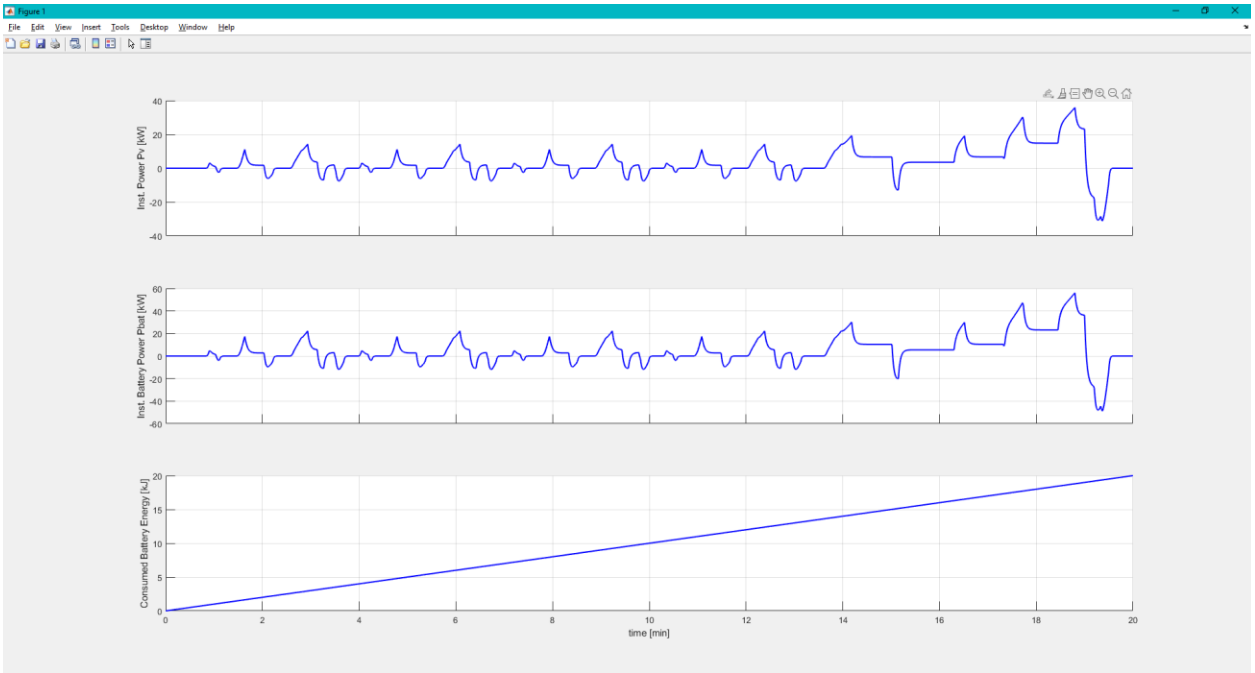


Figure 1
File Edit View Insert Tools Desktop Window Help
Inst. Power Pv [kW]
Inst. Battery Power Pbat [kW]
Consumed Battery Energy [kJ]
time [min]

BATTERY SOC

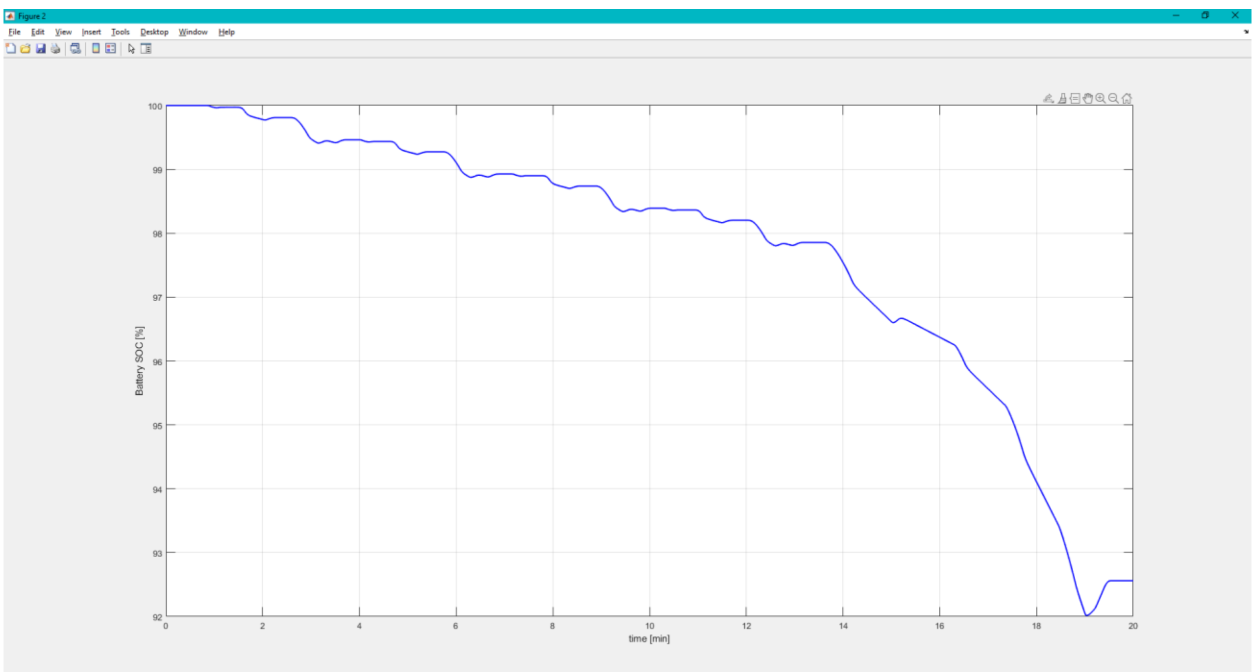
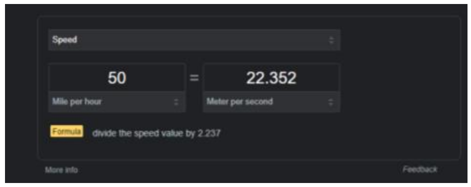
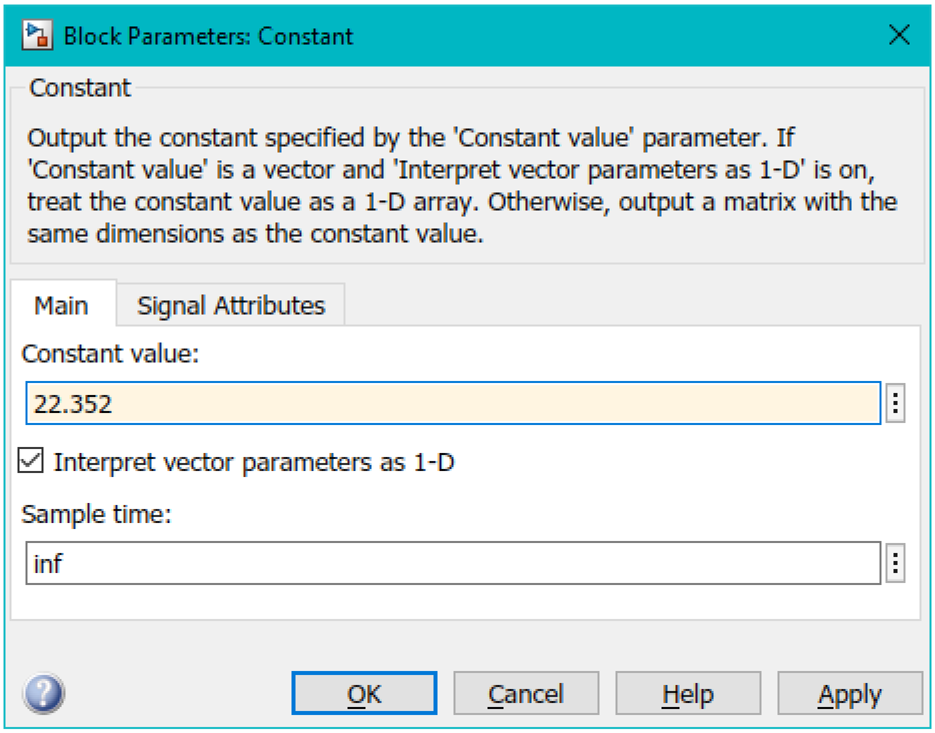


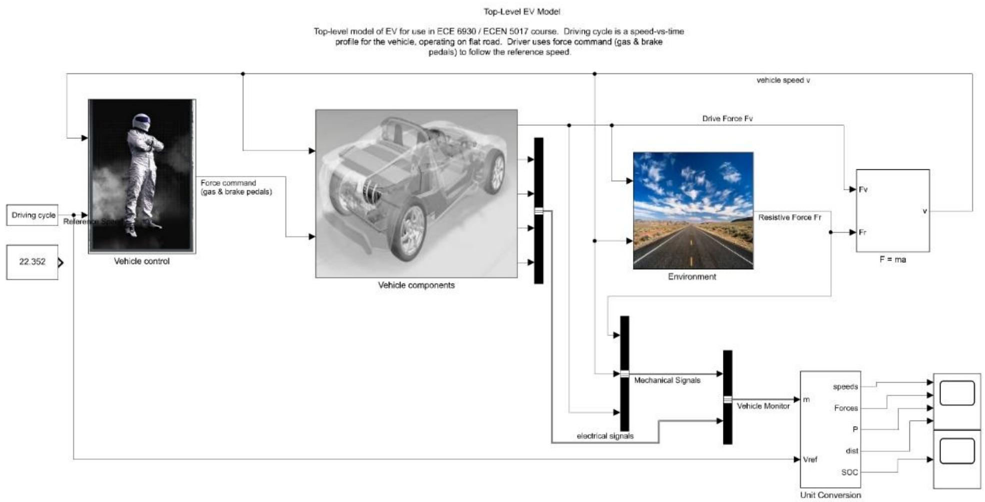
Figure 2
File Edit View Insert Tools Desktop Window Help
Battery SOC [%]
time [min]

System Simulation of Leaf-Sized Electric Vehicle

For the vehicle cruising in steady-state with velocity Vcruise = 50 mph on a flat road,







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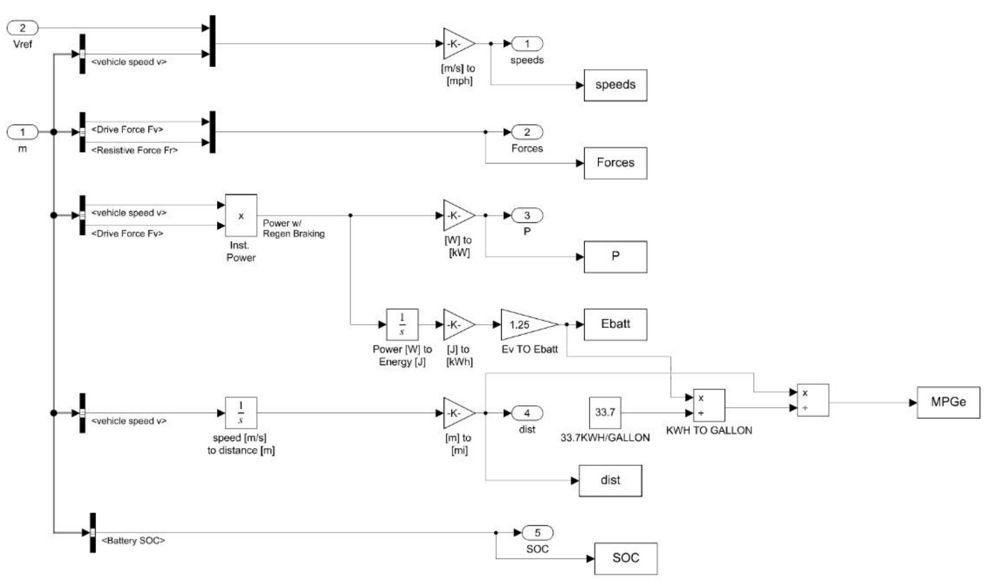

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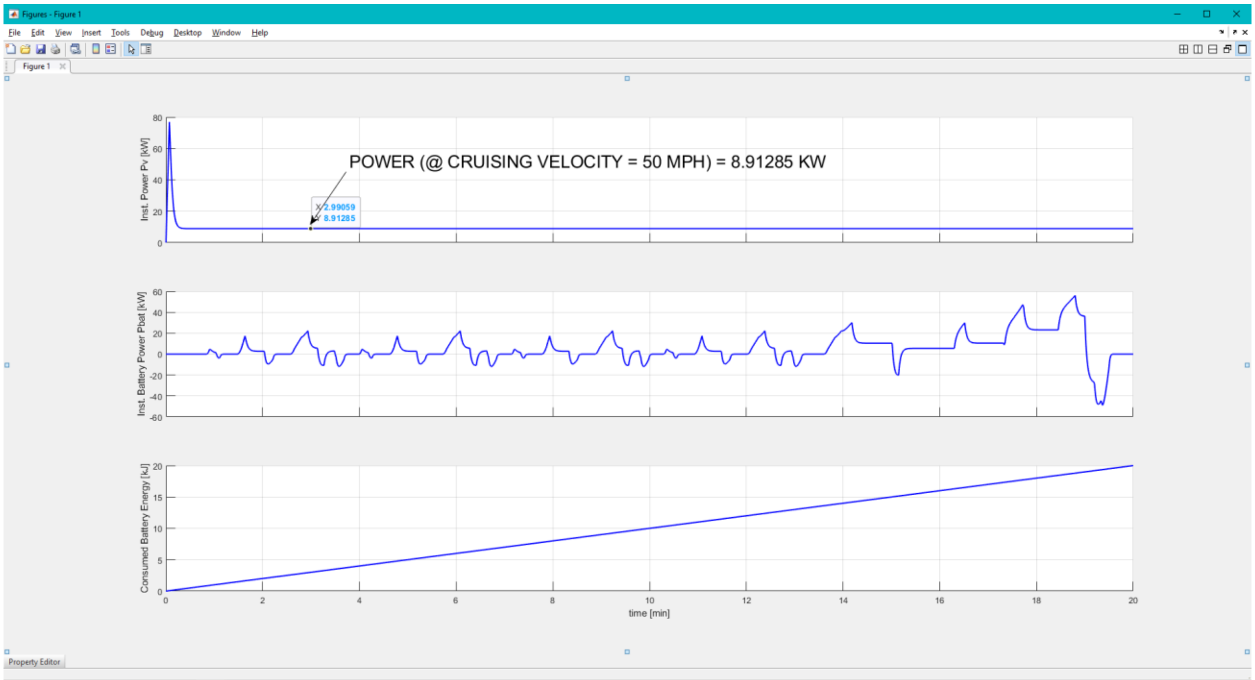
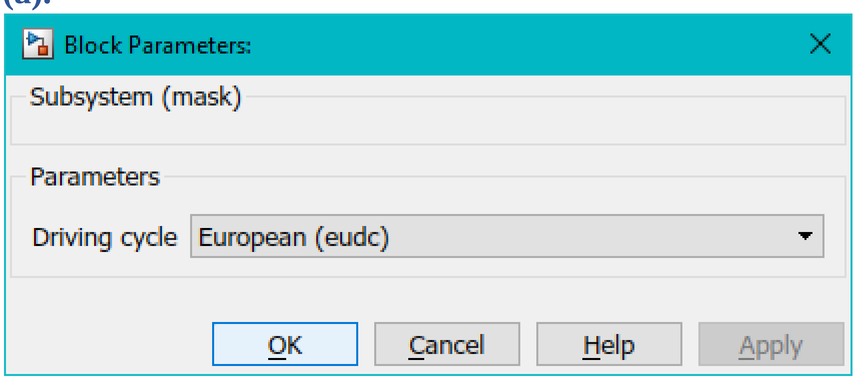
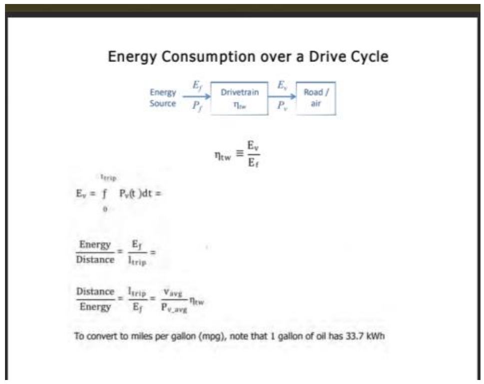
- Calculate the vehicle power Pv required to maintain cruise velocity



Run the driving cycle eudc with tstop=1200 at two gear ratios, gratio = 7.94 and version from (a).

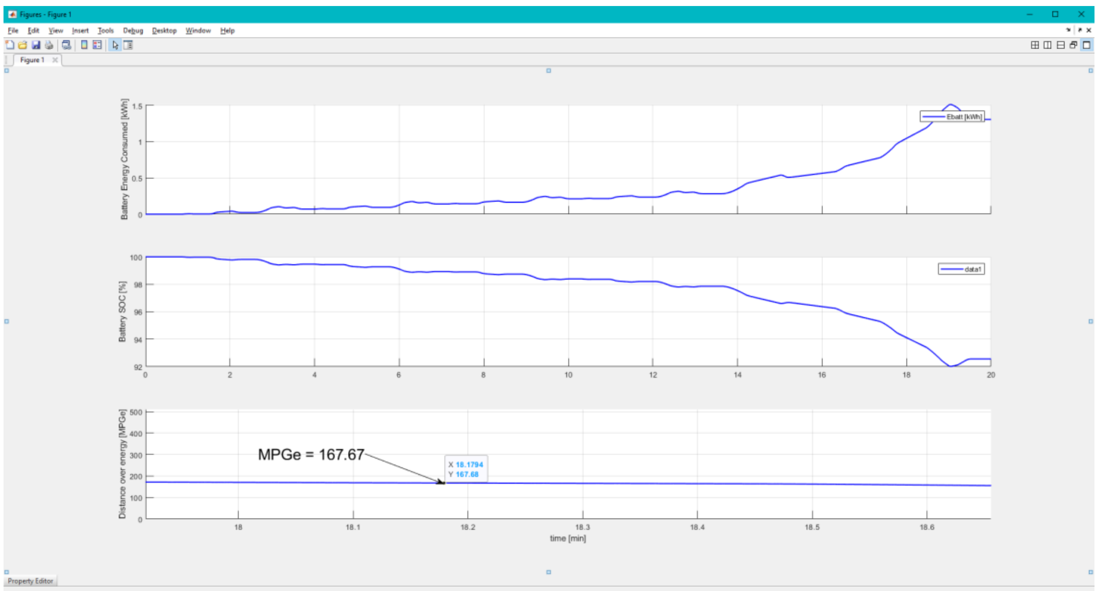


- Measure and report the total energy taken from the battery over the course of the entire driving cycle with your optimal gratio
- Compare the two gear ratios in terms of ending SOC and MPGe



GEAR RATIO=7.94

Ebatt SOC MPGe



- Turn in the plots of the motor torque Tm vs angular speed ωm path of the vehicle over the drive cycle overlaid on the motor efficiency contours

GEAR RATIO = 7.94

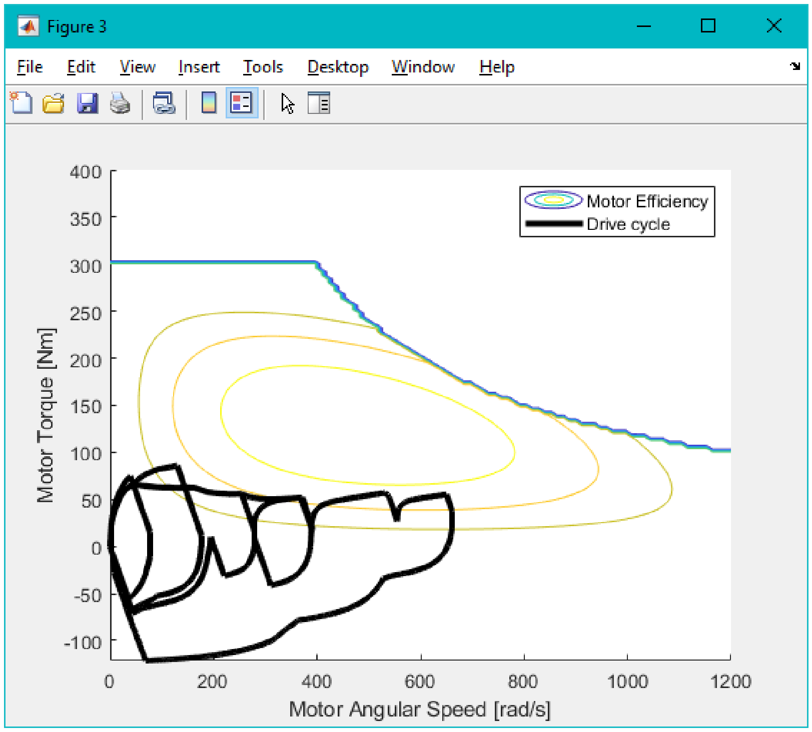


Figure 3
File Edit View Insert Tools Desktop Window Help
Motor Efficiency
Drive cycle
Motor Torque [Nm]
Motor Angular Speed [rad/s]
400
350
300
250
200
150
100
50
0
-50
-100
0
200
400
600
800
1000
1200