Define the vehicle parameters for the drive cycle sim

Load AMK Motor Data

```
load A2370DD_T80C.mat;
```

Conversion Factors

```
k_RPMToRadPerSec = 2*pi/60;
k_radPerSecToRPM = 60/(2*pi);
k_inchesToMeter = 1/39.37;
k_degreesToRad = pi/180;
k_kphToMeterPerSec = 1/3.6;
k_metersPerSecTokph = 3.6;
k_ampHourToCoulombs = 36000;
k_coulombToampHour = 1/3600;
k_joulesTokWH = 1/3600000;
```

Vehicle Setup

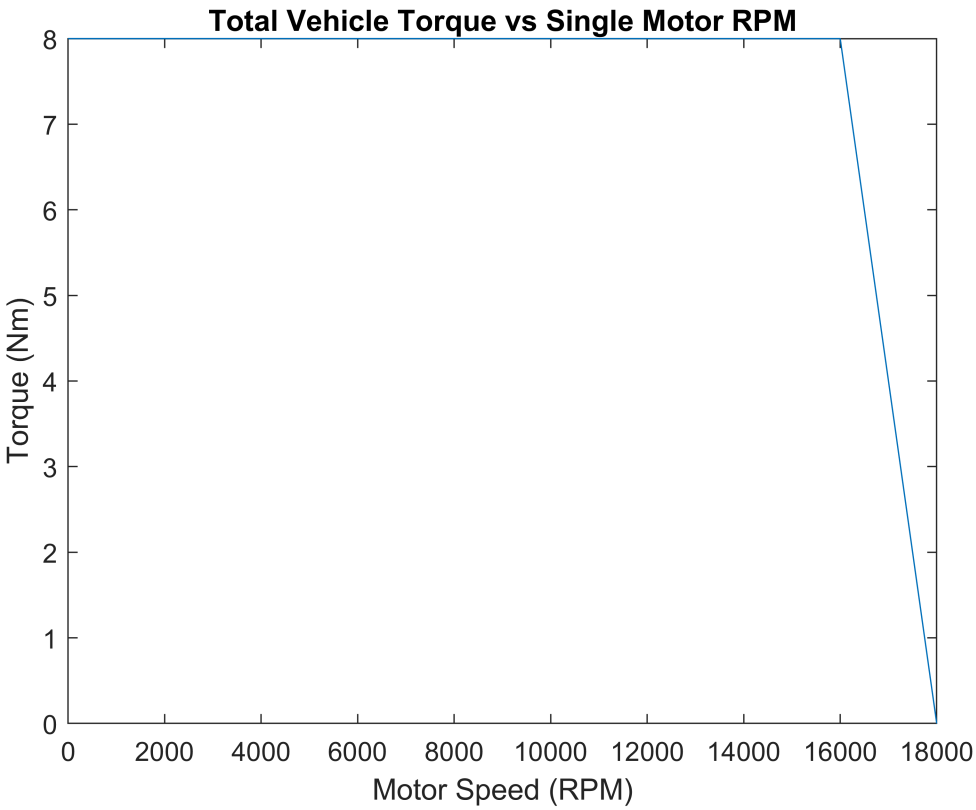
```
k_numberOfMotors = 4;
```

Driver Parameters

```
Driver.k_kp = 10;
Driver.k_ki = 1;
Driver.k_kff = 0.05;
Driver.k_kg = 0;
Driver.k_vnom = k_kphToMeterPerSec * 60;
Driver.k_kaw = 0.1;
Driver.k_tauerr = 0.03;
```

Pedal Mapping

```
PedalMap.k_motorRPMBreakPoints =    [0,     16000,   18000]; %rpm
%PedalMap.k_maxTorqueLookupTable =   [13.75, 7.50,    0.00] * k_numberOfMotors; %Nm
PedalMap.k_maxTorqueLookupTable =   [2, 2,    0.00] * k_numberOfMotors; %Nm
plot(PedalMap.k_motorRPMBreakPoints, PedalMap.k_maxTorqueLookupTable);
title('Total Vehicle Torque vs Single Motor RPM');
xlabel('Motor Speed (RPM)');
ylabel('Torque (Nm)');
```

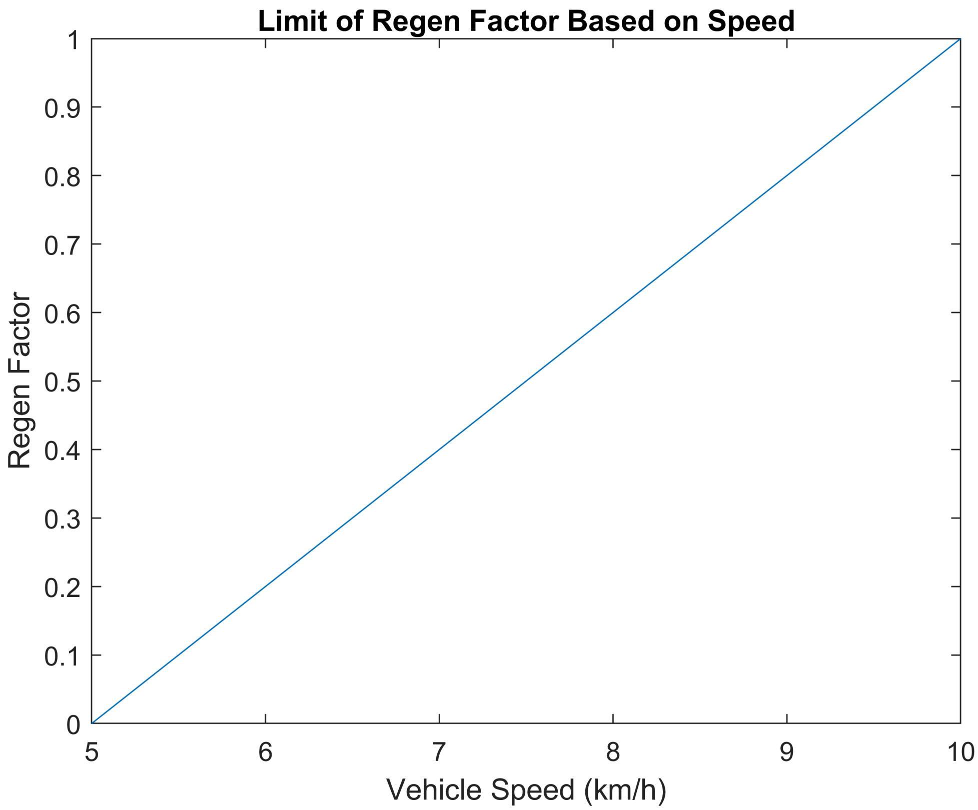


Brakes

```
Brakes.k_maxBrakeTorque = 2400; %Nm
```

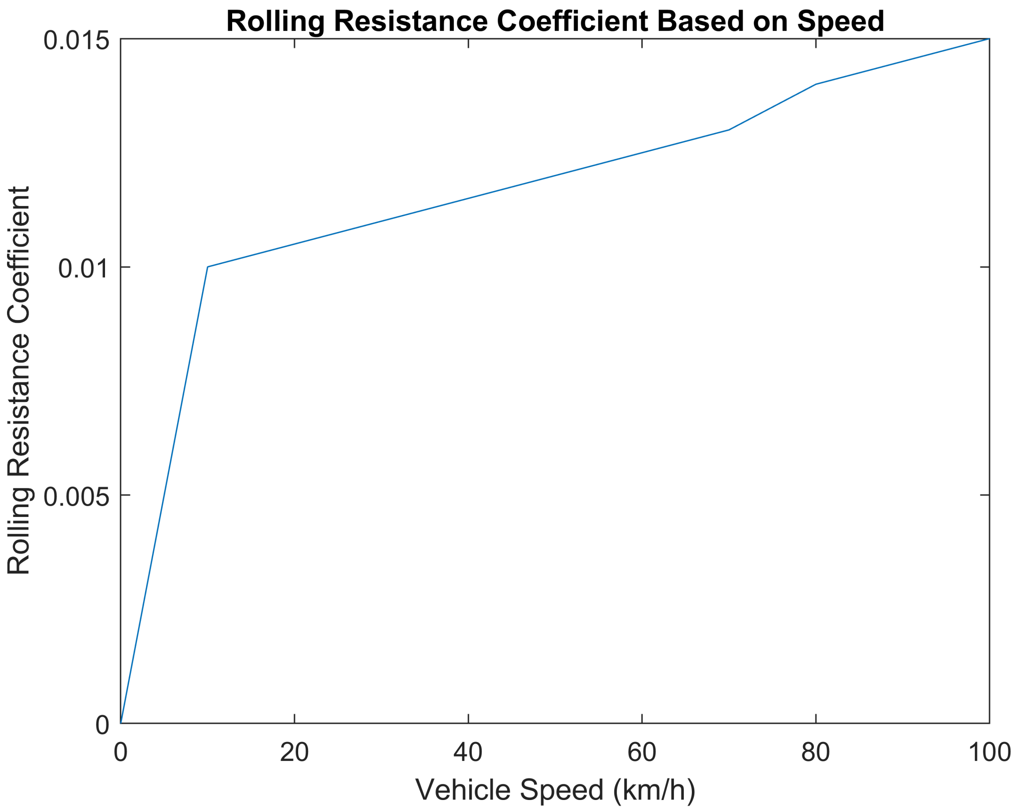
Regen

```
Regen.k_regenEnable =   0;
Regen.k_regenFactorSpeedBreakPoints = [5,10]; %km/h
Regen.k_regenFactorSpeedLookupTable = [0,1];
plot(Regen.k_regenFactorSpeedBreakPoints, Regen.k_regenFactorSpeedLookupTable);
title('Limit of Regen Factor Based on Speed');
xlabel('Vehicle Speed (km/h)');
ylabel('Regen Factor');
```



Tires

```
Tire.k_radius = k_inchesToMeter * 10; %m
Tire.k_rollingRadiusSpeedBreakPoints = [
0,  10,     20,     30,     40,     50,     60,     70,     80,     90,     100]; %km/h
Tire.k_rollingRadiusLookup = [
0,  0.01,   0.0105, 0.011,  0.0115, 0.0120, 0.0125, 0.0130, 0.0140, 0.0145, 0.0150];
plot(Tire.k_rollingRadiusSpeedBreakPoints, Tire.k_rollingRadiusLookup);
title('Rolling Resistance Coefficient Based on Speed');
xlabel('Vehicle Speed (km/h)');
ylabel('Rolling Resistance Coefficient');
```



Motors

```
% rows correspond to speed, columns correspond to torque
Motor.k_voltageLineDCLookpupTable = Voltage_Line_RMS*sqrt(2);
Motor.k_voltageLineDCTorqueBreakPoints = k_numberOfMotors * Electromagnetic_Torque(1,:)';
```

Efficiency Table

The efficiency table includes losses for both the inverter and the motor.

Efficiency: DD5-14-10-xxW-19000 "calculated values @ operating temp. - differences up to

		speed [rpm]						
Current [Arms]	Torque [Nm]	500	1000	2000	3000	4000	6000	10000
5	1,3	64,37	71,33	73,64	74,70	75,43	76,57	77,00
10	2,7	58,42	70,48	77,57	80,40	82,01	83,92	85,16
20	5,4	44,94	60,81	73,35	78,82	81,94	85,43	88,20
30	7,9	35,59	51,90	67,02	74,26	78,54	83,42	87,58
40	10,4	29,14	44,78	61,01	69,41	74,57	80,62	85,93
50	12,5	24,17	38,71	55,22	64,39	70,24	77,30	83,73
60	14,4	20,41	33,76	50,04	59,65	65,99	73,88	81,33
70	16,0	17,31	29,40	45,10	54,87	61,55	70,10	78,56
80	17,4	14,82	25,75	40,67	50,41	57,28	66,34	75,70
90	18,5	12,81	22,67	36,72	46,30	53,25	62,67	72,77
100	19,6	11,17	20,05	33,21	42,51	49,44	59,09	69,82

Variables for a 2D lookup table of the motor efficiency plot. For low speed operation (e.g. below 500 rpm), an efficiency of 0% is used.

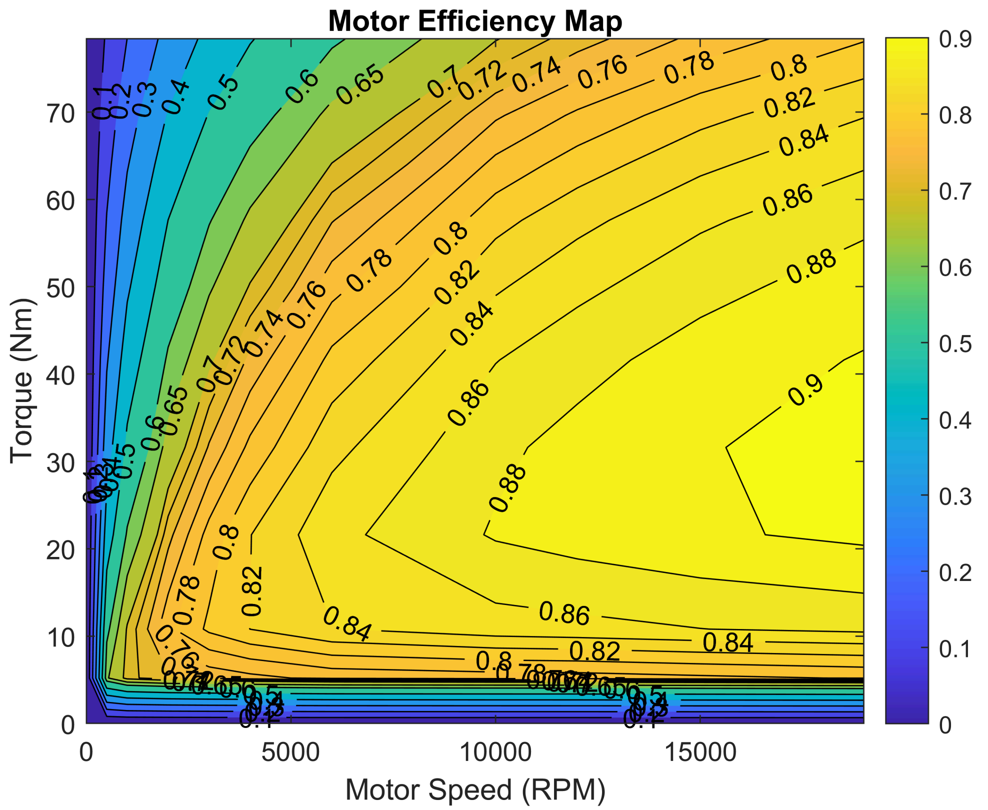
Note: The motor will never be travelling less than 500 rpm.

```
Motor.k_efficiencyTorqueBreakPoints = k_numberOfMotors * [
0,  1.3,    2.7,    5.4,    7.9,    10.4,   12.5,   14.4,   16.0,   17.4,   18.5,   19.6];  %Nm

Motor.k_efficiencyMotorSpeedBreakPoints = k_RPMToRadPerSec * [
0,  500,    1000,   2000,   3000,   4000,   6000,   10000,  12000,  15000,  19000]; %rpm

[MotorSpeedMesh, TorqueMesh] = meshgrid(Motor.k_efficiencyMotorSpeedBreakPoints, Motor.k_effici
```

Rows correspond to different torque values. Columns correspond to different motor rpm values.

```
Motor.k_efficiencyLookupTable = 0.01 * [
0.00,   0.00,   0.00,   0.00,   0.00,   0.00,   0.00,   0.00,   0.00,   0.00,   0.00;
0.00,   64.37,  71.33,  73.64,  74.70, 75.43, 76.57, 77.00,  77.08, 77.56, 78.14;
0.00,   58.42,  70.48, 77.57, 80.40, 82.01, 83.92, 85.16,  85.44, 85.97, 86.50;
0.00,   44.94,  60.81, 73.35, 78.82, 81.94, 85.43, 88.20,  88.88, 89.71, 90.44;
0.00,   35.59,  51.90, 67.02, 74.26, 78.54, 83.42, 87.58, 88.65, 89.84, 90.86;
0.00,   29.14,  44.78, 61.01, 69.41, 74.57, 80.62, 85.93, 87.34, 88.86, 90.16;
0.00,   24.17,  38.71, 55.22, 64.39, 70.24, 77.30, 83.73, 85.48, 87.37, 88.98;
0.00,   20.41,  33.76, 50.04, 59.65, 65.99, 73.88, 81.33, 83.42, 85.66, 87.59;
0.00,   17.31,  29.40, 45.10, 54.87, 61.55, 70.10, 78.56, 80.97, 83.56, 85.81;
0.00,   14.82,  25.75,  40.67, 50.41, 57.28, 66.34, 75.70, 78.40,  81.34, 83.91;
0.00,   12.81,  22.67, 36.72, 46.30, 53.25, 62.67, 72.77, 75.75,  79.02, 81.91;
0.00,   11.17,  20.05, 33.21, 42.51, 49.44, 59.09, 69.82, 73.06,  76.63, 79.83];

contourf(k_radPerSecToRPM .* MotorSpeedMesh,TorqueMesh, Motor.k_efficiencyLookupTable, ...
    [0, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.65, linspace(0.7,0.9,11)],'ShowText','on')
colorbar
```

```
title('Motor Efficiency Map')
xlabel('Motor Speed (RPM)')
ylabel('Torque (Nm)')
```




```
% LossPower = (1/eff - 1)*MechPower
Motor.k_powerLossLookupTable = (1./Motor.k_efficiencyLookupTable - 1).*(TorqueMesh.*MotorSpeedM
% Replace the NaN entries caused by the division by zero from the efficiency table
Motor.k_powerLossLookupTable(isnan(Motor.k_powerLossLookupTable)) = 0;

Motor.k_totalDischargeMotorPowerLookupTable = (TorqueMesh.*MotorSpeedMesh + Motor.k_powerLossLo
Motor.k_totalChargeMotorPowerLookupTable = (TorqueMesh.*MotorSpeedMesh - Motor.k_powerLossLooku
% Set total charge motor power to 0 where the loss is greater than the regen power
Motor.k_totalChargeMotorPowerLookupTable(Motor.k_totalChargeMotorPowerLookupTable <= 0) = 0;
```

Gearbox

```
Gearbox.k_gearRatio = 13.1;
Gearbox.k_efficiency = 0.95;
```

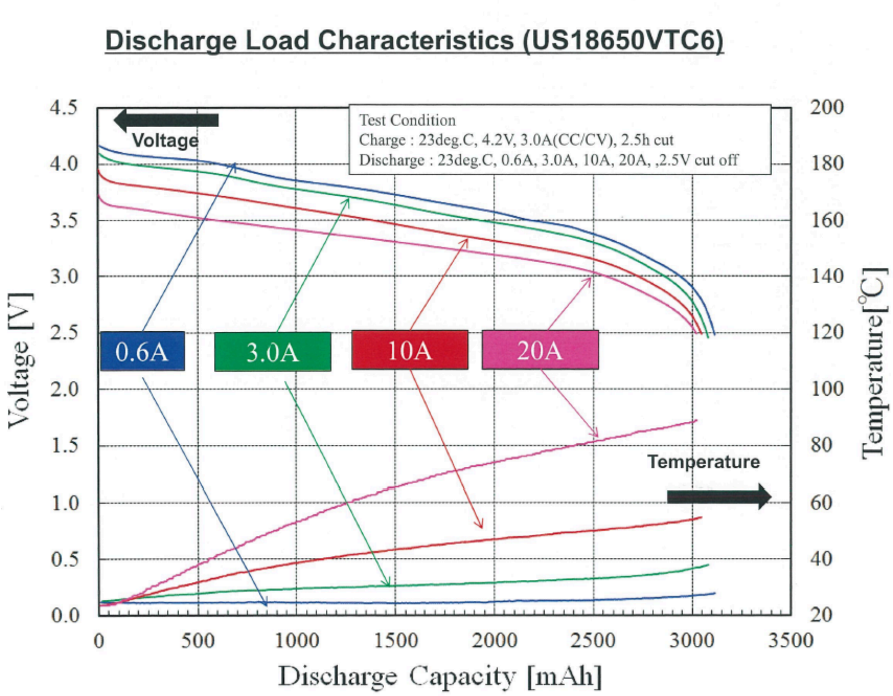
Accumulator

Cell Parameters

```
Accumulator.k_cellCapacity = 3.12; %Ah
Accumulator.k_cellCapacityCoulombs = Accumulator.k_cellCapacity; %Ah
Accumulator.k_cellResistance = 0.001 * 18; % ohm
```

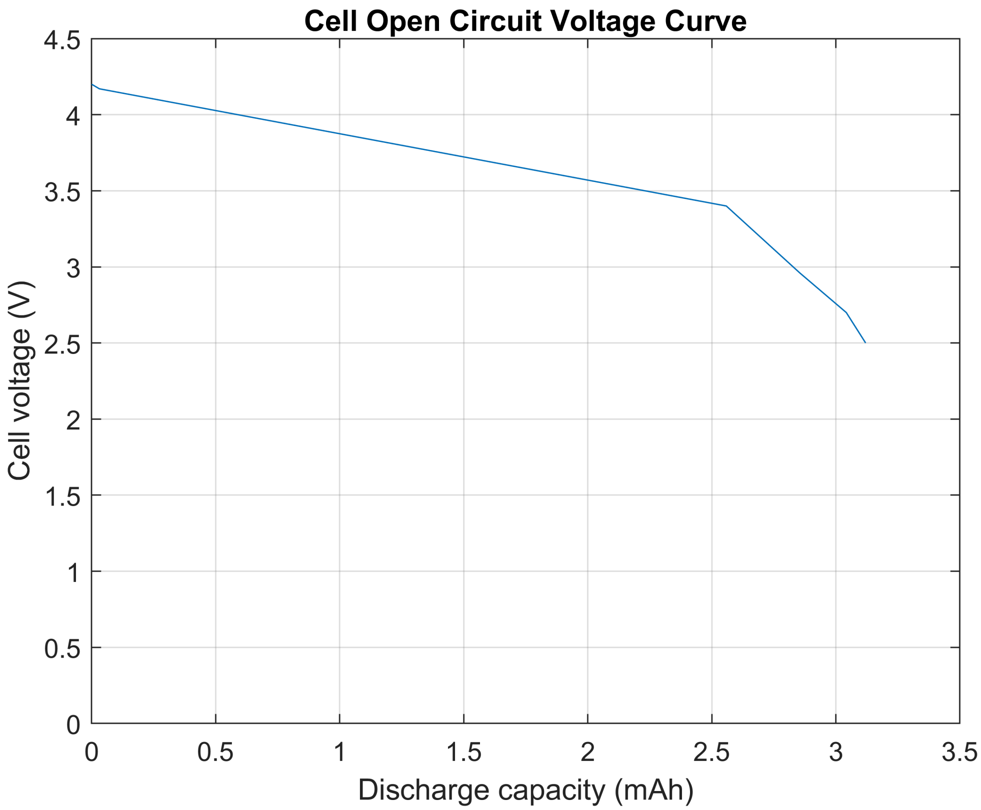
```
Accumulator.k_nominalCellVoltage = 3.6; %V
Accumulator.k_maxCellVoltage = 4.2; %V
Accumulator.k_minCellVoltage = 2.5; %V

Accumulator.k_maxCellDischargeCurrent = 20; %A
Accumulator.k_maxCellChargeCurrent = 3; %A

Accumulator.k_cellMass = 0.001 * 46.6; % kg
```

The open circuit voltage curve is based on the following discharge load curve:



The open-circuit voltage for the cell is obtained by approximating a curve above the 0.6A discharge current curve.

```
Accumulator.k_cellSOCBreakPoints = [0, 0.025, 0.085, 0.18, 0.99, 1];
Accumulator.k_cellOpenVoltageLookupTable = [Accumulator.k_minCellVoltage, 2.7, 2.96, 3.4, 4.17,
plot((1-Accumulator.k_cellSOCBreakPoints)*Accumulator.k_cellCapacity, Accumulator.k_cellOpenVol
title('Cell Open Circuit Voltage Curve');
xlabel('Discharge capacity (mAh)');
ylabel('Cell voltage (V)');
ylim([0,4.5])
grid on
```



Accumulator Pack Configuration

```
Accumulator.k_numOfParallelCells = 5;
Accumulator.k_numOfSeriesCells = 126;
```

Accumulator Pack Specs

```
Accumulator.k_totalNumOfCells = Accumulator.k_numOfParallelCells * Accumulator.k_numOfSeriesCel
Accumulator.k_packMass = Accumulator.k_cellMass * Accumulator.k_totalNumOfCells;

Accumulator.k_nominalPackVoltage = Accumulator.k_nominalCellVoltage * Accumulator.k_numOfSeries
Accumulator.k_maxPackVoltage = Accumulator.k_maxCellVoltage * Accumulator.k_numOfSeriesCells; %
Accumulator.k_minPackVoltage = Accumulator.k_minCellVoltage * Accumulator.k_numOfSeriesCells; %

Accumulator.k_packCapacity = Accumulator.k_cellCapacity * Accumulator.k_numOfParallelCells; %Ah
Accumulator.k_packCapacityKWhour = Accumulator.k_packCapacity * Accumulator.k_nominalPackVoltag

Accumulator.k_packResistance = (Accumulator.k_cellResistance / Accumulator.k_numOfParallelCells
Accumulator.k_maxPackDischargeCurrent = Accumulator.k_maxCellDischargeCurrent * Accumulator.k_n
Accumulator.k_maxPackChargeCurrent = Accumulator.k_maxCellChargeCurrent * Accumulator.k_numOfPa
```

Accumulator specs based on the cell configurations:

```
fprintf('The total mass of the cells in the pack is: %f kg', Accumulator.k_packMass);
```

```
The total mass of the cells in the pack is: 29.358000 kg
```

```
fprintf('The pack capacity is: %f Ah, %f kWh', Accumulator.k_packCapacity, Accumulator.k_packCa
```

```
The pack capacity is: 15.600000 Ah, 7.076160 kWh
```

```
fprintf('The pack nominal, max, and minimum voltages are: %f V, %f V, %f V respectively', ...
    Accumulator.k_nominalPackVoltage, Accumulator.k_maxPackVoltage, Accumulator.k_minPackVoltag
```

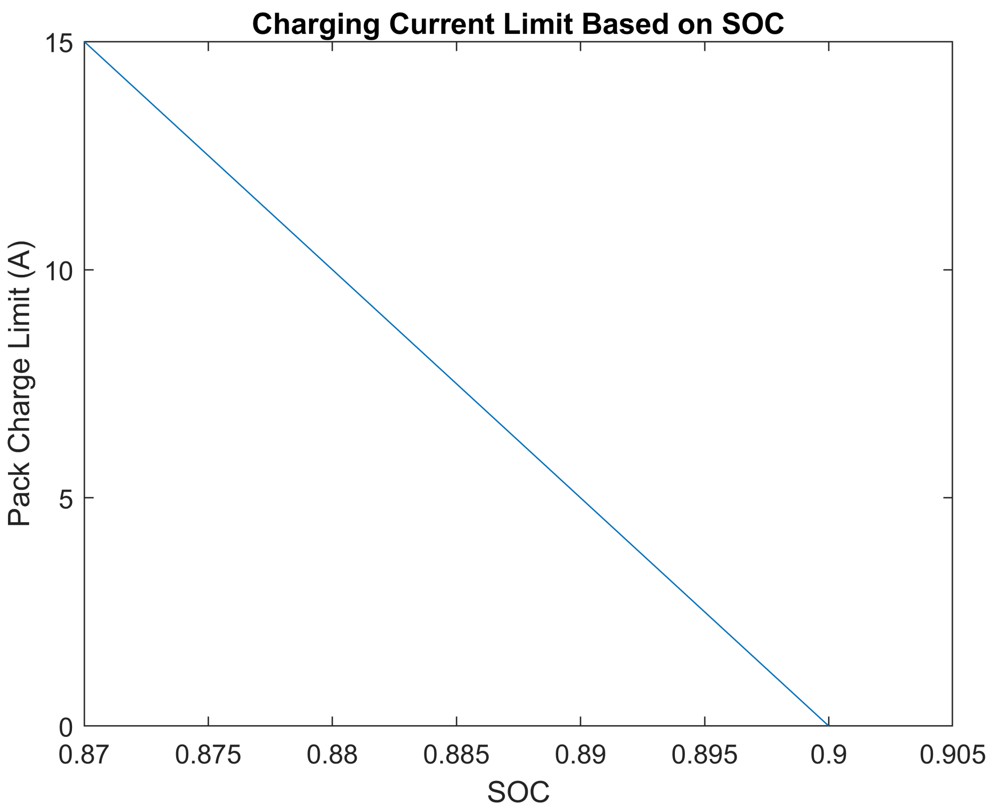
```
The pack nominal, max, and minimum voltages are: 453.600000 V, 529.200000 V, 315.000000 V respectively
```

```
fprintf('The pack max discharge and charge currents are: %f A, %f A respectively', Accumulator.
```

```
The pack max discharge and charge currents are: 100.000000 A, 15.000000 A respectively
```

Charge Limit Curve

```
Accumulator.k_chargeLimitSOCBreakPoints = [0.87,0.9];
Accumulator.k_chargeLimitLookuptable = [Accumulator.k_maxPackChargeCurrent, 0]; %A
plot(Accumulator.k_chargeLimitSOCBreakPoints, Accumulator.k_chargeLimitLookuptable);
title('Charging Current Limit Based on SOC');
xlabel('SOC');
ylabel('Pack Charge Limit (A)');
```



Initial Conditons

```
Accumulator.k_initialCellCapacity = Accumulator.k_cellCapacity *1;
Accumulator.k_initialPackVoltage = Accumulator.k_maxPackVoltage;
```

Vehicle Parameters

```
SimVehicle.k_massWithoutAccumulator = 185 + 62; %kg
SimVehicle.k_totalMass = Accumulator.k_packMass + SimVehicle.k_massWithoutAccumulator; % kg
SimVehicle.k_heightOfCenterOfMass = 0.254; %m
SimVehicle.k_distanceCOMtoFrontAxle = 0.7733; %m
SimVehicle.k_distanceCOMtoRearAxle = 0.7517; %m
SimVehicle.k_frontArea = 1.8; %m^2
SimVehicle.k_dragCoefficient = 0.32;
SimVehicle.k_liftCoefficent = 0.1;
SimVehicle.k_maxElectricalPower = 80000; %kW
```