SUBJECT: PROJECT ON ELECTRIC AND HYBRID DRIVES

TITLE: PROJECT NO.1 [PURE EV DRIVE]

Student name&surname: Mert Akdag

Student ID: 309284

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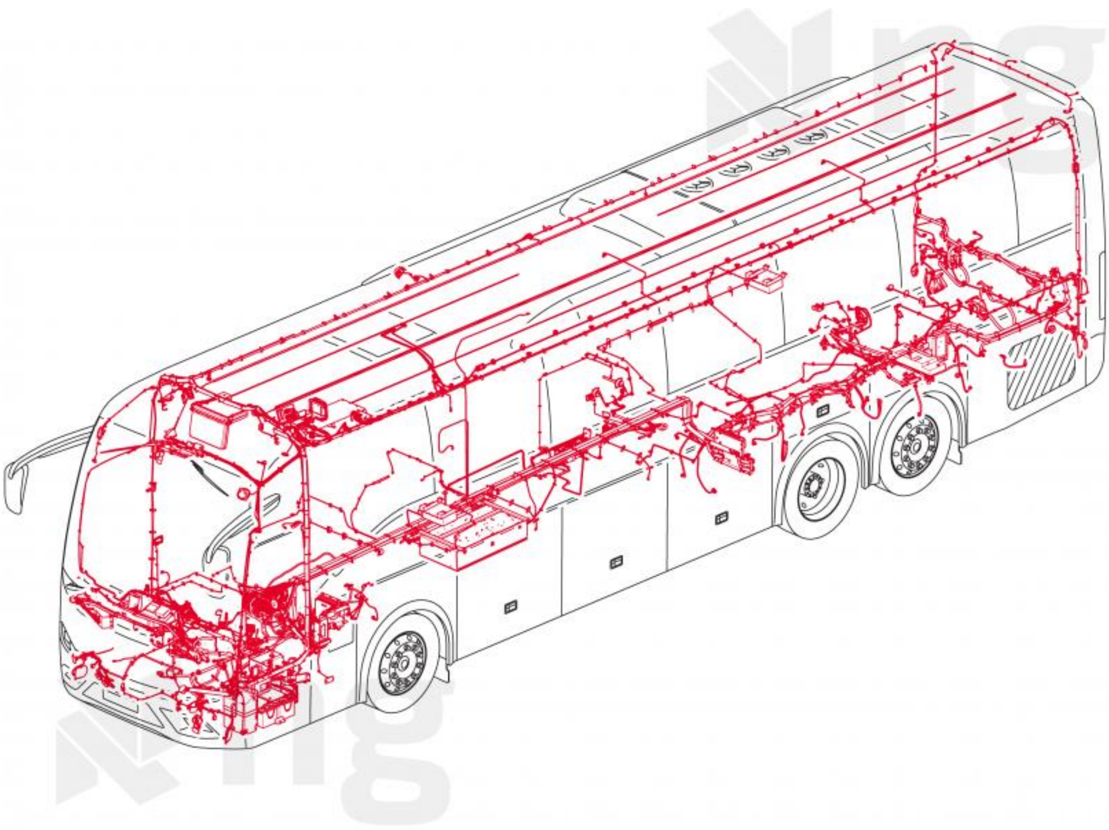
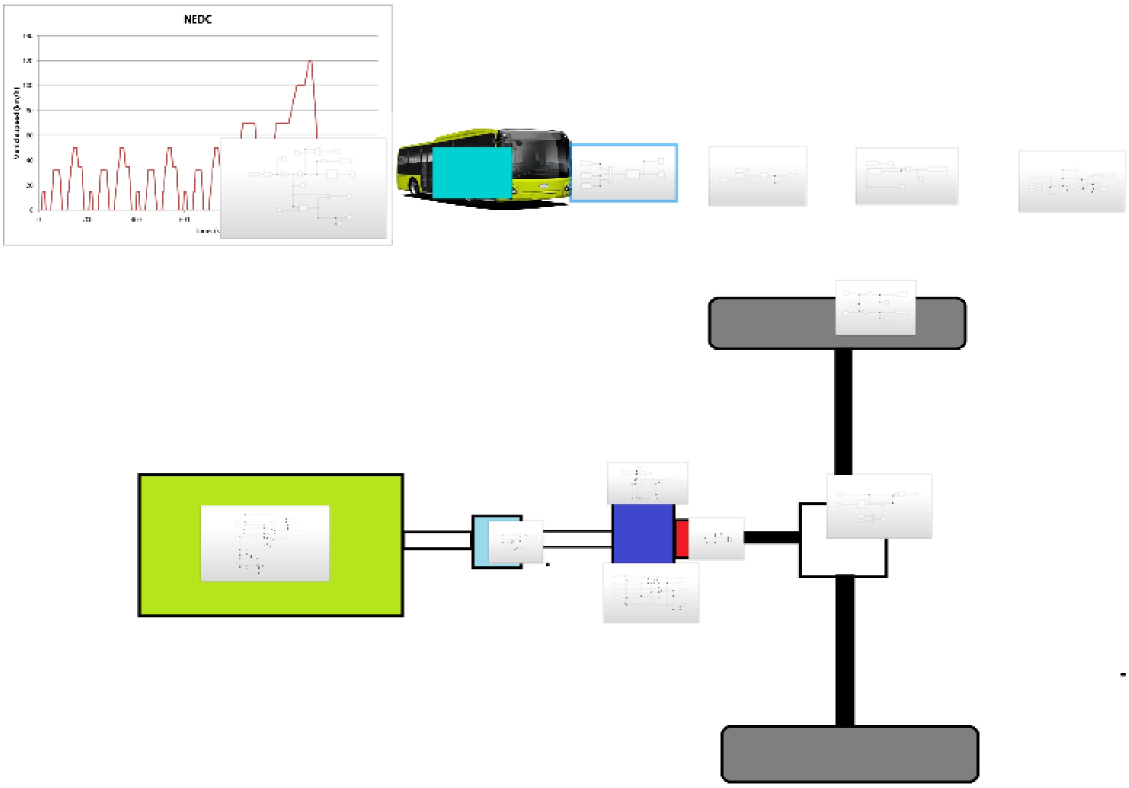


1) INTRODUCTION TO THE PROJECT

- Scope of the project was to build a simulation of pure electric drive for a city bus. While considering the vehicle parameters, passengers have taken into account for the value of vehicle mass for an example. To simulate this system each detailed information such as dynamic radius, drag and rolling resistance forces, frontal area and other parameters has considered.

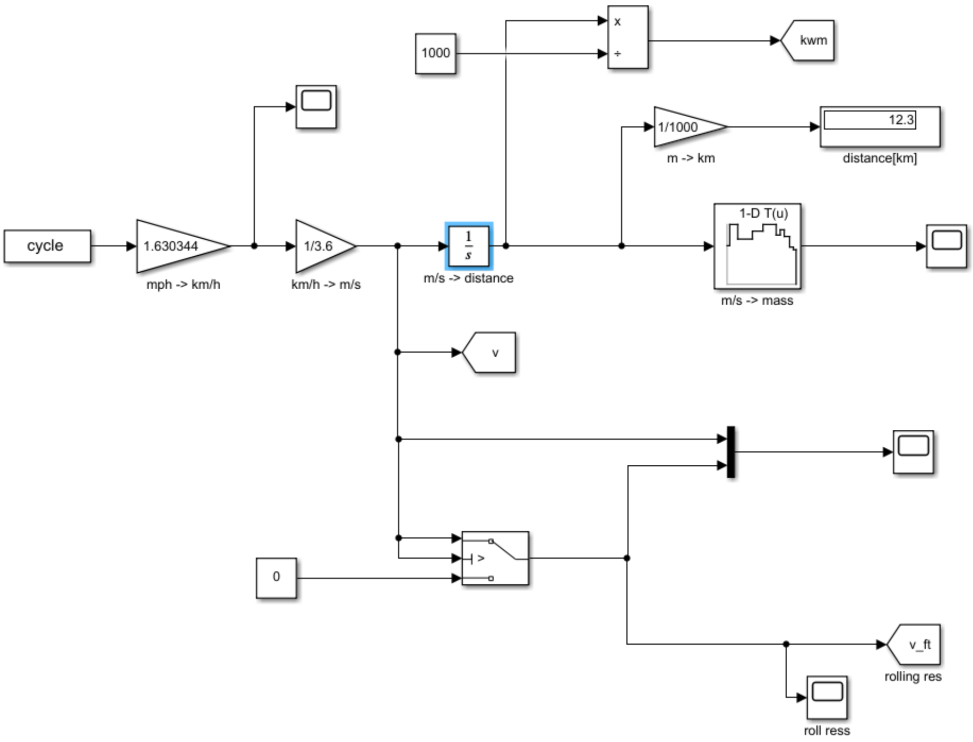
GENERAL OUTLINE TREE OF THE SIMULATION:



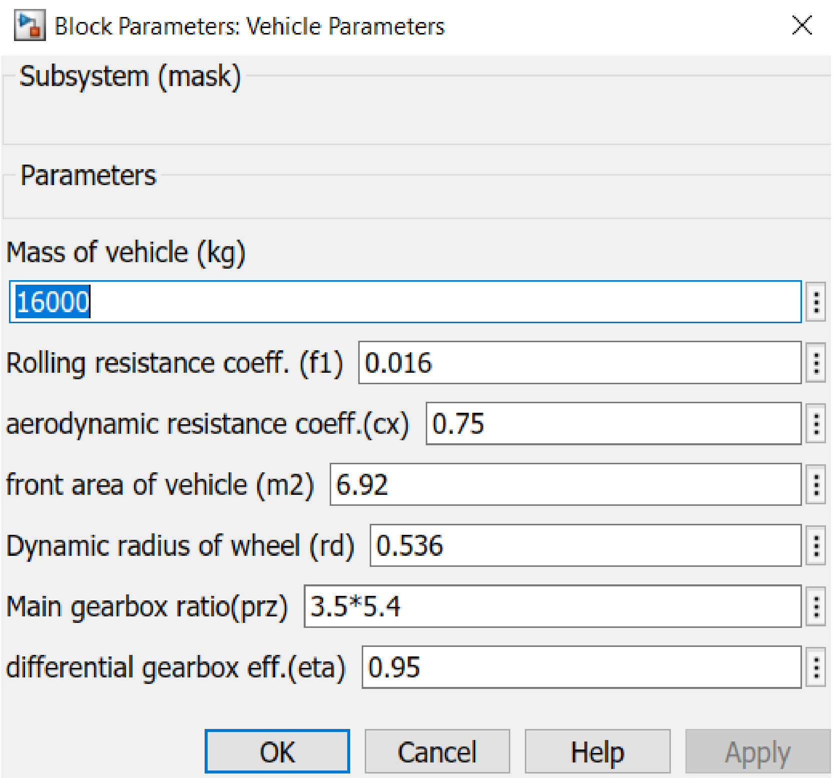
- *In this figure above, calculations and representations for the ev drive has shown. Including driving cycle and vehicle parameters, subsystems above the drawing representing drag forces and demanded power energy and force.*

2) DETAILED LOOK TO THE SIMUALTION

a) driving cycle(plus velocity and distance calculations)



b) Vehicle parameters



Block Parameters: Vehicle Parameters

Subsystem (mask)

Parameters

Mass of vehicle (kg)

16000

Rolling resistance coeff. (f1) 0.016

aerodynamic resistance coeff.(cx) 0.75

front area of vehicle (m2) 6.92

Dynamic radius of wheel (rd) 0.536

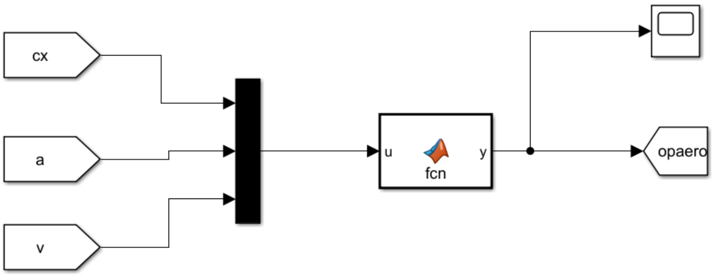
Main gearbox ratio(prz) 3.5*5.4

differential gearbox eff.(eta) 0.95

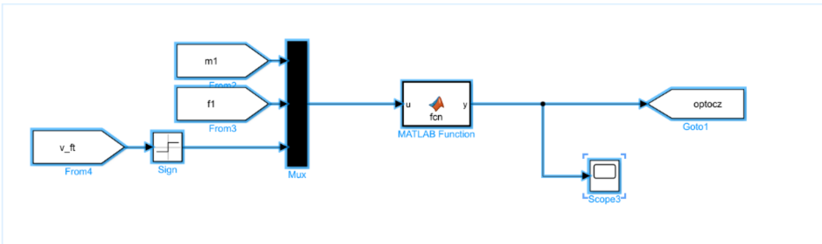
OK Cancel Help Apply

c) drag forces

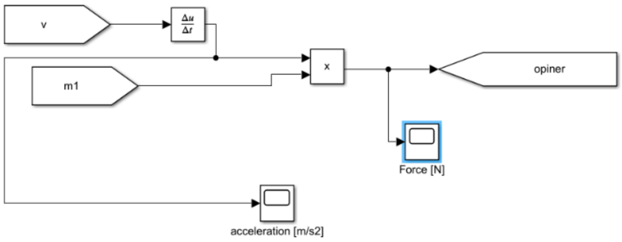
aerodynamic resistance

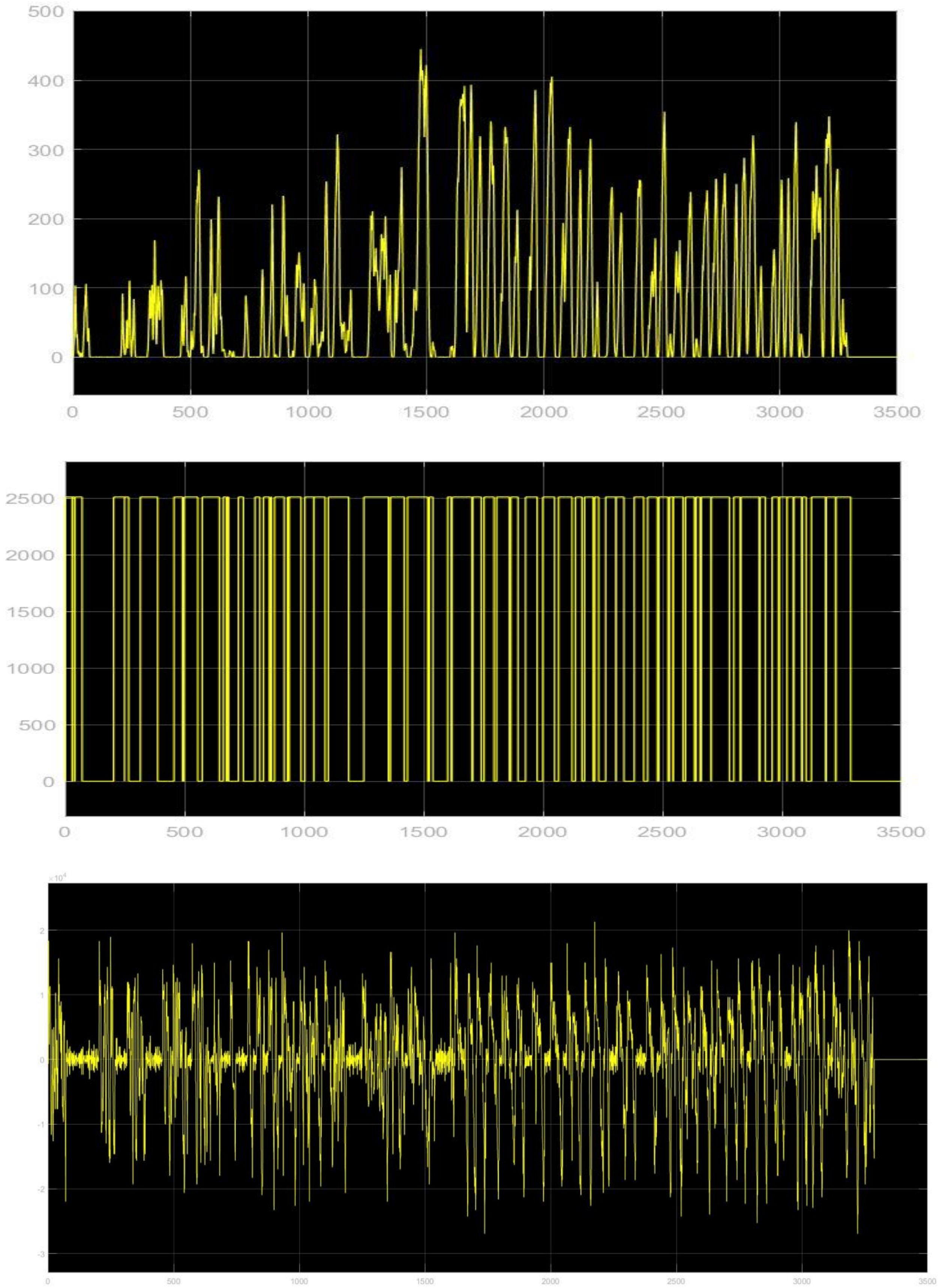


Rolling resistance



Inertial Force and acceleration resistance

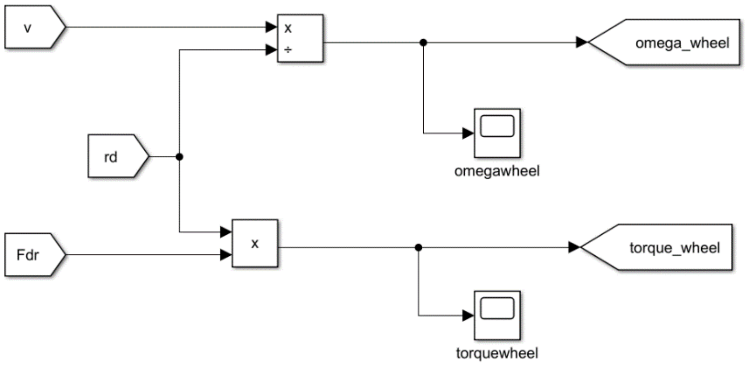


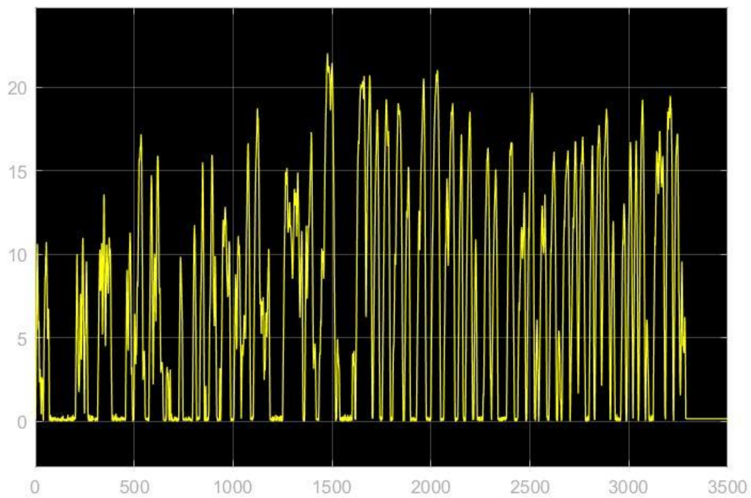


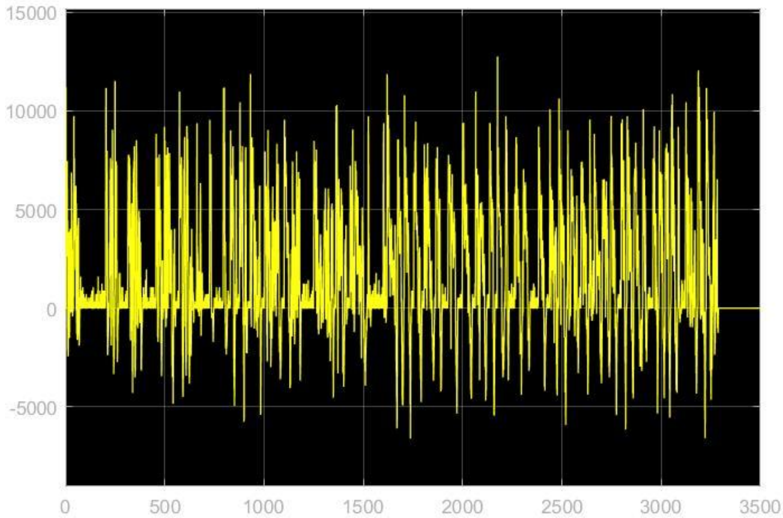
[FROM TOP TO BOTTOM: AERODYNAMIC RESISTANCE, ROLLING RES., INERTIAL FORCE]

- After observing the graph of drag forces and inertial force distribution over the cycle, it is clearly seen that this simulation is fit for urban drive. I can say this because of the force graph that in some periods force drops to 0 and increases in one direction again. This means the vehicle stops and starts periodically also can be said as accelerate and decelerate time to time.

3) WHEELS MODEL







OMEGA WHEEL (angular vel.)

TORQUE PRODUCED WHEEL

USED FORMULAS:

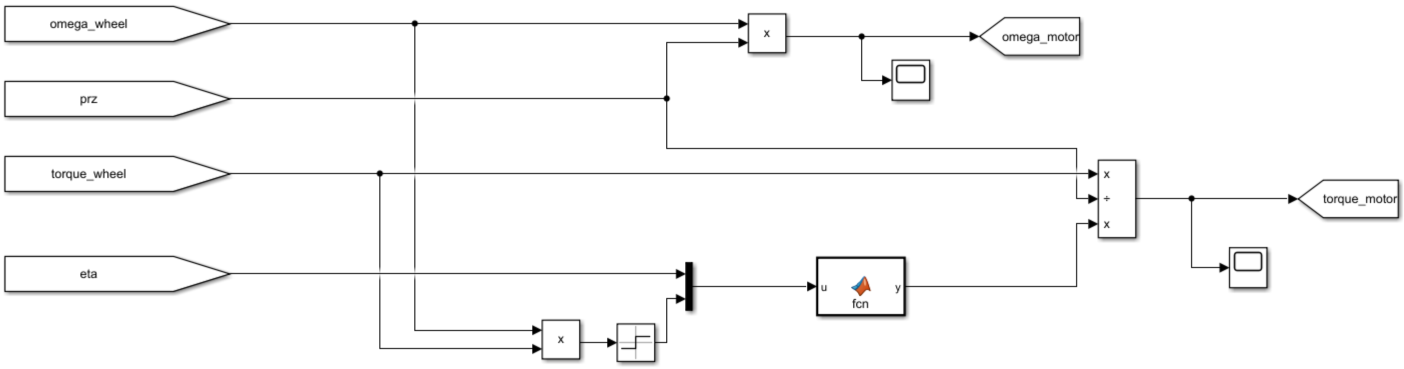
$$\omega_{wheel} = \frac{V_{vehicle}}{r_d}$$

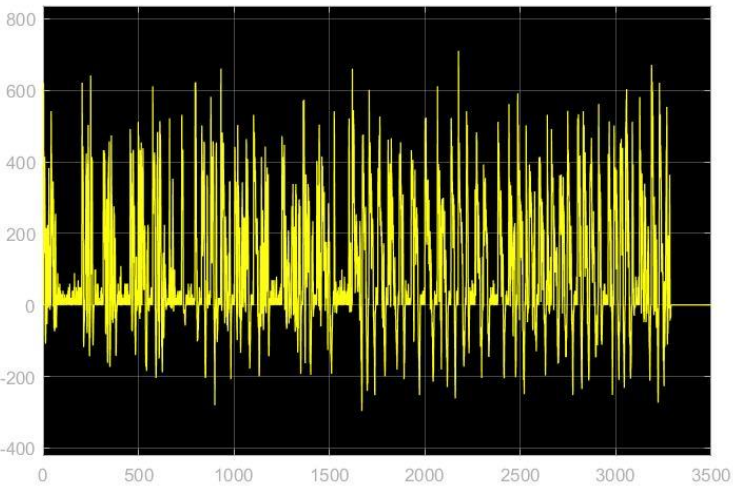
$$M_{wheel} = F_{drive} \cdot r_d$$

4) MODEL OF A MAIN GEARBOX

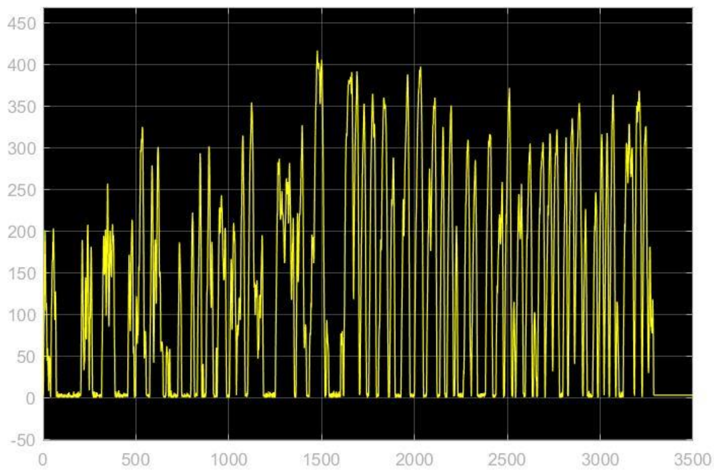
eta -→ differential eff.

prz → main gearbox ratio





TORQUE MOTOR[RPM]

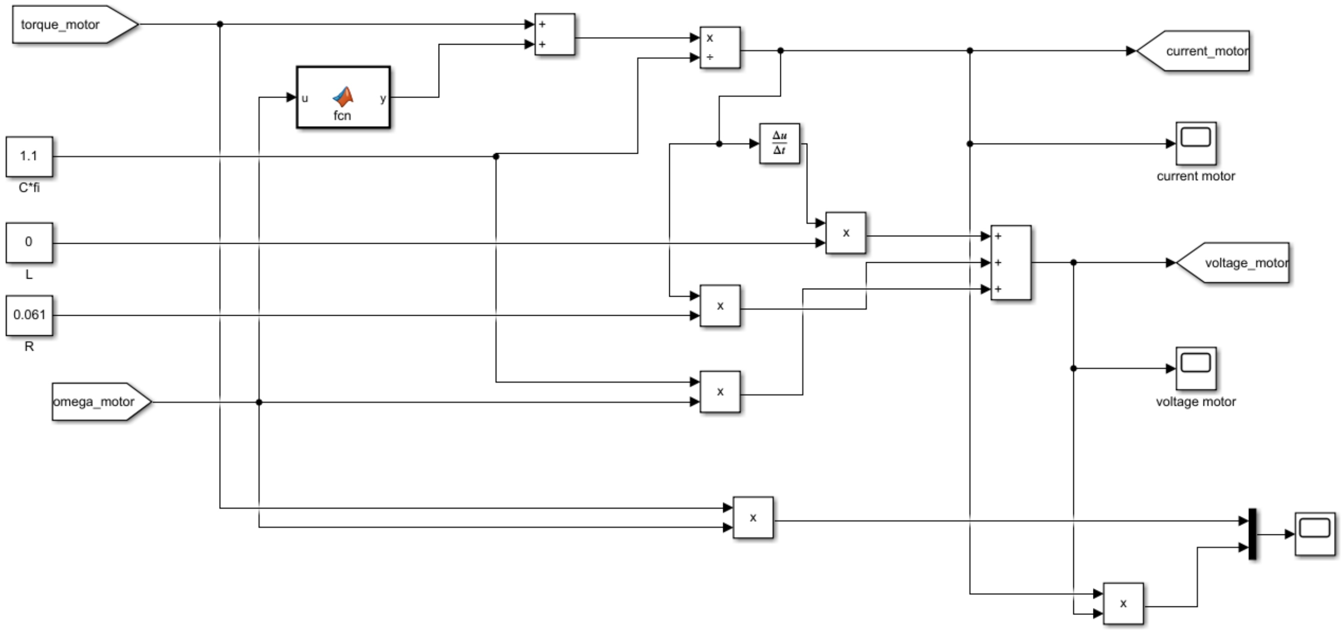


OMEGA MOTOR(angular vel.)

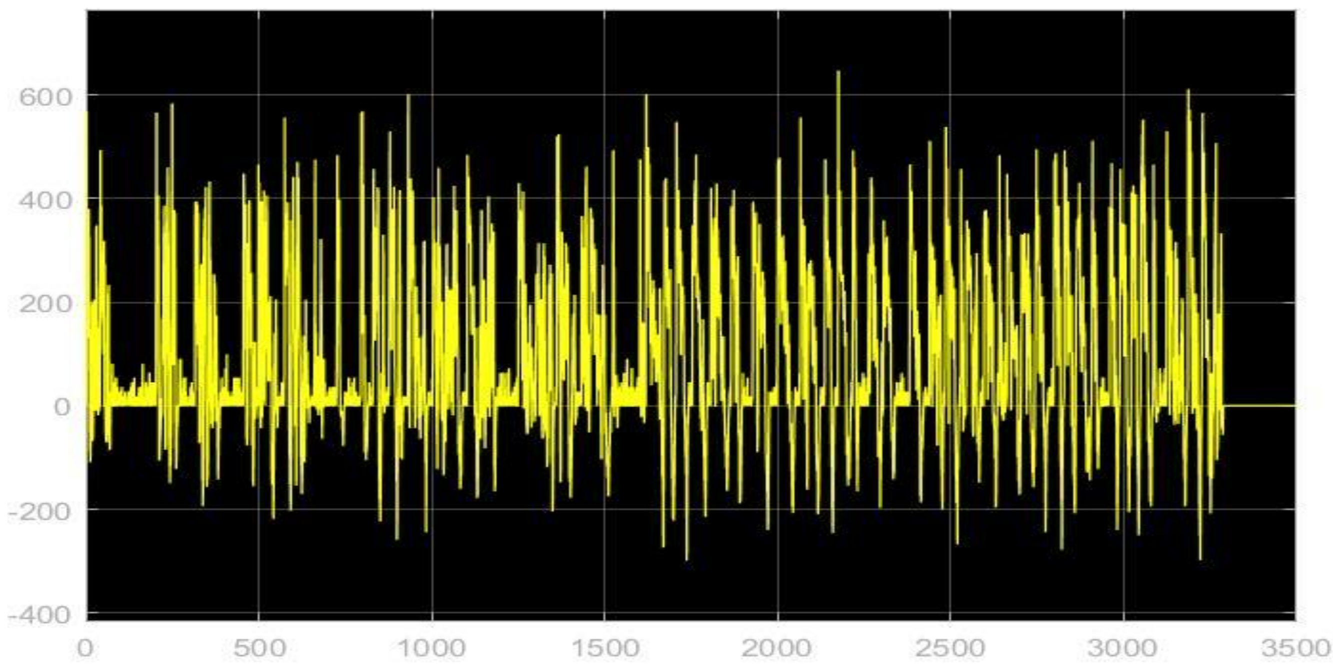
$$\omega_{motor} = k \cdot \omega_{wheel}$$

$$M_{motor} = \begin{cases} \dfrac{M_{wheel}}{k} \cdot \eta_{m\_wheel}^{-1} & \text{for } M_{wheel} \cdot \omega_{wheel} > 0 \\ \dfrac{M_{wheel}}{k} \cdot \eta_{m\_wheel} & \text{for } M_{wheel} \cdot \omega_{wheel} < 0 \end{cases}$$

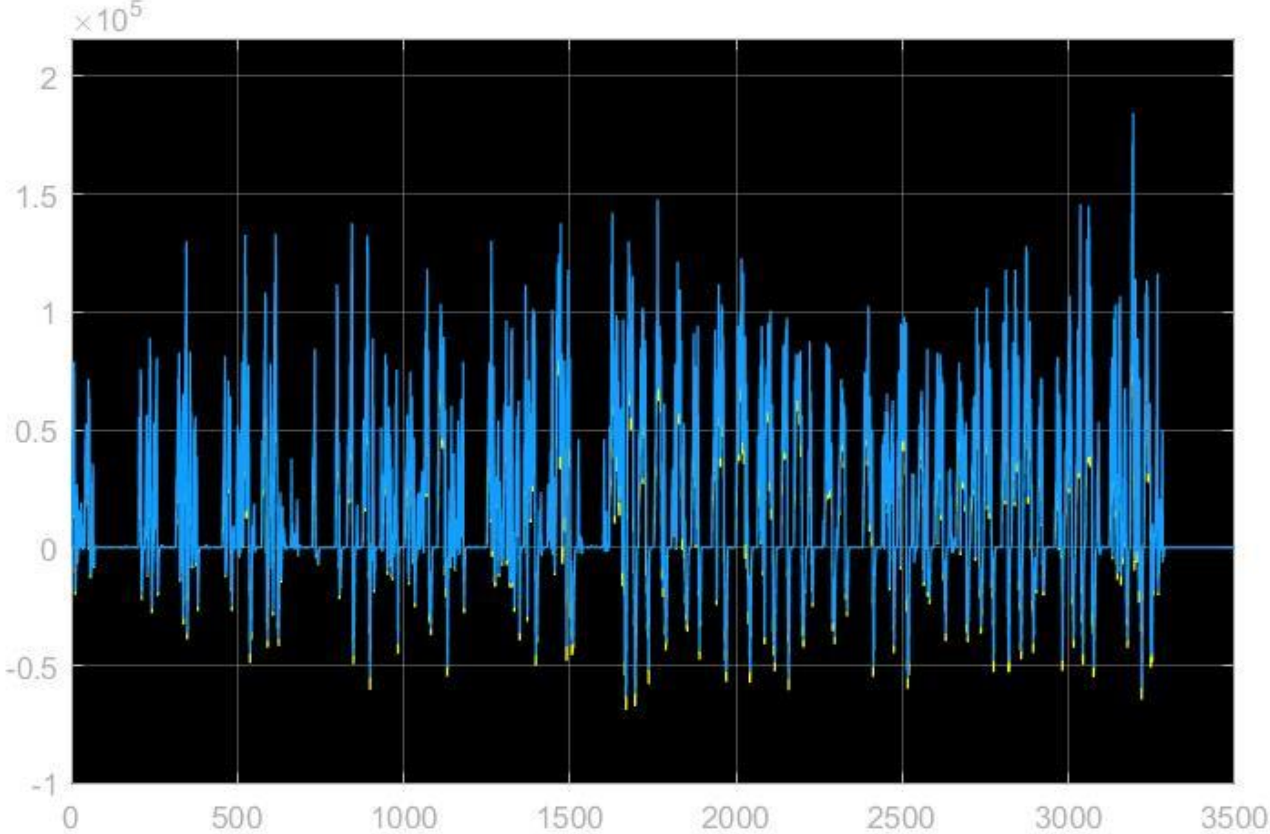
5) MODEL OF A DC MOTOR



CURRENT MOTOR:

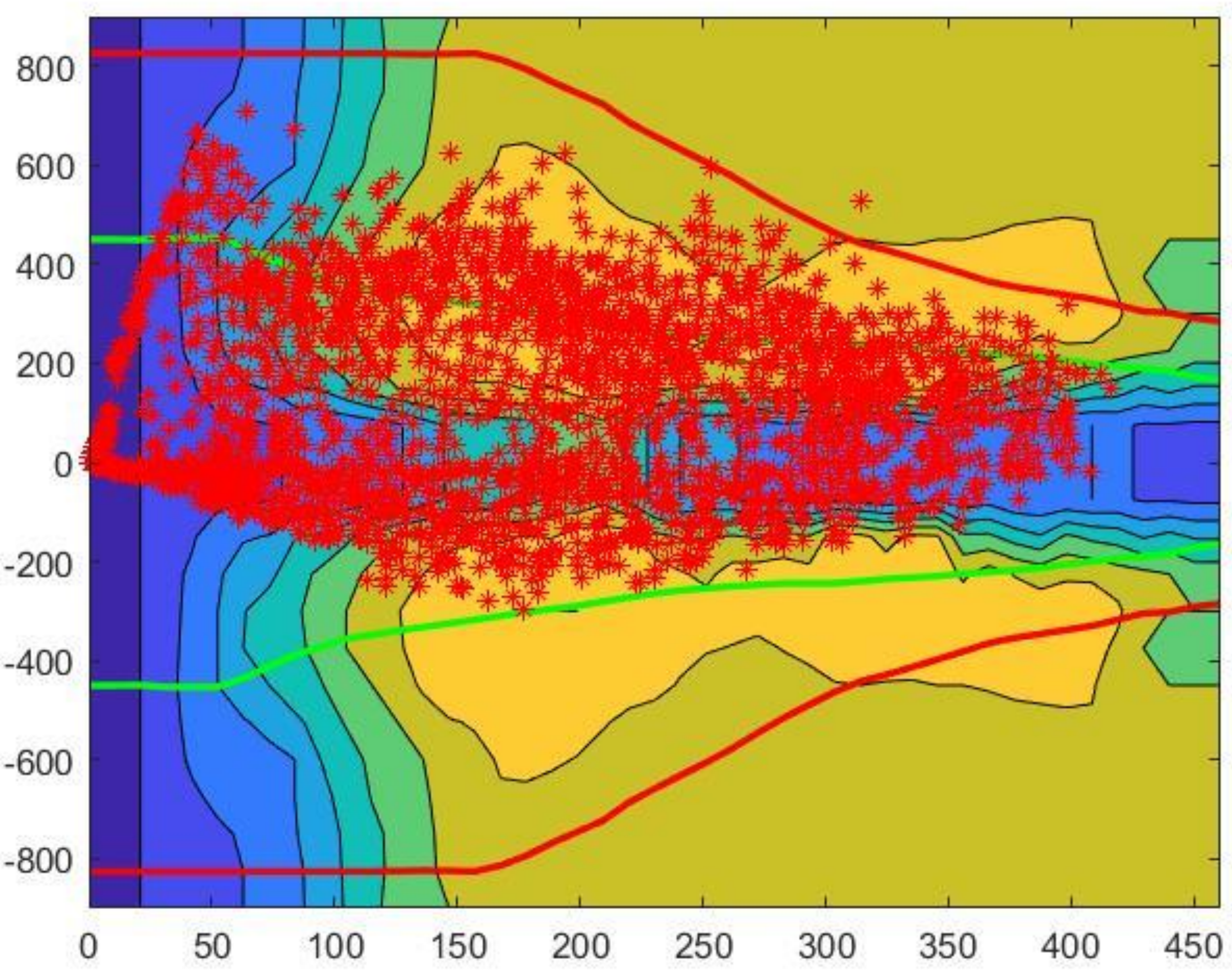


POWER DISTRUBITION OF DC MOTOR:

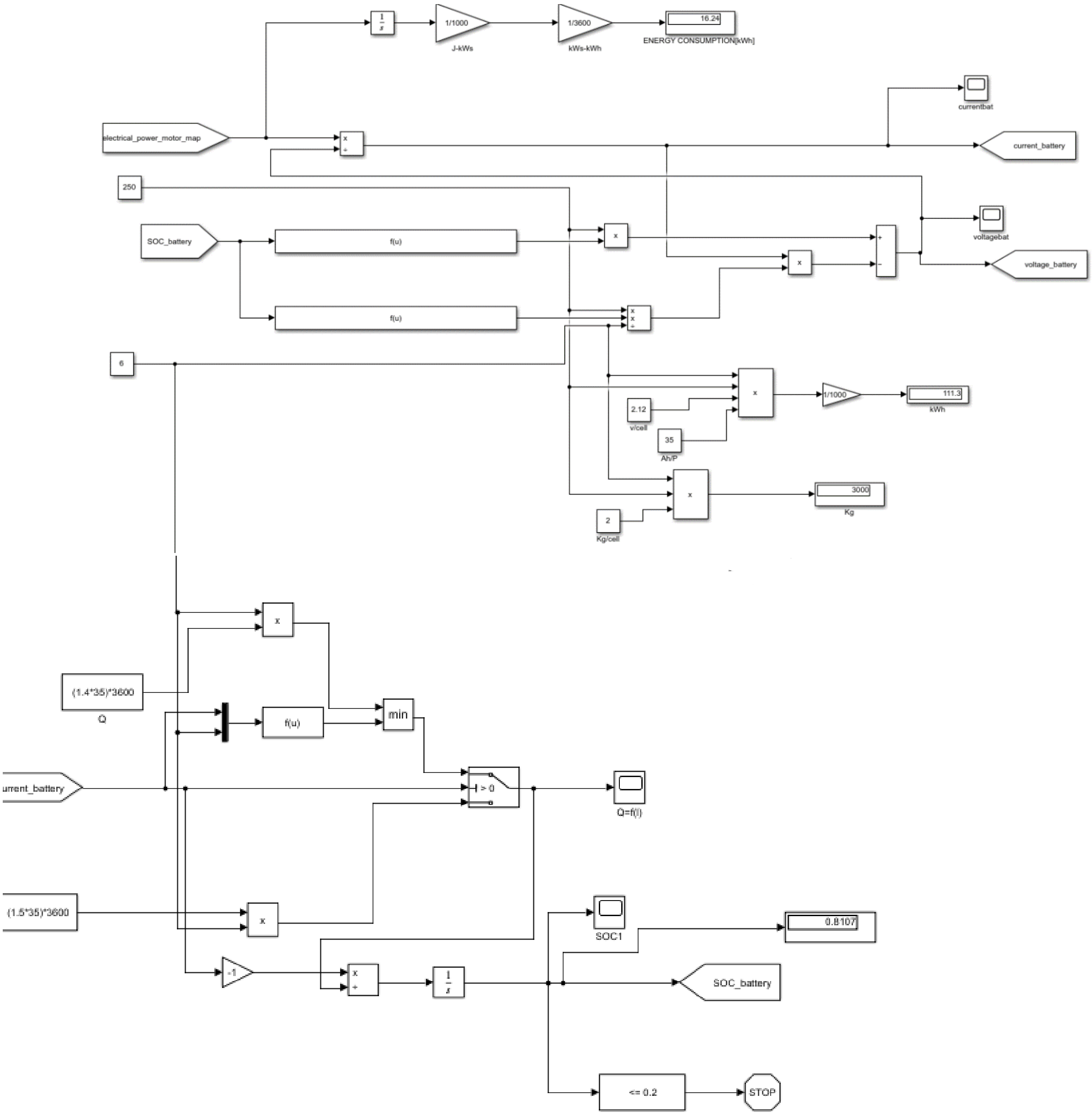


EFFICENCY MAP OF DC MOTOR:

- The map shows the maximum operation limits and optimal working area for our vehicle and total efficiency of the motor/inverter. Green line is a continuous power curve which indicates the vehicle can operate without any heat exceeding for instance in this area. Red line is the maximum power line which means if the power crosses this line motor/inverter can take permanent damage.



6) BATTERY MODEL



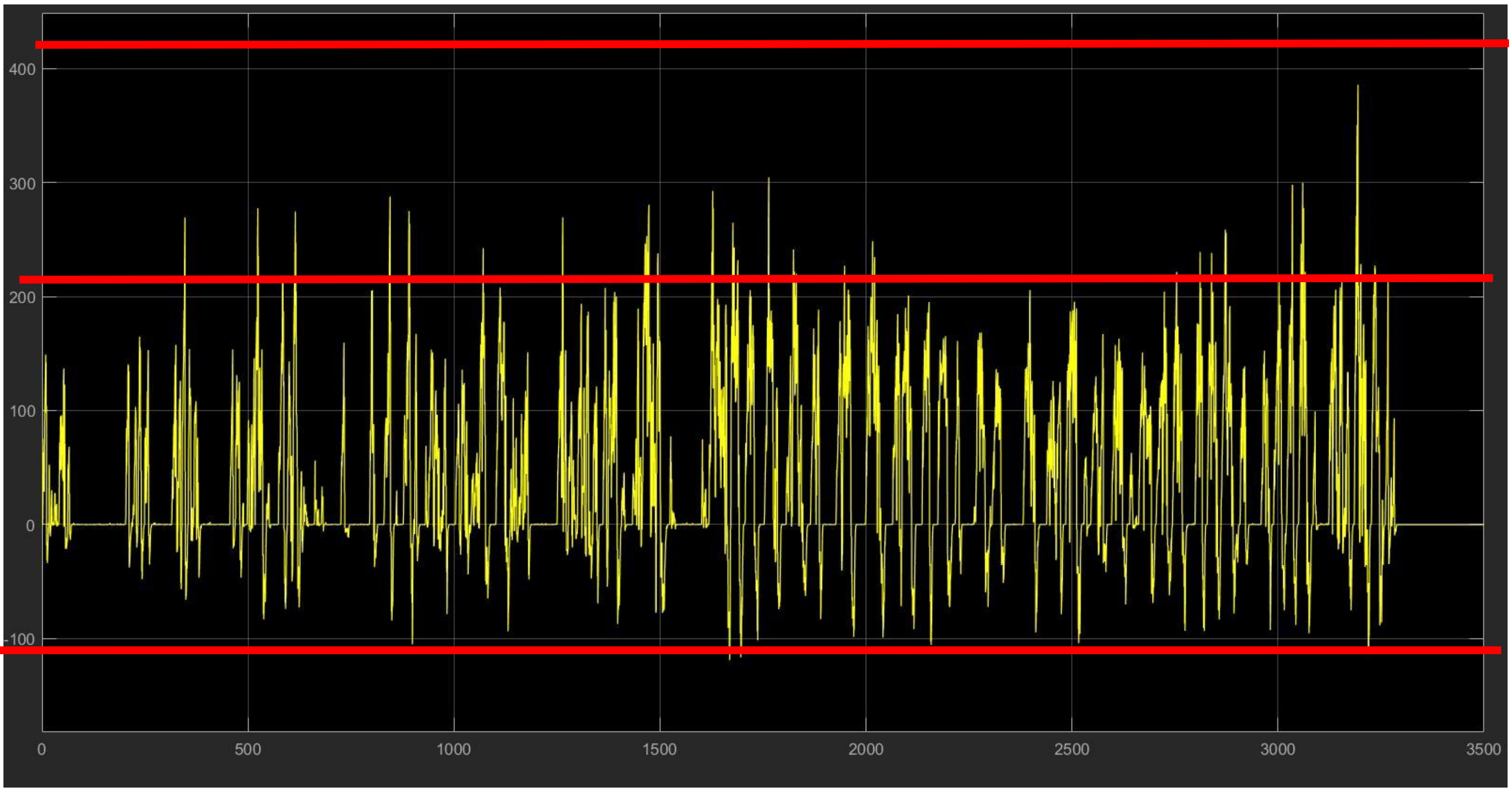
We assume nominal capacity for 1h is 35 Ah [Qmax = 1.5*35, Qcharging = 1.4*35]

6 PARALLEL CONNECTIONS [35*6 = 210 Ah]

We assume 2C as discharge current(30min) 2C current = 210*2 = 420A

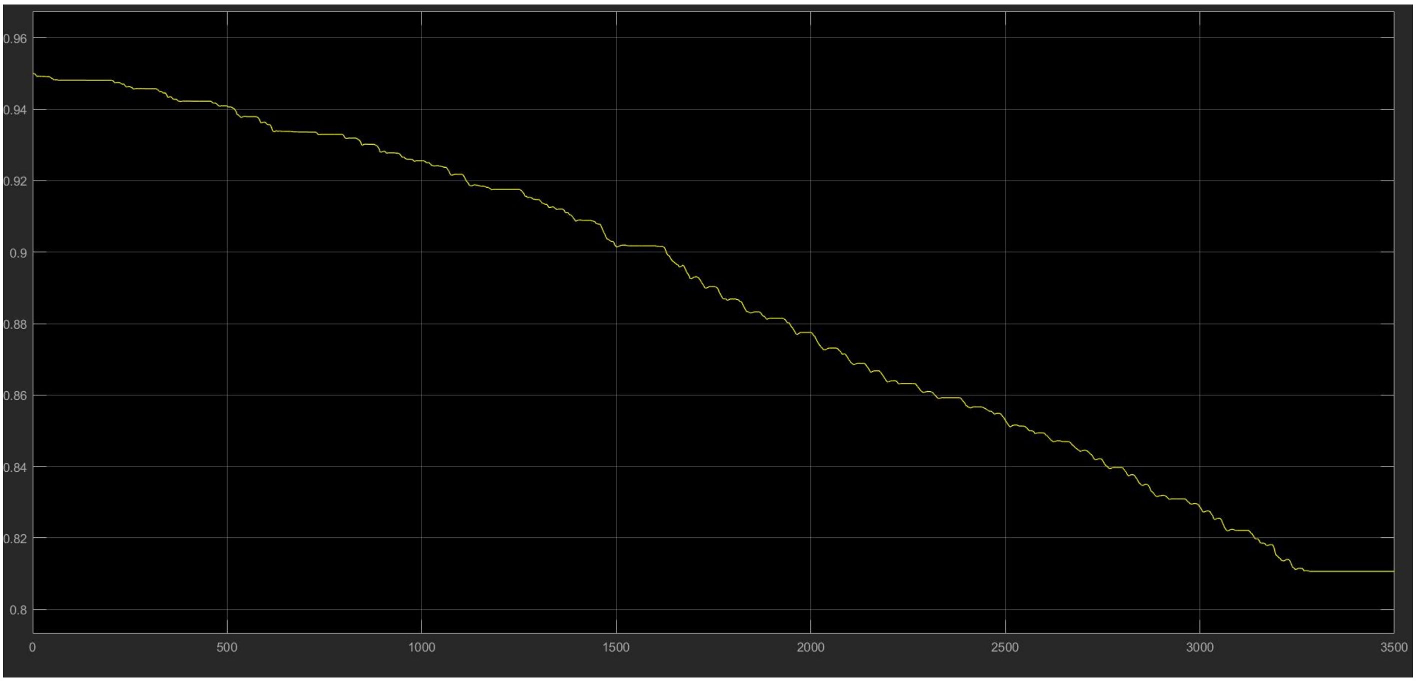
0.5C as charging(2h)[1C temporarily and 0.1 continuously] 1C current = 210*1 = 210A

-0.5 charging → -210/2 = -105A



CURRENT BATTERY: When we observe the scope data, we can say it is more or less fit to our assumptions.

SOC CHART:



In case of not facing the over discharging situation we set the minimum soc value to %20.

SOC experiment (energy consumption and distance measurements)

CALCULATED ENERGY CONSUMPTION RATE: 1.322383429

1.3 is the average value for 12m buses

SOC	distance	en. cons
0.95	12.3	16.24
0.8107	12.3	16.24
0.6715	12.3	16.24
0.5316	12.3	16.24
0.3912	12.3	16.24
0.2494	4.254	5.752
SUM=	65.754	86.952

EXERCISE 1: EFFECT OF NO. OF PARALLEL CONNECTIONS FOR BATTERIES ON SOC AND BATTERY MASS

- When the number of parallel connections was decreased to 4, mass is obviously dropped to significant value 2000 kg and SOC is dropped to 0.70 from initial value of 0.95. This soc change means that we are forced to discharge the battery more in the same time period and with the same energy consumption.

- As I increased the number of connections to 8, mass is raised to 4000 kg which is of course a disadvantage. Additionally, more parallel connections for batteries mean that there is more possibility to face a failure of single cell. SOC value was raised to 0.85 which means we are discharging or using one can say the battery more slowly, which is the only advantage of this case because lifetime of the battery cell is increased in this situation so finally it gives more efficient usage to us in practise.

CONCLUSIONS:

During the project we have experienced how to implement a electric drivetrain simulation into MATLAB software. It was also good practise to improve the MATLAB and Simulink skills. After this we have learned the design of calculating important electrical and mechanical values out of given vehicle parameters that provided from the professor. Then with some additional exercises, we have measured the effect of battery default parameters on mass and state of charge values. Most important values that we observed were distance travelled and the energy consumption of the battery part. With all the experiment the goal was to match the assumptions with the efficient practical application. Finally, I believe that I have managed to achieve that goal successfully.