SUBJECT: PROJECT ON ELECTRIC AND HYBRID DRIVES

TITLE: PROJECT NO.2 [HEV DRIVE]

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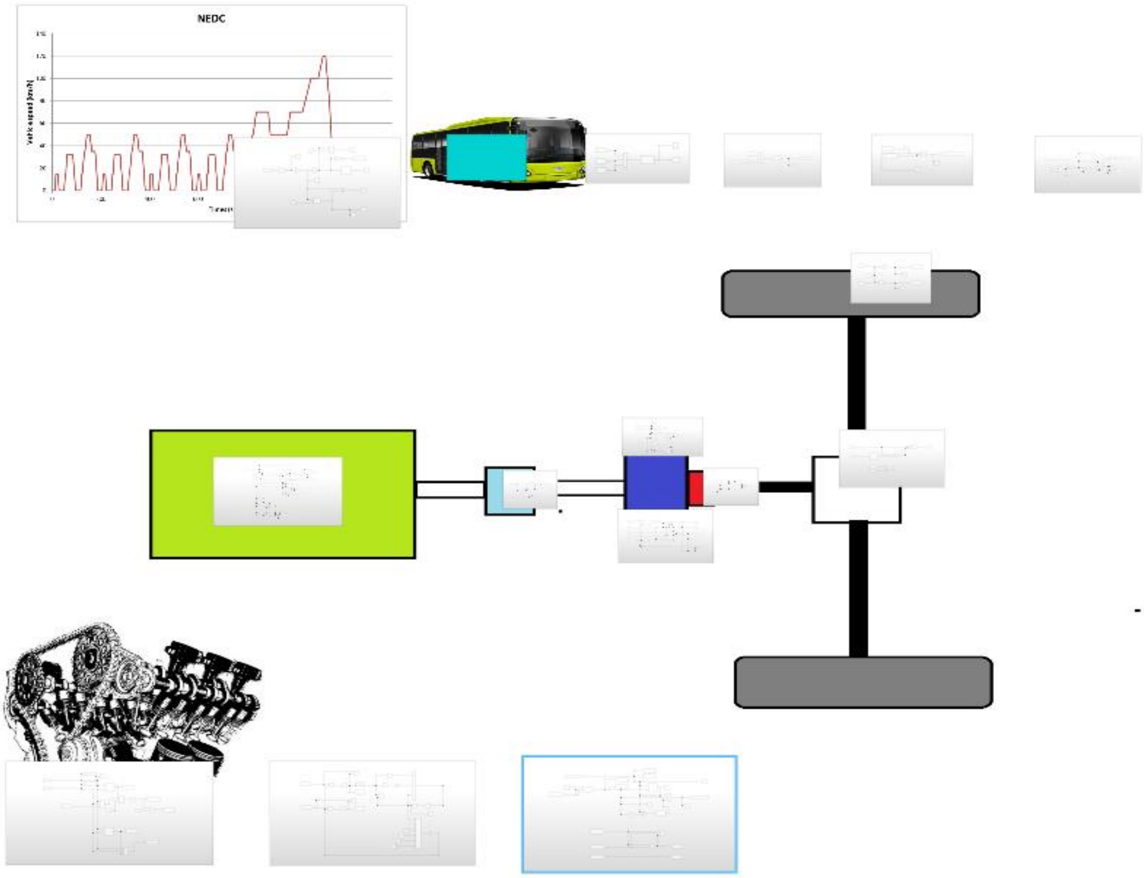
1) INTRODUCTION TO THE PROJECT:

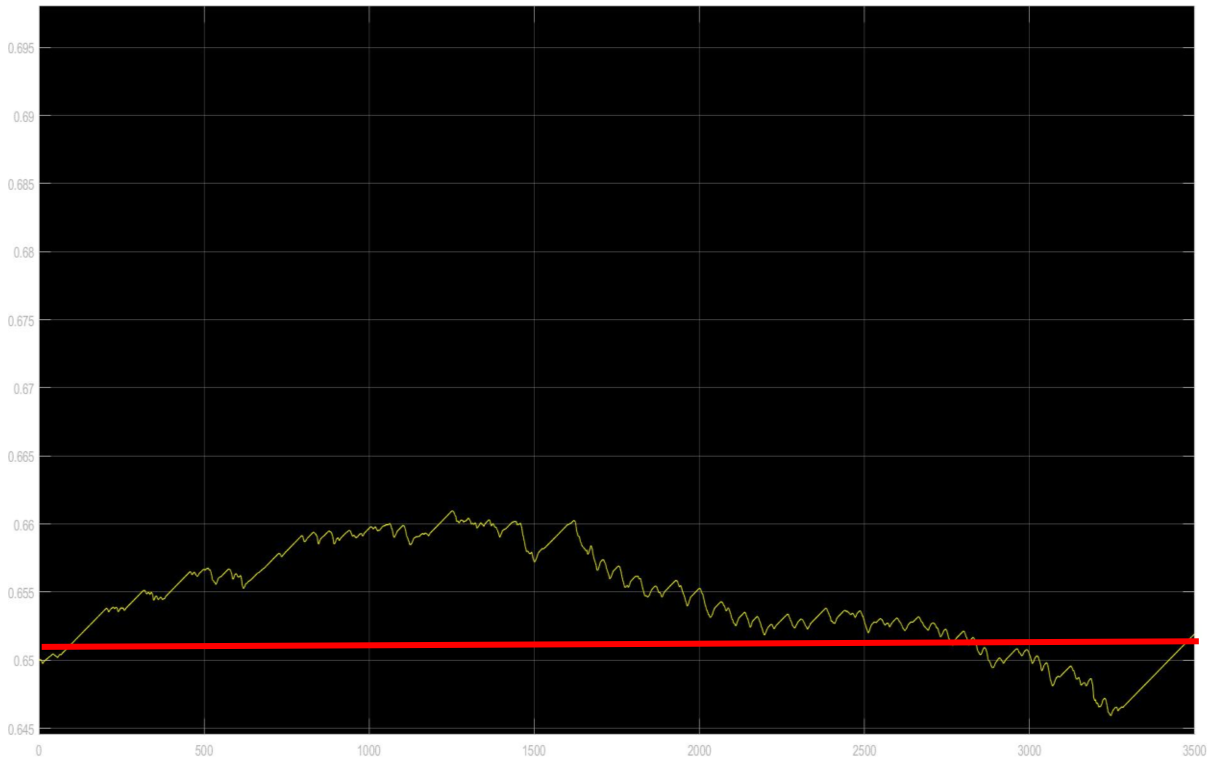
- *Scope of the project was to build a simulation of HYBRID-ELECTRIC drive for a city bus. While considering the vehicle parameters, passengers have taken into account for the value of vehicle mass for an example. To simulate this system each detailed information such as dynamic radius, drag and rolling resistance forces, frontal area and other parameters has considered. To implement the hybrid drive, we need to integrate a combustion engine into our simulation model.*

- **GENERAL OUTLINE TREE OF SIMULINK: (WITH 3 ADDITIONAL SUBSYSTEM TO OLD PROJECT; ICE/ELECTRIC MOTOR MODEL/GEARBOX!!)**

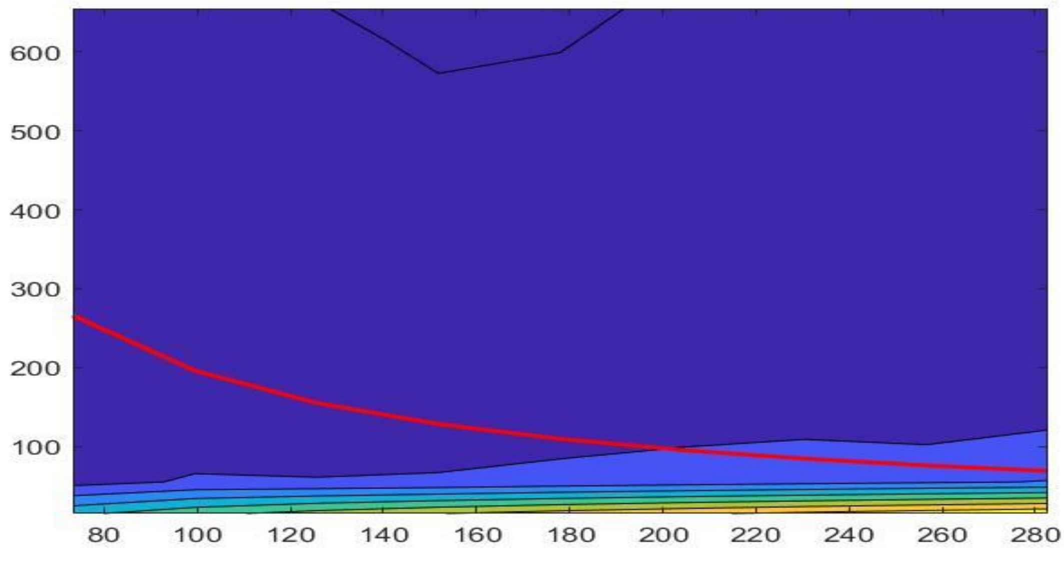


2) SOC CONFIGIRATION:

- *In the chart below, we can see that the change of SOC = 0(decreased to 0.65). To do that I assumed the power of the battery is 19.5 kW.*



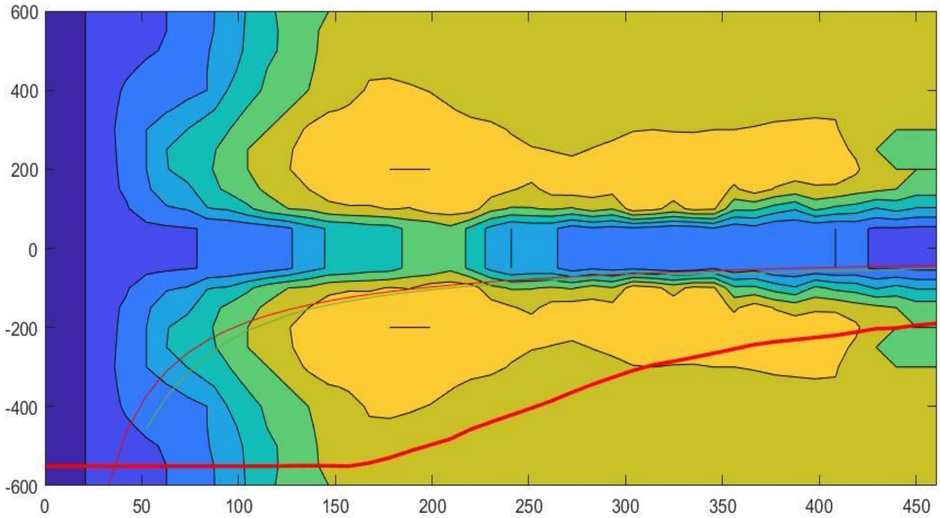
3) ICE DIESEL 170 kW constant power supply characteristics:

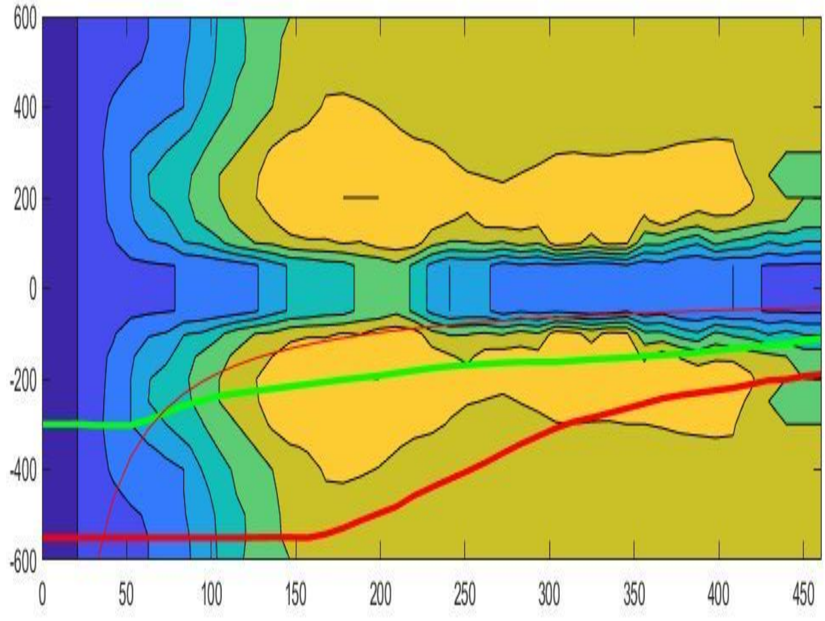


- *Area of the graph shows the fuel consumption in gpkWh. (colors refers the level).*

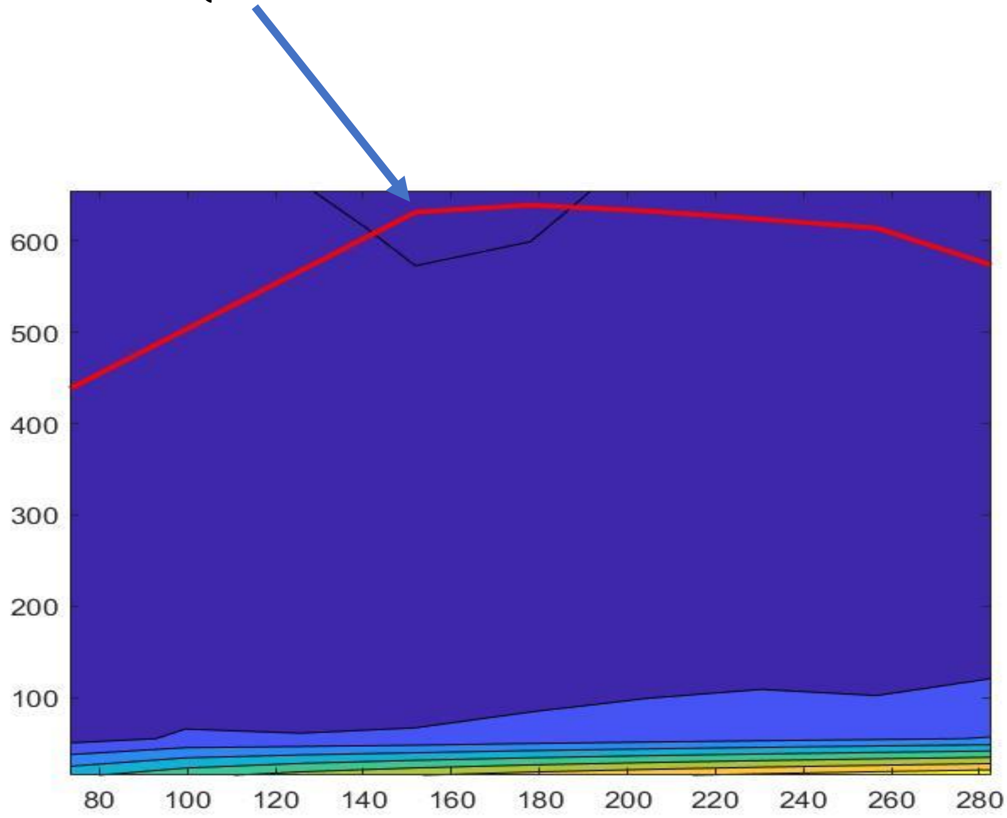
4) MODE ‘ELECTRIC GENERATOR’ CHARACTERISTICS: TORQUE(Y) VS OMEGA(X)

- *Red hyperbolic curve is output power of generator(electrical). Light color curve under the red one shows the mechanical input power(small difference due to high efficiency).*





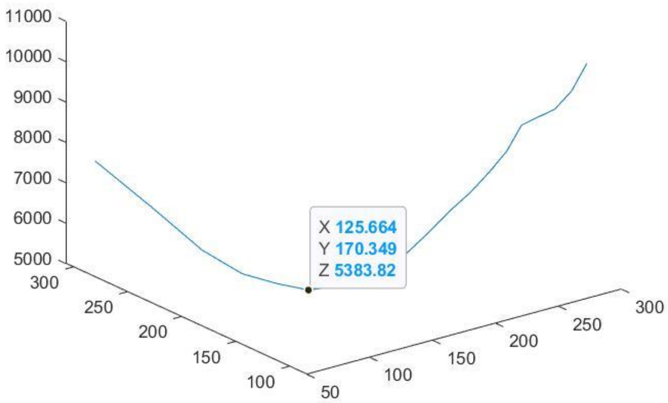
5) MAXIMUM TORQUE CHARACTERISTICS OF ICE:



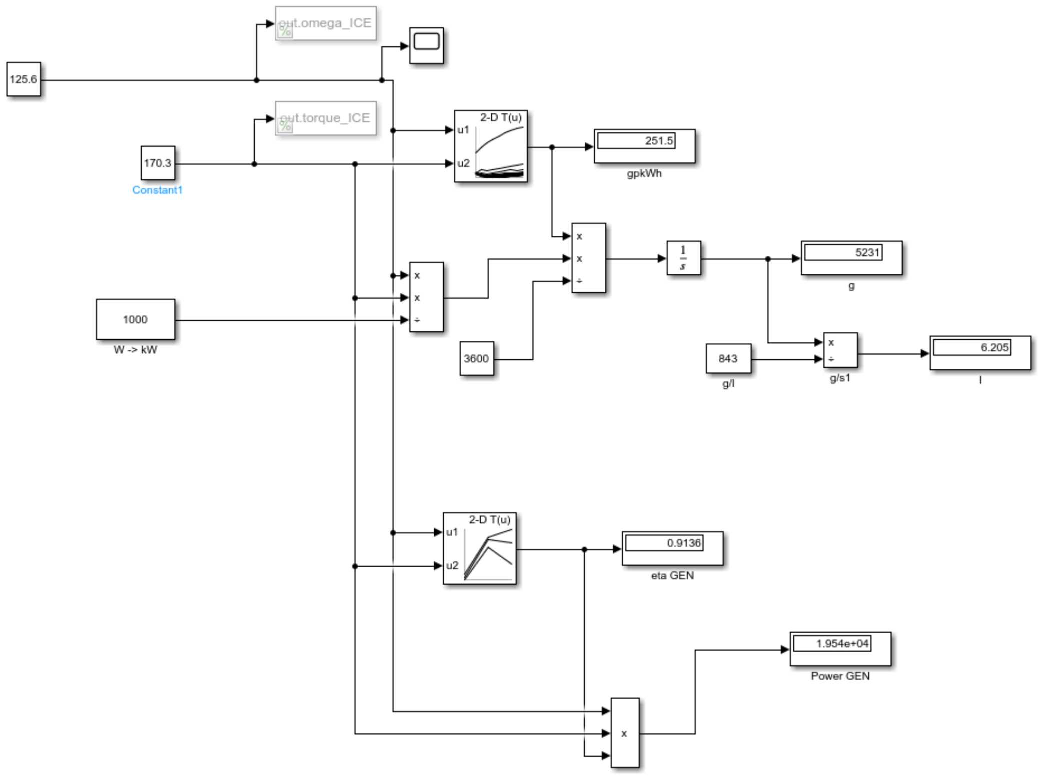
6) 3D characteristics of angular vel.&torque&fuel cons.

- *The point highlighted below is the most efficient place where engine runs.*

125.6 = omega_ice *170.34 = torque_ice* *5383 = gph (fuel consumption)*



7) ICE/generator model (implementing selected efficient values for omega and torque from previous observations)



FUEL CONSUMPTION IN LITER IS =6.2 L in 12.3km

Used formula in Simulink:

$$\text{fuel consumption } [l/100km] = \frac{\text{fuel consumption } [l]}{\text{distance } [km]} * 100$$

(6.2/12.3)*100 = 50.4L (in 100km)

- *At this point we are testing if the smaller ICE consumes less fuel or more. To do this we need to rescale the torque of ICE(before: 170 kW after 0.3*170 kW).*

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fc_map_trq*0.3
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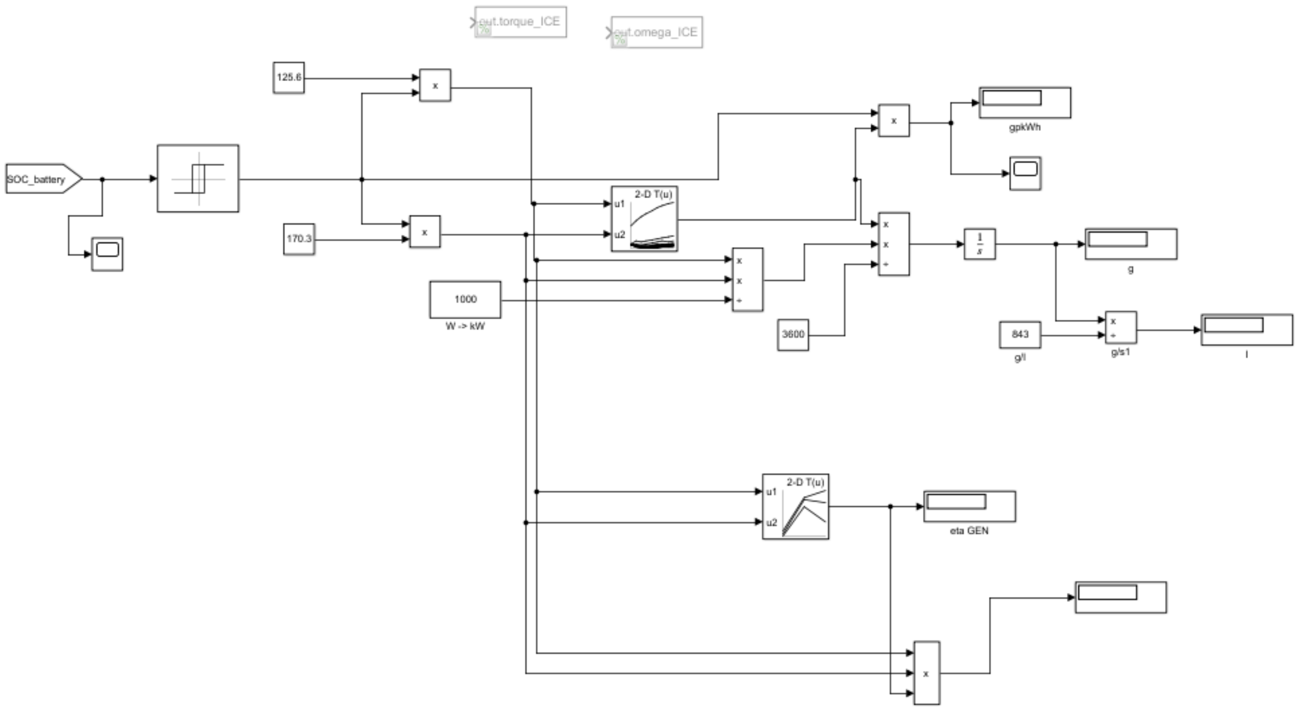
- *After rescaling the new fuel consumption is 5.18 l . That means in the range of 100 km it is 42.1 L.*
- *So we can say that reducing torque of ICE in our model is also reducing the fuel consumption significantly.* ***So ICE power is matter.***

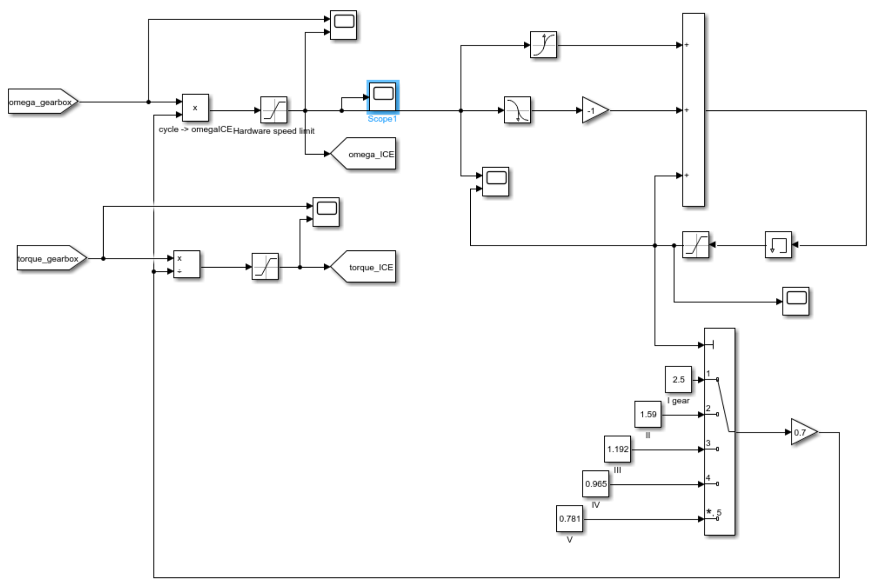
- *In the figure below the new SOC graph presented with high_power_uphill strategy. Again, the deltSOC = 0. To do that we used relay block in our simulation (on-off operation VALUES ARE 0.7 /0.57).*

- *Simulink model captured below shows the configuration of temporary high-power strategy*



- **AFTER THAT POINT, WE ARE SWITCHING TO <u>PARALLEL HYBRID DRIVE</u> (CONSTANT STARTEGY)!!**

- *To analyse the fuel consumption for this drive, we are introducing new gearbox configurations:*



GEARBOX RATIOS AND USED FORMULAS:

1- 2.5
2- 1.59
3- 1.192
4- 0.965
5- 0.781

$$M_{0gear} = \begin{cases} \dfrac{M_{wheel}}{k\eta_{gear}} & M_{wheel}\omega_{wheel} > 0 \\ \dfrac{M_{wheel}}{k}\eta_{wheel} & M_{wheel}\omega_{wheel} < 0 \end{cases}$$

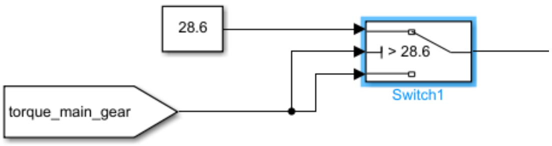
$$M_{gearbox} = M_{0gear} - M_{motor}$$

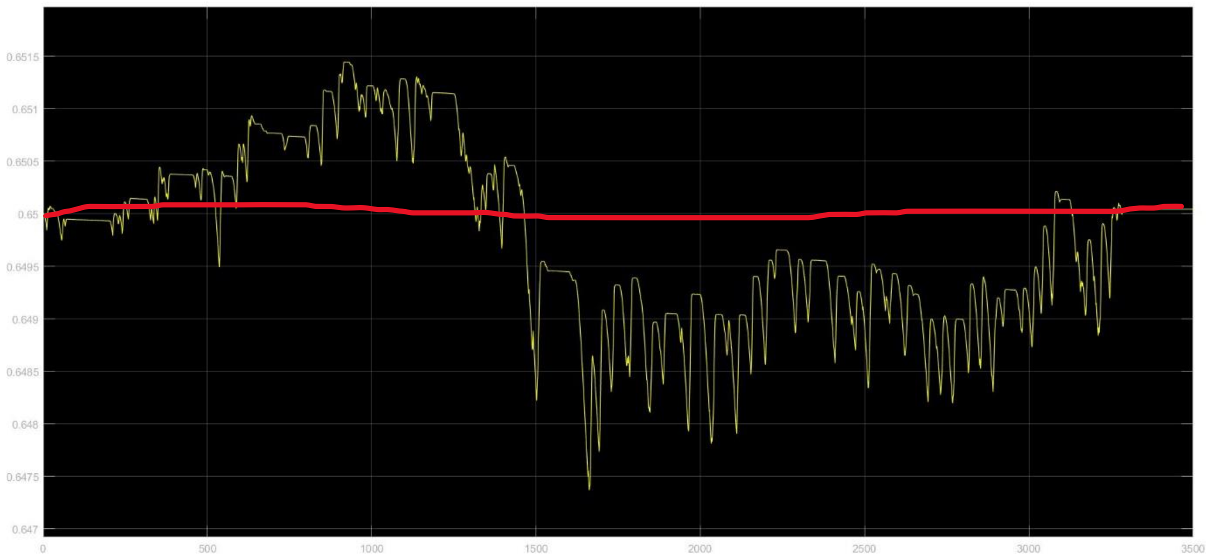
$$M_{ICE} = \frac{M_{gearbox}}{0.7i}$$

$$\omega_{gearbox} = \omega_{0gear}$$

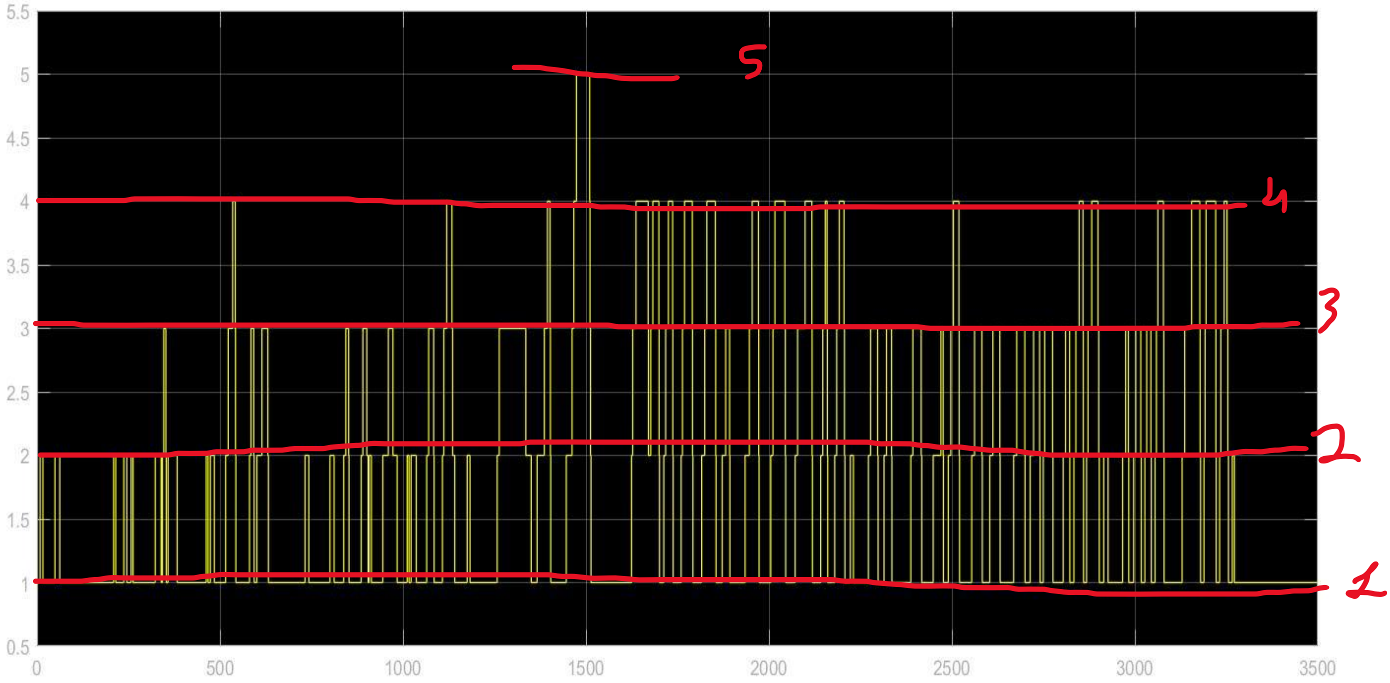
$$\omega_{ICE} = \omega_{gearbox} * 0.7i$$

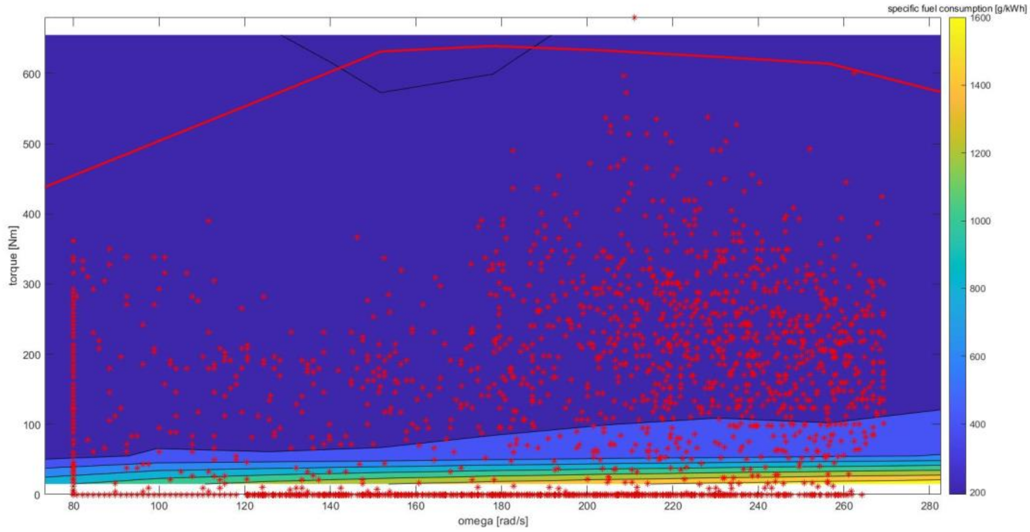
- *SOC Configuration to deltSOC =0: (switch value is 28.6 to balance SOC)*



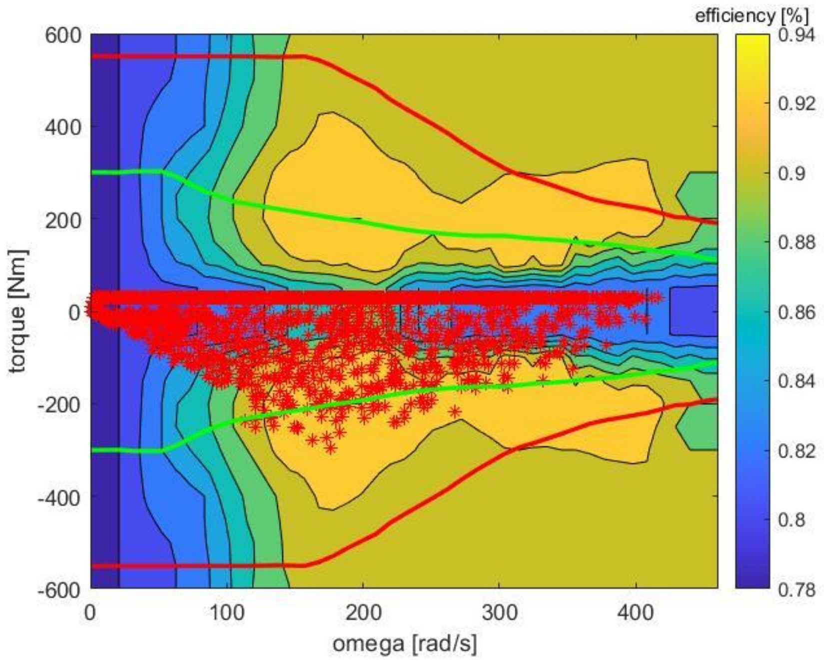


GEAR NUMBER CHANGES IN TIME:



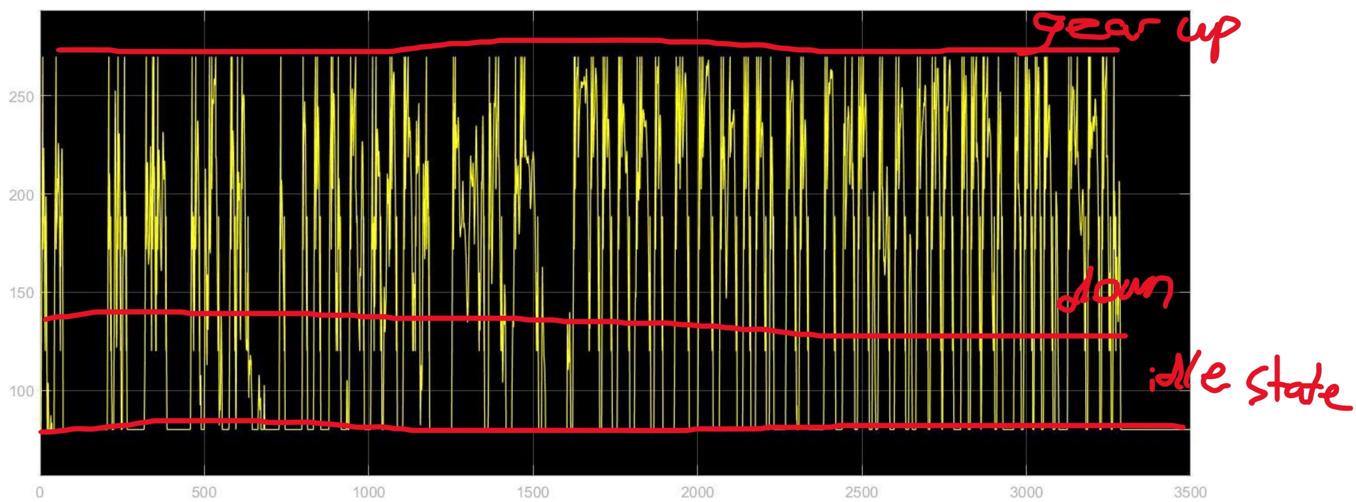


- *The graph above shows the specific fuel consumption disturbation by our working points. Mostly our operating are is between 400-800 gpkWh.*



- *The graph on left its clearly seen that operating points are in mostly In range of the green lines. Thus, we can say our ICE works in nominal conditions and not overcoming which we desire.*

- *OMEGA ICE:*



FINAL CONCLUSIONS

- *In this project, we basically know the strategy of both series and parallel electric hybrid vehicle. At first, we modelled of constant power strategy. This power should be balanced the SOC, so we did that by setting genset power value to optimal (19.5 kW in my case). Then we were able to get the characteristics of our vehicle like engine power curve, efficiency, and maximum torque of ICE. From this data we got the most efficient operating angular velocity and torque combination by comparing fuel consumption value. In this case we considered the efficiency of generator. Then, we were able to calculate fuel consumption in 100km ride. We can easily find that the engine is big for our calculated by model. It was seemed like the ICE was too big for our economical target. So, we decrease the scale of engine and get the higher efficiency for the hybrid vehicle. By this we decreased the specific fuel consumption. After that we considered the temporary high-power situation(uphill). We go back to full size of ICE in this step. After completing this test, we considered the parallel hybrid drive. After comparing all specific fuel consumption rates per 100km ride, best option seems to be scaled size the ON/OFF strategy for series hybrid drive.*