PROJECT REPORT

Electrical Vehicle Modelling with DC Motor using MATLAB/Simulink

PROGRAM: EPICO

BATCH: 2024-26

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References

1. Chatterjee et al., Electric Vehicle Modeling in MATLAB and Simulink with SoC & SoE Estimation of a Lithium-ion Battery.
2. Simulation of Electric Vehicles Based on Simulink- Qingzheng Yang School of Electrical Engineering, Northeast electric power university, Jilin, China.

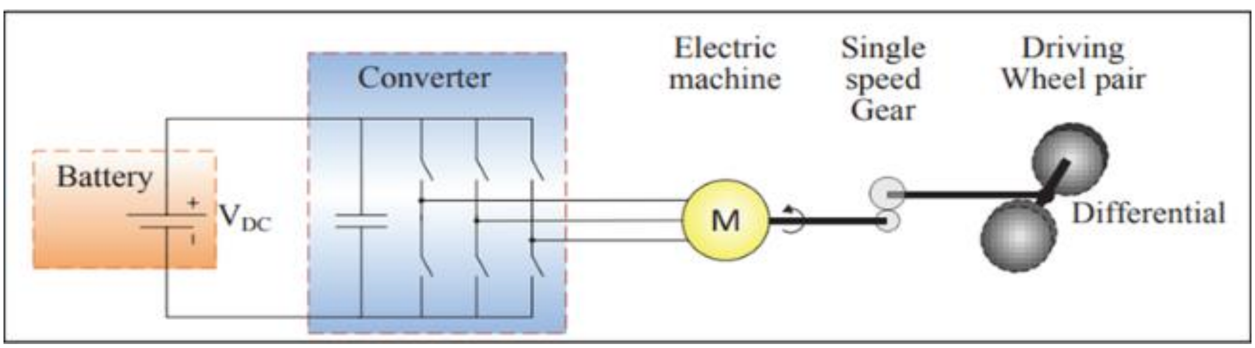
1. Abstract

This project presents a comprehensive simulation of an Electric Vehicle (EV) powered by a DC motor using MATLAB/Simulink. The aim is to develop a realistic model that includes vehicle dynamics, motor behavior, and battery energy flow. A simple controller is used to regulate vehicle speed under varying load conditions. The results highlight the performance, energy consumption, and behavior of key components during operation. This model serves as a foundation for understanding EV propulsion systems and can be extended with advanced features like regenerative braking or motor switching.

2. Introduction

Electric vehicles have emerged as a promising solution to reduce dependency on fossil fuels and lower greenhouse gas emissions. The propulsion system, which replaces the internal combustion engine with an electric motor, plays a central role in an EV's performance and efficiency. Among various types of motors, DC motors are widely used in educational and early commercial EV prototypes due to their simple construction and control.

This project models the complete EV system, with a DC motor as the propulsion source, and simulates its behavior under different operating conditions. MATLAB/Simulink is used for modeling because of its powerful simulation environment and block-based interface.



3. System Overview

The EV model is composed of the following major components:

Battery Pack: Supplies electrical energy to the motor.

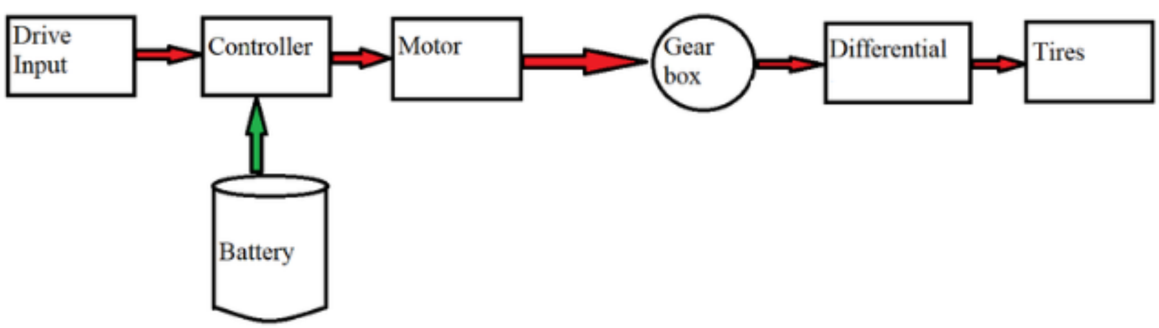
DC Motor: Converts electrical energy into mechanical torque.

Controller: Maintains the desired speed using current or voltage control.

Vehicle Dynamics Block: Simulates mass, friction, air drag, and road gradient effects.

Load/Torque Feedback: Represents Road resistance and load.

System Block Diagram:



4. Components Overview:

1)Lithium-Ion Battery:

The battery of an electric car can be charged through the use of ordinary grid electricity at a specialized power station. But aside from the conventional lithium-ion battery technologies, there are also other major battery technologies which can be used for electric cars.

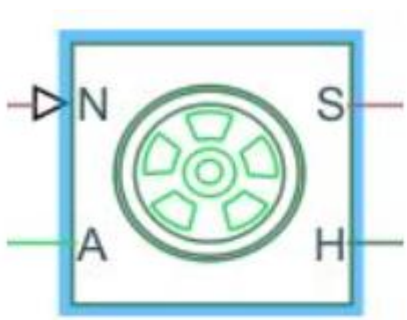
This battery technology gives extra performance and range. However, it also carries the highest price tag. Lithium-ion batteries are lighter than Lead acid and Nickel metal. These are also the batteries used in digital cameras and smartphones.

2)Motor Controller:

The motor controller of an electric car administers its complete operation and the distribution of its power at any given moment. It acts as a floodgate between the motor and batteries. It helps monitor and regulates all key performance indications such as the vehicles operator, motor, battery, and accelerator pedal. It has a microprocessor which can limit or redirect current. It is used to either improve the mechanical performance of the car or suit the operators driving style. There are also more refined controllers which are capable of greater accuracy and thus, higher efficiency

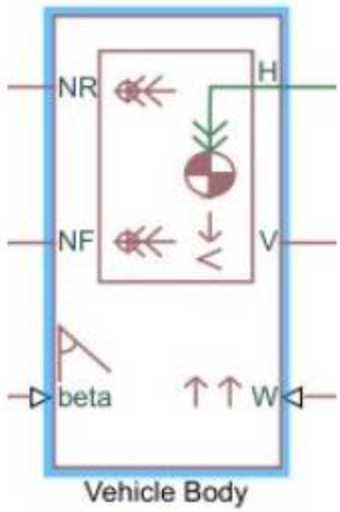
3) Vehicle Body System:

The vehicle is assumed to be a front axle driven (4 wheels - 2 on each axle) and wheels are modelled using simple Tire (Magic formula) Simulink block



The N port of the tire corresponds to the Normal Reaction acting on it. port corresponds to the Mechanical Rotational conserving port for the wheel axle. both the wheels on the same axle should form a connection through their respective A ports.

The tires are parameterized by Peak longitudinal force and corresponding slip, other block parameters such as - rated vertical load, peak longitudinal force at rated load and slip at peak force at rated load - are kept with their default values.



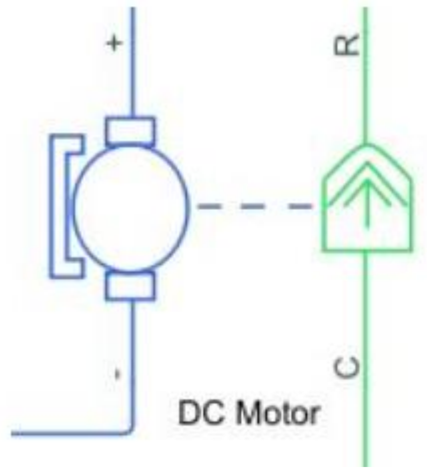
This block basically represents a two-axle vehicle body in longitudinal motion. The block accounts for

- Body Mass
- Aerodynamic Drag
- Road Incline
- Weight distribution between axles due to acceleration
- Road Profile

Here, the connection H is the mechanical translational conserving port hub. NF correspond to the output ports for normal reaction forces on front axle and rear axle wheels respectively. Connection V represents the actual output translational velocity of the vehicle is the road inclination angle W corresponds to the headwind speed (headwind - direction opposite to that of vehicle

4)DC Motor:

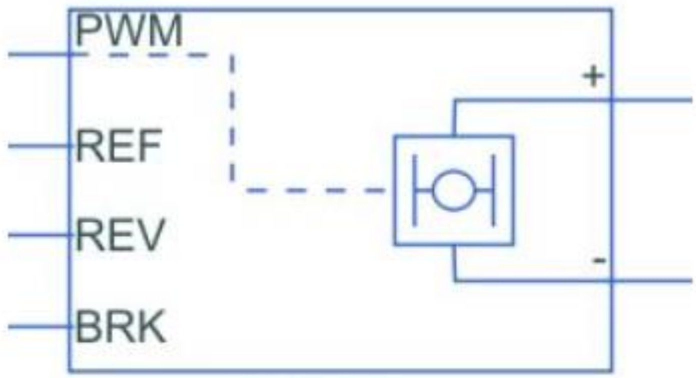
Simulink provides an inbuilt model block for DC motor which converts electrical input into mechanical rotational output. Here, the blue colour corresponds to the electrical side of the motor and the green colour corresponds to the mechanical side. Hence the motor field type is kept as Permanent magnet and the model parameterization is done by rated load and speed. The armature inductance and the mechanical parameters are given their default values.



connection R represents the Rotor while the connection C is for the Casing (stationary). Thus, the R port is connected to the input of the vehicle subsystem created earlier. The C port is connected to a mechanical rotational reference, e + and - terminals of the motor are connected to the motor controller. If these terminals are directly connected to a battery, the required DC motor will run on the rated capacity of the battery. This will eventually result into no control over the DC motor and the vehicle will run at top speed throughout the simulation. Thus, a motor controller is very much needed.

5)Motor Controller: (H-Bridge)

This block represents an H-bridge motor drive. The block can be driven by the Controlled PWM Voltage block in or Averaged mode. In PWM mode, the motor is powered if the PWM port voltage is above the enabled threshold voltage. In Averaged mode, the PWM port voltage divided by the PWM signal amplitude parameter defines the ratio of the on-time to the PWM period, Connection REF is for the reference input. This combined with the PWM connected will form the pulse input for the H-Bridge. Here, the REF input is connected to the Electrical Reference (ground).



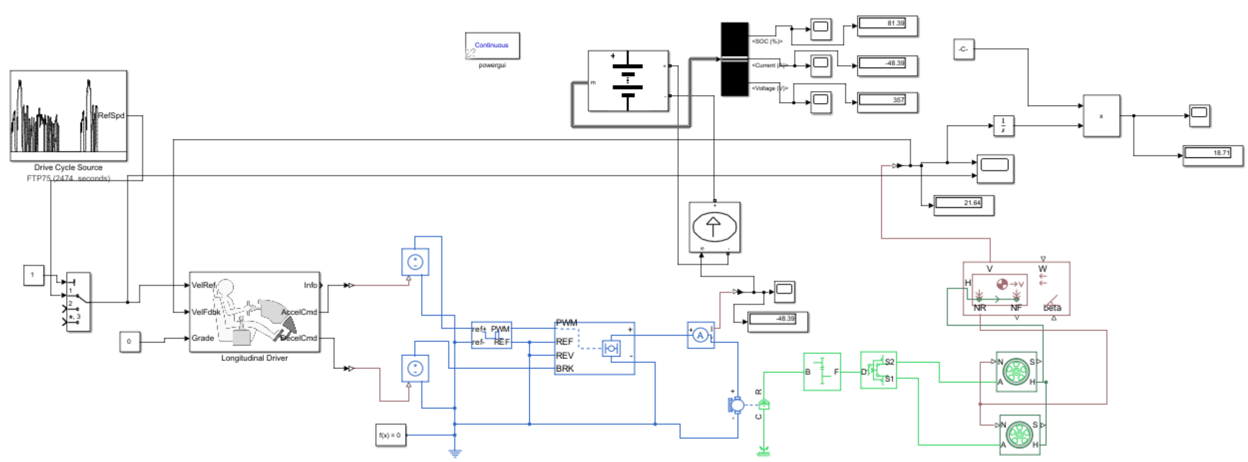
Connection REV corresponds to the reverse motion of the motor which essentially means, the backward motion of the vehicle. Here, the backward motion of the vehicle is not accounted for and so, the port is connected to the electrical reference. Connection BRK is for the braking of the vehicle. Since, the PWM mode results in a huge amount of simulation time, Averaged mode is selected for this simulation. Load current characteristics are considered to be smoothed here. Also, the regenerative braking is enabled for the simulation. This means, when the vehicle starts decelerating, corresponding amount of charge will be fed back to the battery. Accordingly, the BRK input is connected to a Controlled Voltage Source. This will generate emf corresponding to the intensity of brakes applied and fed the power back to the battery.

6) Longitudinal Driver:

It is a parametric longitudinal speed tracking controller for generating normalized Acceleration and Braking commands based on reference and feedback velocities. The VelRef port is the reference velocity port where the input drive cycle data is fed. The VelFdbk port corresponds to the feedback velocity. The actual velocity output given by the vehicle body is connected here. By comparing the actual (feedback) velocity with the reference velocity, the driver block generates acceleration and braking signals in order to minimize the error between the two concerned velocities.

Grade corresponds to the grade angle. For this simulation, no inclination is considered and hence, a constant block with value 0 is connected. Info gives the output for the bus signal for different block calculations like difference in reference vehicle speed and vehicle speed, etc. AccelCmd DecelCmd correspond to the acceleration and deceleration commands generated respectively and are connected to the corresponding ports of the Controlled PWM Voltage block.

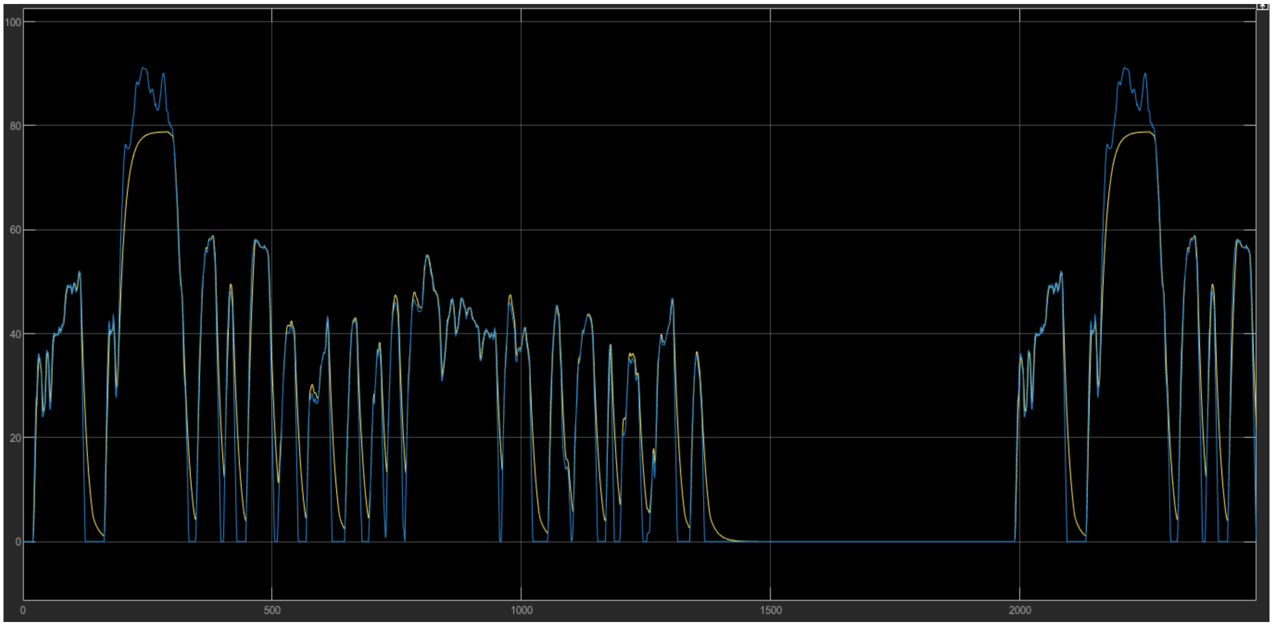
5. Simulation:



The system is running for simulation for 2474 s which is the total time for which the input drive cycle is defined and A Solver Configuration is added to ensure proper solving of the mathematical equations by the mode. Scopes are connected to analyze different outputs such as the SOC of the battery, the reference velocity the actual velocity of the vehicle and the distance covered by the vehicle during the total run.

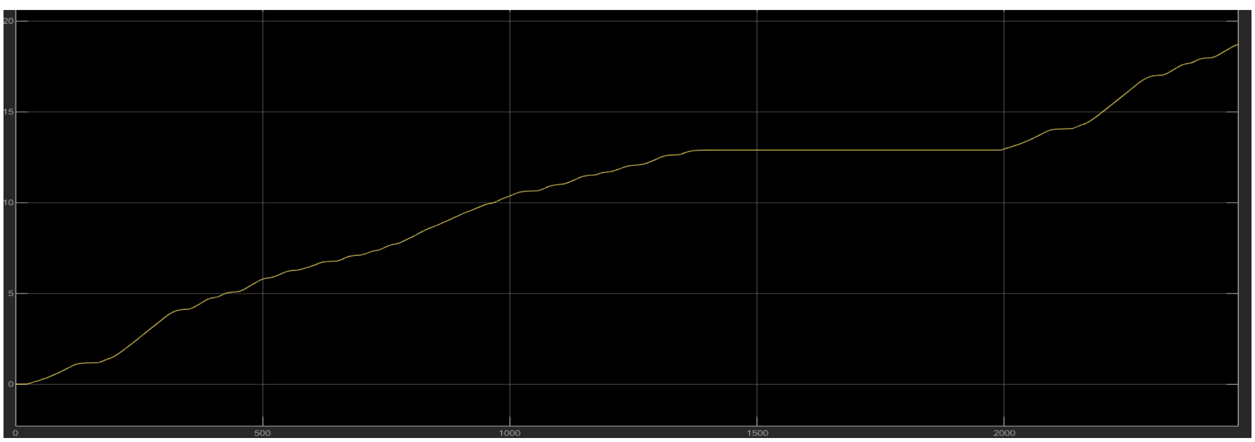
6. Results and Graphs:

Reference Speed VS Actual Speed



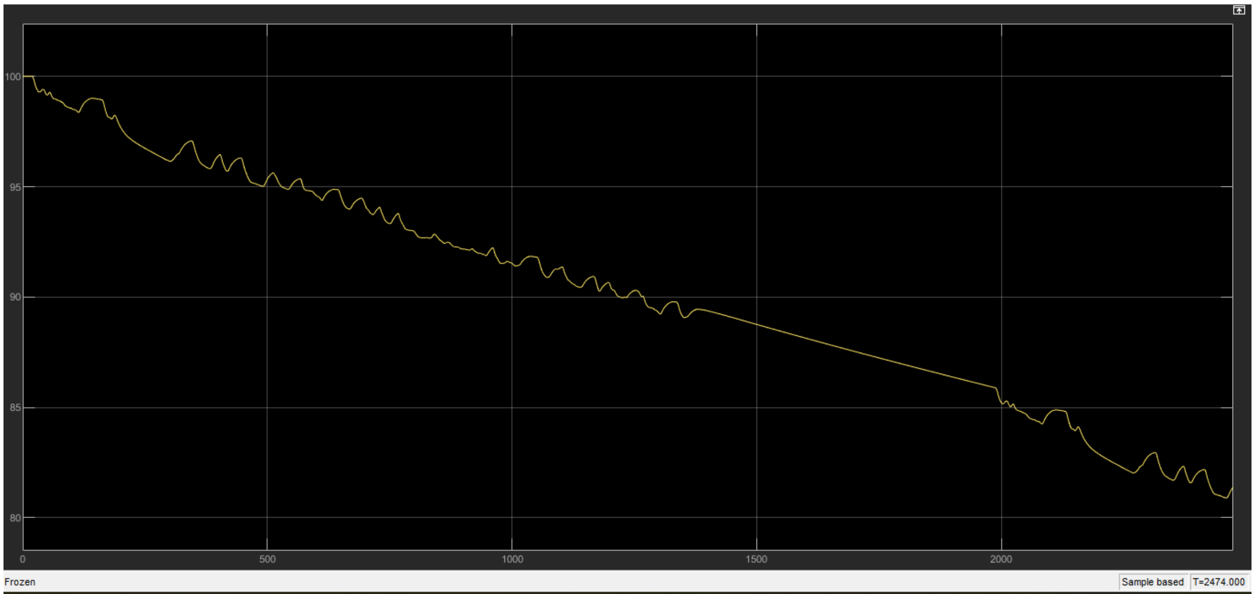
The Blue line represents the Reference speed and the Yellow represents the actual vehicle speed.

Distance Covered



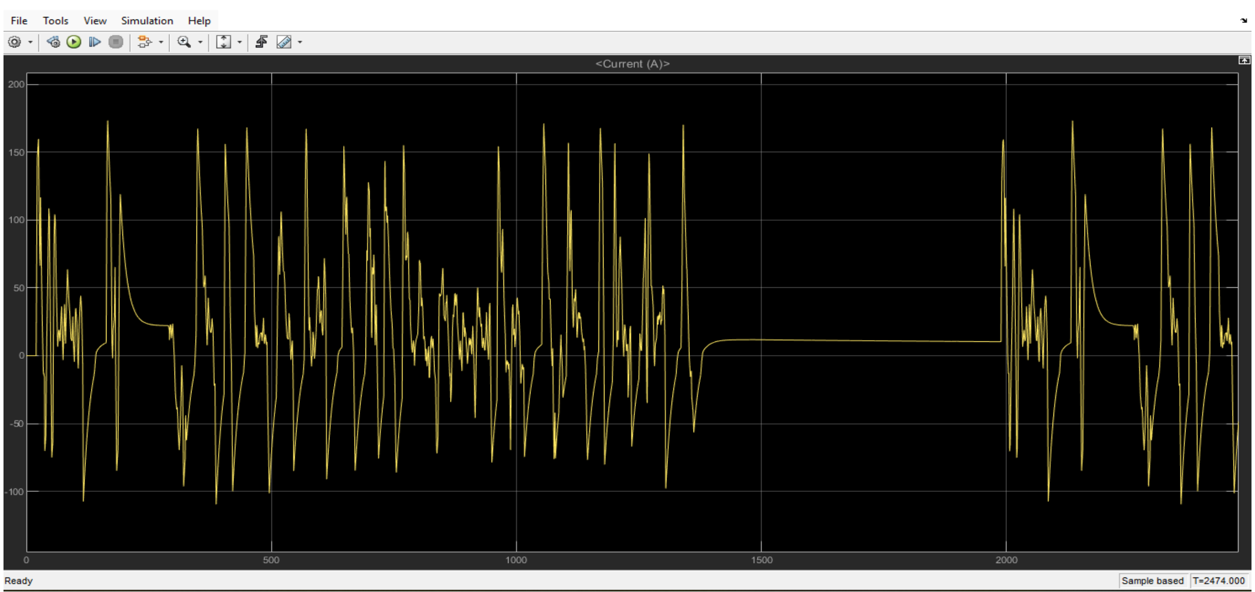
The total distance covered during the Run is 18.71 Kms.

Battery State of Charge:

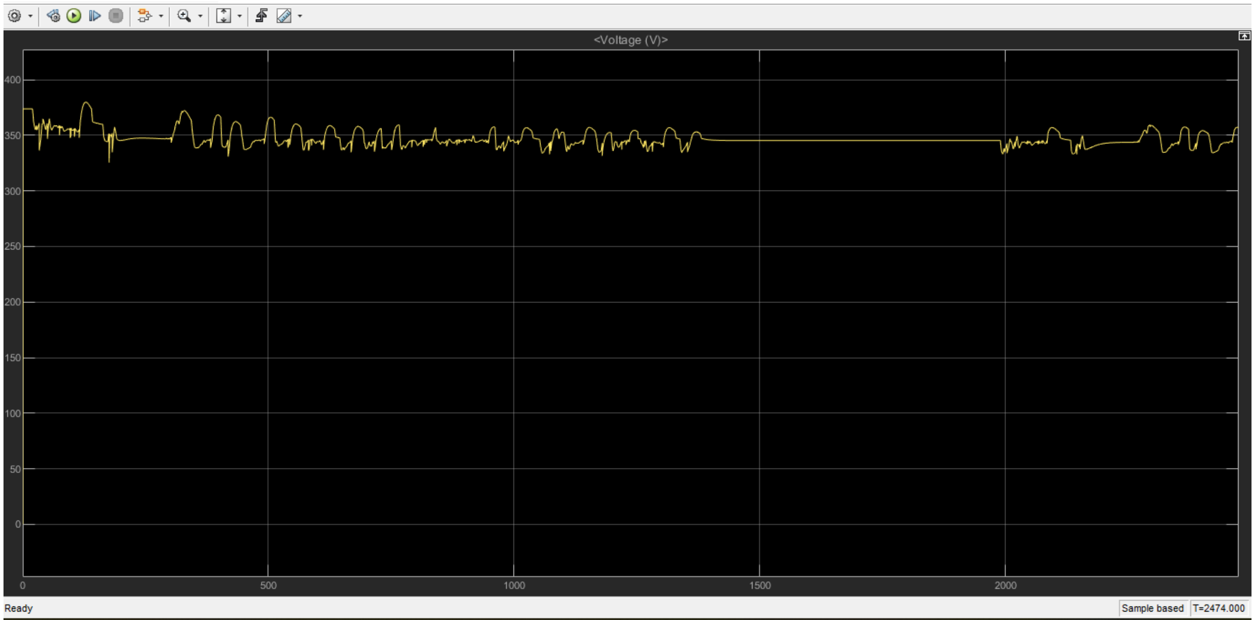


The State-of-Charge of the battery at the end of simulation run is nearly about 81.39%

Current



Voltage:



7. Conclusion:

The State-of-Charge of the battery at the end of simulation run is nearly about 82%, his means that the battery is not completely drained at the end and the vehicle can run on the same drive cycle. Also, the thing to be noted here is, since we had enabled the regenerative braking for the simulation, the battery SOC increases slightly whenever the vehicle undergoes heavy deceleration.

This depends upon the generating tendency of the motor and the maximum amount of current that the battery can take, the model was successfully running and the results have been properly analyzed. It was very interesting in doing the model and learnt lot of things like calculating the battery state of charge the distance covered by the vehicle at the end of run time etc. The system was able to track a desired speed using a PI controller, and the dynamics of battery discharge and motor load were simulated effectively.

8. Appendices

Appendix A: Simulink model screenshots

Appendix B: Parameter table (motor specs, battery, etc.)

Appendix C: MATLAB code snippets if used (e.g., SoC integration)

THANK YOU