Hybrid electric vehicle parameter analysis and adaptation using PID controller

[1]Tejinder Singh M Tech Scholar, Department of Electrical Engineering, IEC Group of Institutions Greater Noida, Uttar Pradesh, India.

[2] Manisha Agarwal, Assistant professor, Department of Electrical Engineering, IEC Group of Institutions, *(AKTU Lucknow)* Greater Noida, Uttar Pradesh India.

[3]Arpit Varshney, Assistant professor, Department of Electrical Engineering, IEC Group of Institutions, *(AKTU Lucknow)* Greater Noida, Uttar Pradesh, India.

Abstract— **In this project an introduction of parameter analysis and adaptation is done through integrated method. The described method is taken into consideration which affect system performance through a set of parameters. This project presents an approach for modeling of electric vehicle considering the rotational wheels, vehicle dynamics, drive train and load dynamics. Due to difficulty in optimal gain selections the vehicle performance is unsatisfactory. To fulfill this issue, a new type of PID controllers is required for better performance. Therefore, in this project the gain tuning method for PID controller is proposed and compared with some previous control techniques for the better performance of electric vehicle with an optimal balance of speed, acceleration, travelling range, improved controller quality and response. This model is updated and developed in MATLAB/Simulink; results are observed with performed simulations.**

Keyword **—Hybrid Electric Vehicle, Electric vehicle, MATLAB/Simulink, power system**

I. Introduction

The replacement of combustion engine is needed because of issue of oil depletion and air pollution [1]. Electric and hybrid electric are declared as future cars due to their high efficiency, silent running and free from pollution. At the same time, there are still some issues that still need to be solved, like limited driving range and long charging time [2]. This is constantly developing, and it is assessed that product will drive more than 90% of the auto frameworks before very long. Considering this, the effect of programming in electric vehicles will be exceptionally high [3].

To have great accomplishments in the testing cycle, the test climate should be extremely sensible. Somewhat recently, the car business is headed to more mind-boggling electronic control frameworks. Simultaneously, numerical demonstrating and recreation apparatuses turned out to be further developed and the idea of reproduction turned into a real plan device. Reproduction is currently the essential apparatus utilized before genuine word testing is conceivable [4]. Wellbeing practices and norms are getting more managed as enterprises embrace a normalized set of practices for item plan and tests. Each maker needs to furnish proof of consistence with the most recent guidelines. As electric vehicles are driven by a put away electrical fuel source, the driving reach is constantly restricted relying on the productivity of the framework and the limit of the fuel source. One approach to improve the proficiency of the framework is by improving the control arrangement of the electric vehicle. Accordingly, a viable control framework is needed for the strong and energy-proficient activity of the electric vehicle. For this, a versatile PID method is proposed in this work to control the framework working productively. Utilizing PID rationale permits managing the vulnerabilities or obscure varieties in plant boundaries in a superior method to build the framework vigor [3, 4].

This control technique is steadier and permits different plan destinations. PID regulators dissimilar to PI regulators don't need the precise numerical model of the interaction, rather it needs the experience and information about the controlled cycle to develop the standard base [5, 6].

Recently utilized control procedures include regulators like PID, PID rationale, neuro PID. Lately, different examination techniques dependent on cutting edge control systems in electric vehicles have been presented. In [7, 8], creators utilized wise PID control to build the productivity of the framework while managing the intricate activity modes. In [9, 10] diverse control techniques dependent on PI strategies are utilized to control the electric vehicle framework by performing numerical demonstrating of electric engine and electric vehicle elements. These regulators are basic and don't perform well for control frameworks with changing boundaries and require regular internet tuning. Tuning is finished by manual or hit and preliminary techniques to pick appropriate additions. The underlying increase determination is a significant factor in the presentation of any regulator, cautious decision of these additions can lead towards better framework reaction.

Already this underlying increase determination is made upon the information about the control framework conduct yet on account of a control framework with changing boundaries these additions ought to be tuned by the changing framework boundaries. These days PID rationale is utilized to control such control frameworks by deciding the regulator acquires on the web, in view of the mistake signal and their time subsidiary. These PID rationale regulators might be considered as nonlinear PID regulators. The PID rationale functions admirably under the changing framework boundaries yet to make the regulator much exact the static introductory increase should be chosen appropriately to keep away from the imperfect reaction. For this, another PID rationale is utilized to painstakingly tune the static beginning increases working in corresponding with the PID tuned PID regulator.

This extra PID rationale regulator gives the pay in the addition tuning with the capacity to react under changing framework boundaries and making the framework.

II. ELECTRIC VEHICLE

The electric vehicle (Kaushik Rajashekara 1993) is a reconciliation of vehicle body, electric impetus, energy stockpiling battery, and energy the board. It isn't just a vehicle yet in addition another kind of electric hardware. The electric vehicle is a street vehicle dependent on current electric drive, which comprises of an electric engine, power converter, and fuel source, and it has its unmistakable qualities. Figure 1 shows the arrangement of the electric vehicle

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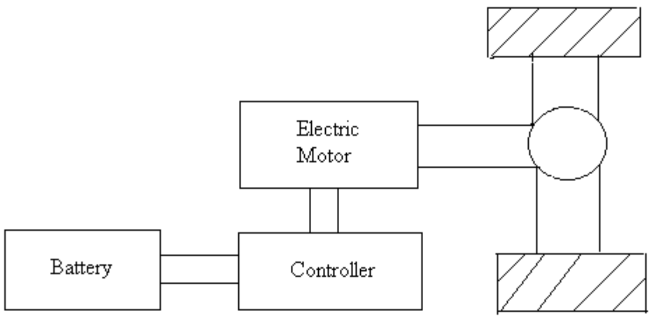


Figure 1 Electric vehicle configuration.

A. Electric Motors in Electric Vehicle

The electric drive arrangement of electric vehicles (Iqbal Husain et al 1999) is liable for changing over electrical energy into mechanical energy so that the vehicle is moved to defeat streamlined drag, moving opposition drag, and active obstruction. In a cutting-edge engine drive, high force, low speed, and steady force rapid districts can be accomplished through electronic control. Besides, the electric vehicle impetus configuration can be more adaptable, specifically single or numerous engines, with or without decrease equipping, with or without differential outfitting, and a hub or wheel engines. The electric impetus framework comprises of the engine drive, transmission gadget, and wheels with the transmission gadget being discretionary.

One of the half breed engines is an extraordinary sort of perpetual magnet brushless engine. In this engine, an assistant dc field winding is fused to the point that the air hole motion is a resultant of the lasting magnet engine motion and field winding motion. By changing the field winding excitation current, the air hole motion can be differed to any degree, thus offering ideal proficiency over a wide speed range. Exchanged hesitance engines offer promising highlights for electric vehicle applications due to their straightforwardness and dependability in both engine development and force converter arrangement, wide speed range, positive warm dissemination, effective regenerative slowing down. Notwithstanding, they experience the ill effects of force waves and acoustic commotion issues.

All in all, for electric vehicle drives, dc engine drives have been progressively supplanted by acceptance engine drives, perpetual magnet engine drives with different designs, and exchanged hesitance engine drives.

These high-level engine drives are exceptionally intended to meet the unique necessities of electrical vehicles.

B. Hybrid Electric Vehicle (HEV)

The crossover electric vehicle contains the consolidating or blend of an electric vehicle with a regular inward ignition motor vehicle. Along these lines, there are two drive sources present in the vehicle, an inside ignition motor, and an electric engine. It utilizes both these sources to give the total impetus needed to the vehicle. The association plans concerning power stream to wheels depend on these two sources relying upon arrangement or equal association. At the point when the electric engine and ICE are associated in arrangement, the vehicle becomes arrangement mixture, and the necessary mechanical force for the wheels is given by the electric engine. At the point when the electric engine and ICE are associated in equal, the vehicle turns into an equal crossover, and the necessary mechanical force is given by both the ICE and electric engine for the wheels. In HEV, ICE uses fluid fuel as a fuel source and electric engine uses a battery as a fuel source. By using the electric engine perfectly with ICE, by changing the force and speed, fuel utilization in the motor can be limited. It gives a choice to more prominent driving reach due to the presence of two impetus sources consequently defeating the burdens of an unadulterated electric vehicle

Figure 2 shows the arrangement equal half breed. It joins both the highlights of arrangement and equal cross breed vehicles. Subsequently, it tends to be worked as both arrangement and equal crossover electric vehicles. Here there is a mechanical coupling present between the motor and the driving wheels of the vehicle. As Compared to resemble mixture, in arrangement equal half breed electric engines acts more as generator and less as the engine.

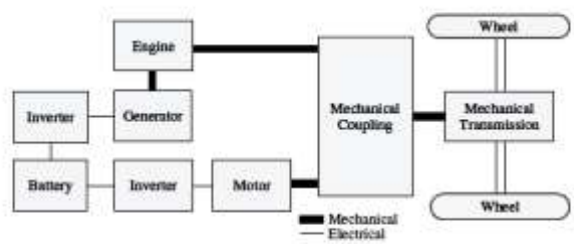


Figure 2: Series-Parallel Hybrid Configuration.

As this kind of half breed goes about as both arrangement and equal cross breed types, eco-friendliness can be improved dependent on the working conditions. In any case, plan, and advancement of this sort of crossover are more mind boggling and costly contrasted with other half and half sorts.

C. HEV Fundamentals

Half and half electric vehicles (HEVs) are vehicles that include both inner burning motors (ICE) with an electric footing framework for determining the drive of the vehicle. It generally comprises of one or the other at least two impetus wellsprings of energy stockpiling gadgets or at least two force sources inside the vehicle. In this, the ICE is primarily utilized for consistent state activity while the electric machine powertrain is used or depended on for dynamic activity. A portion of the benefits offered By HEVs are as per the following:

- Regenerative slowing down is a productive innovation not accessible in traditional vehicles.
- As ICE will be working in less standing by, it prompts more efficiency.
- Easy drivability through electric foothold powertrain.
- Reduced emanations.

III. LITERATURE REVIEW

The writing review was done under the accompanying general classes with the plan to comprehend the highlights of electric vehicle and their designs.

a) Hybrid Electric Vehicle

b) Electric Vehicle

c) PID Logic Controller

d) Electric DC Motor

e) Electric AC Motor

f) Batteries

g) Field Programmable Gate Array

Niles et al (2002) fostered a PID rationale-based force regulator for half and half vehicles with equal setup. This regulator has been planned so that it improves the energy stream between the primary parts of the equal half and half vehicle (PHV) and streamlines the energy age and change in the individual segments. The proficiency guides of the vehicle parts were utilized to plan the regulator. The force regulator planned guarantees that the driver contributions from brake and speed increase pedals are fulfilled reliably, the battery is adequately consistently charged, and the efficiency of the PHV is advanced. The recreation results show expected improvement by utilizing PID rationale, over different methodologies that advance just the inner ignition motor proficiency

Chan (1993) audits the status and future patterns in Electric Vehicle innovation, with accentuation on the effect of fast improvement of electric engines, power hardware, microelectronics, and new materials. Examination has been done on the most recent innovations of electric vehicle and it was tracked down that engine drives with cutting edge power converter and regulator just as cutting-edge batteries are progressively being acknowledged. Enactment prods the electric vehicle market. The creator likewise accentuates that normalization and framework are fundamental for the advancement of electric vehicles

Paresh C. Sen (1990) presents a thorough audit of the cutting edge in the field of electric engine drives and control techniques. It has additionally been expressed that new rapid, high effectiveness exchanging gadgets, new engine structures, new converter design, new control methods, and new fast microcontrollers would add to the further improvement of superior engine drives.

Farrall et al (1993) talked about the unmistakably various qualities of the car control issues, which brought about two uses of PID rationale with totally different accentuation. The main use of PID control was ride control for semi-dynamic suspension frameworks. The recreation results showed that the PID rationale regulator with next to no presentation tuning accomplished better vehicle reaction to the two streets and driver inputs, along with best damper exchanging conduct. The second utilization of PID rationale was in energy the executives in a crossover power train. The control objective of PID rationale was to keep up the reaction of the vehicle while changing how energy was utilized along these lines endeavoring to limit the utilization of the put away energy. In this way, it was suggested that PID strategies lead to amazingly important outcomes in car designing

Singh et al (1995) presented the PID rationale approach in the auto field to decide the distance that an electric vehicle would have the option to cross over dependent on some ordinary battery conditions. The creators fostered a product bundle 'DIANE' which decides the reach from the given condition of charge states of the battery. Two boundaries expressed were traffic thickness and wind speed, which influence the scope of the electric vehicle. It was likewise recommended that this procedure could be applied to a few other significant elements, which influence the scope of the electric vehicle. This methodology is a productive methodology for handling a difficult issue in the plan of electric vehicles.

Chuen Chien Lee (1990) introduced an overview of the PID rationale regulator, an overall procedure for building a PID rationale regulator. The creator incorporated a conversation of fuzzification and Defuzzification methodologies, the induction of the data set and PID control administers, the meaning of PID suggestions, and examination of PID thinking systems

Salah G. Foda (2000) planned a PID rationale regulator for a quarter vehicle dynamic suspension framework. The planned PID rationale regulator extraordinarily upgraded ride execution. They likewise introduced great damping abilities for various street inputs, utilizing both the body ride and suspension workspace reactions.

Rizzotto et al (1994) contrasted the productivity of PID rationale and that of conventional numerical strategies to decide street fuel utilization model by utilizing just four estimated factors of a vehicle driven in thick rush hour gridlock regions.

Funabiki et al (1991) depicted the current order for the exceptionally effective force control of DC shunt engine thinking about the attractive immersion and armature response. The impact of the attractive immersion and the armature response was considered by addressing the coefficients of the electromotive power and the force as a component of the field current, the armature current, and the spinning speed were featured. The deficiency of the engine driver framework in the proposed technique decreases than the misfortune in the steady field ebb and flow control, particularly in the scope of the little force order. The creator likewise talked about the impact of the attractive immersion and armature response on force control and the decrease of loss of the engine drive framework

Philip D. Olivier (1991) talked about the plan of input regulators for arrangement and shunt-associated engines that depended on the criticism linearization methodology. It likewise had been expressed that such regulators can be planned and are substantial at all working focuses with the exception of when the flows have unmistakable connections.

Kourosh sedghisigarchi et al (2001) considered three distinctive nonlinear control plan techniques for the speed of a shunt DC engine. The three strategies were criticism linearization, input-yield linearization, and PID rationale control. The initial two techniques utilized the numerical model of the DC shunt engine to wipe out the non-linearity and attempt to think of direct conditions. In these two techniques, various methodologies were utilized to plan the regulator. The reproduction results show that the information yield linearization technique had a generally excellent reaction in contrast with the other one

The benefit of the info yield linearization technique was to control the position and speed for the DC shunt engine though the criticism linearization strategy was utilized for speed control alone. The PID rationale-based regulator was planned by the creators to show how a keen nonlinear regulator can respond for capacities and characterizing reasonable standards and PID sets. At long last, the creators close by expressing that, for those frameworks that might not approach their numerical models, or they have complex non-direct models, shrewd control techniques, for example, PID control could be an answer

Ajay Yelne et al (1996) introduced the outcomes which showed a few advantages of applying SR (exchanged Reluctance) engine in Electric Vehicle drives, including, high effectiveness and brilliant force attributes over a wide speed range, rough and deficiency open minded plan, and the potential for monetary large-scale manufacturing. The rotor/stator plan and development, selection of materials, electronic segment determination, and creation expenses of SRD (exchanged Reluctance Drive) were examined. Execution attributes, for example, drive control, force wave, and commotion, adaptation to non-critical failure, effectiveness, force speed qualities, and recovery were additionally examined. A few of these plans and assembling issues are contrasted and comparable issues for drive frameworks as of now utilized for Electric vehicle applications were additionally introduced.

At long last, it was recommended that the exhibition of SRDs is practically identical to other best in class EV drive innovations Luca Salero (2001) depicted the arrangements embraced for the wheel direct drive of a unique - three-wheel electric vehicle (EV) model dedicated to metropolitan versatility. An in-wheel Axial transition perpetual magnet engine is utilized to create consistent force of 4.5 KW at 500 fires up/min with 15Kg of all out mass at an effectiveness of about 90%. It is imagined that the assembling expenses of large-scale manufacturing of the proposition EV drive game plan would contrast well and those of traditional warm energies having a similar rating, which opens openings for novel, financially savvy, lightweight EV's planned as business items.

IV. Result & Simulation

The electric vehicle utilized in this exploration is a type of improvement of a little vehicle that appropriate for metropolitan regions in Indonesia. Vehicles planned to be electric vehicles with parts, for example, acceptance machine as the main player, the inverter as a media contact between dc source with enlistment machines, and battery as a fuel source can be found in Figure 3. The model is planned by utilizing the program Simulink/MATLAB.

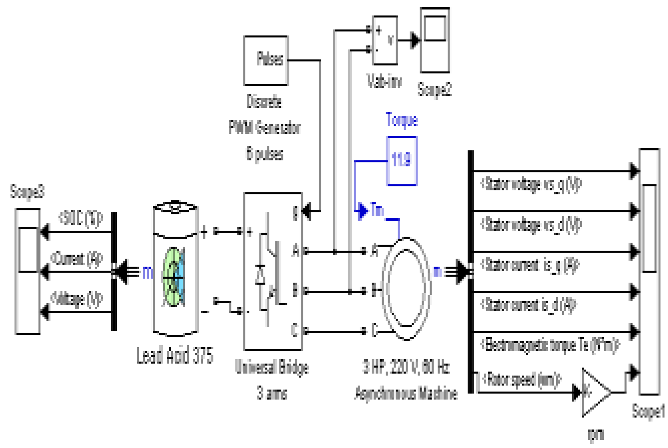
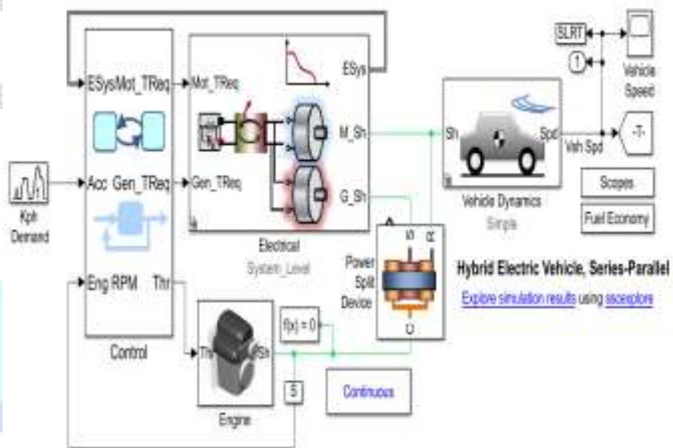


Figure 3: The model of electric vehicle in this study.



An enlistment engine is utilized as the driver enjoys numerous benefits of vigorous, less expensive, generally utilized for electric driving with consistent speed, huge idleness, no require routine upkeep. The acceptance engine as the driving has been displayed in nook arranges. This model more adaptable than ordinary models. Since the model is feasible to work with a non-sinusoidal voltage, in any event, for states of non-even source, the model can in any case be examined.

The battery which utilized as a fuel source are lead-corrosive batteries type, they regularly found on the lookout and the moderately reasonable cost. This is one central point for what reason should this kind of battery chose. Moreover, this kind of battery can be utilized for the motor turning over measure that requires a high current. The yield of this battery is a dc voltage/flow, while the engine of an electric vehicle utilizing an enlistment engine, at that point the force converter is needed as the force supply to the acceptance engine. The force converter innovation which utilized in this model is the PWM converter.

The presentation of the framework is given by the exactness of the model. Generally, the continuous model is underlying MATLAB/Simulink ordered and stacked on a test system. The recreation model sudden spikes in demand for the processor equipment (single-processor or multiprocessor frameworks). The Simulator Mid-Size creates and gauges I/O signals by means of the incorporated space I/O sheets. The capacity range is supplemented by burden and disappointment recreation [11]. UI programming can handle the test system that runs the recreation model. This framework permits direct admittance to all sources of info and yields of an EEC under test. The data sources and yields of an EEC in this test climate can be viewed as a thing if an item situated prearranging language is utilized to consequently control them. The model which can be handily consolidated into a HIL framework is utilized to dissect the exhibition of mixture vehicle design. A recreation model of the HEV block chart of one half and half vehicle design is introduced in Figure 4.

Figure 4: Complete Architecture of Hybrid Electric Vehicle, Series-Parallel with Simple Vehicle Dynamics.

The Electronic Control Unit communicates with all main components: Battery, DC/DC Converter, Electric Motor/Generator, and Internal Combustion Engine (ICE). The structure shown in Figure 2 can be modeled and the HEV system architecture.

 Physical component models at various levels of fidelity are necessary for HEV development.

 Modeling the plant and controller in a single environment enables system level optimization.

 Integration with MATLAB and Simulink enables efficient development, post-processing, and development.

4.2 OVERVIEW HYBRID ELECTRIC VEHICLE MODEL

1. Modeling
 Electrical System
 Mechanical, thermal, other domains
 Mode logic and control system
2. Simulation and Post Processing
 Optimization and series-parallel computing
 Result Generation
 Power analysis
3. Deployment /Integration
 Local Solver
 Code generation

4.3 HYBRID ELECTRICAL VEHICLE MODEL

1. Electrical System
 System Level: Test integration, optimize system
2. Battery System
There are three types of battery are used.
 Predefined Battery
 Generic Battery
 Cells Battery
3. Vehicles System
 Inertial & Aero Effects (Simple Model)
 Tire Models (Full Model)

4.4 SIMULATION REQUIREMENTS

 Overall System Requirements
The following requirements apply to the HEV
Dimensions
1. Curb Weight: 1325 kg
2. Length 4450 mm
3. Width 1725 mm
4. Height 1490 mm

Performance
1.
2. Total Range
Electric Range 870 km
18 km

 Engine System Requirements
The following requirements apply to the functionality of this module.
ICE
1.
2.
3.
4. Power
Min Speed
Max Speed
Torque
57 kW @5000 RPM
1000 rpm
4500 rpm
115 Nm @ 4200 RPM

 Fuel Consumption
The following requirements apply to the fuel consumption:

Regular Gas
1. City: 51 MPG
2. Highway: 49 MPG
3. Combined: 50 MPG
Elec + Gas
1. Combined 95 MPG - e
 Speed Controller Module Requirements
The following requirements apply to the Speed Controller module.
• The controller module will implement at a minimum proportional and integral control.
• Upon a change of angle, the system must be within 5% of the final value within 0.1 seconds (Settling Time).
• Upon a change of 10% the system must achieve 10% of the final value within 0.7 seconds.

V. SIMULATION RESULT

Here used three different type of acceleration data and battery system for hybrid electric vehicle. The vehicle dynamics are also used two different model which is presented in above section.

 Result Simulation for Duty Cycle 1, Electrical System Level, Predefined Battery, Simple Vehicle Dynamics Model

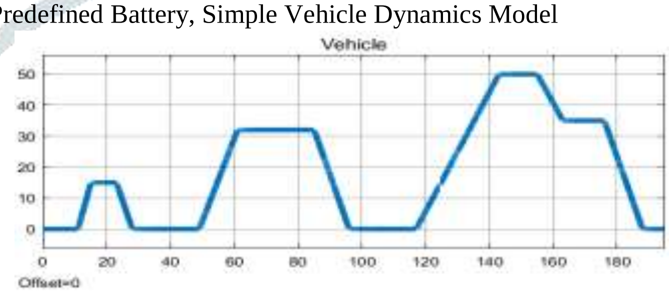


Figure 5: Simulation Analysis for Acceleration of Hybrid Electric Vehicle Model on Duty Cycle1.

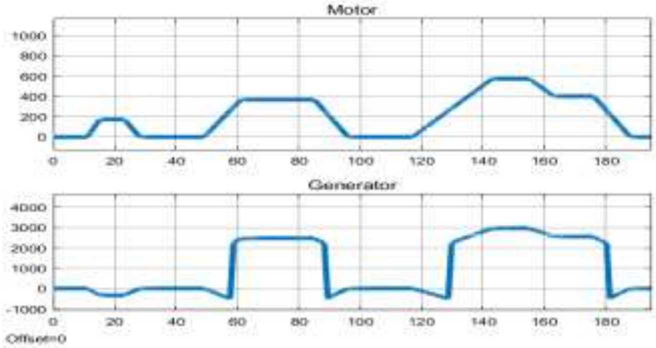


Figure 6: Motor and Generator Speed versus time of Hybrid Electric Vehicle on Duty Cycle1.

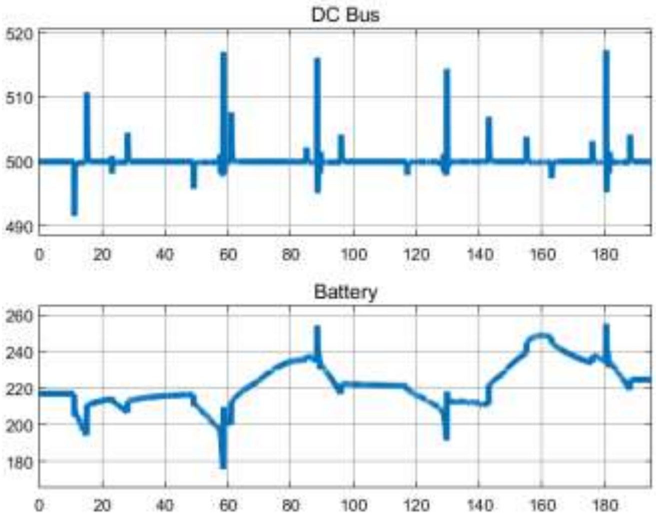


Figure 7: DC Bus and Battery Voltages versus time of Hybrid Electric Vehicle on Duty Cycle1.

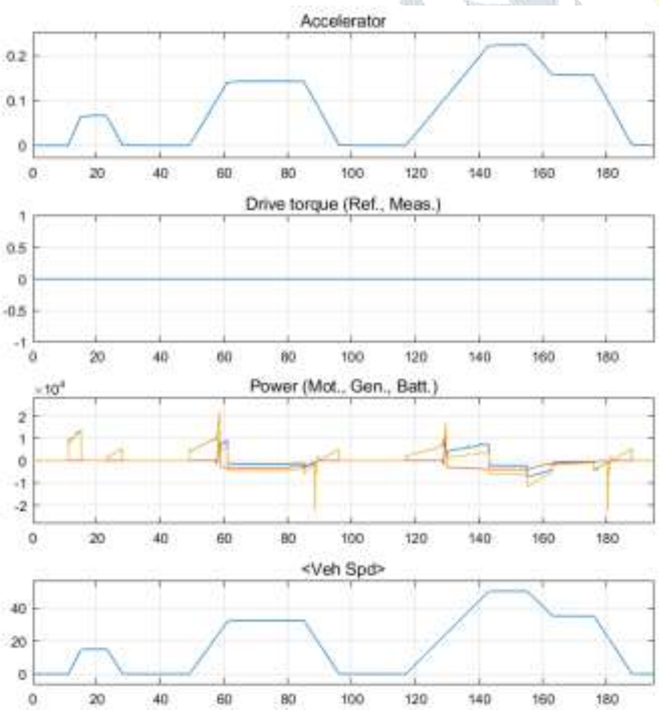


Figure 8: Result Analysis of Vehicle model of the Hybrid Electric Vehicle on Duty Cycle1.

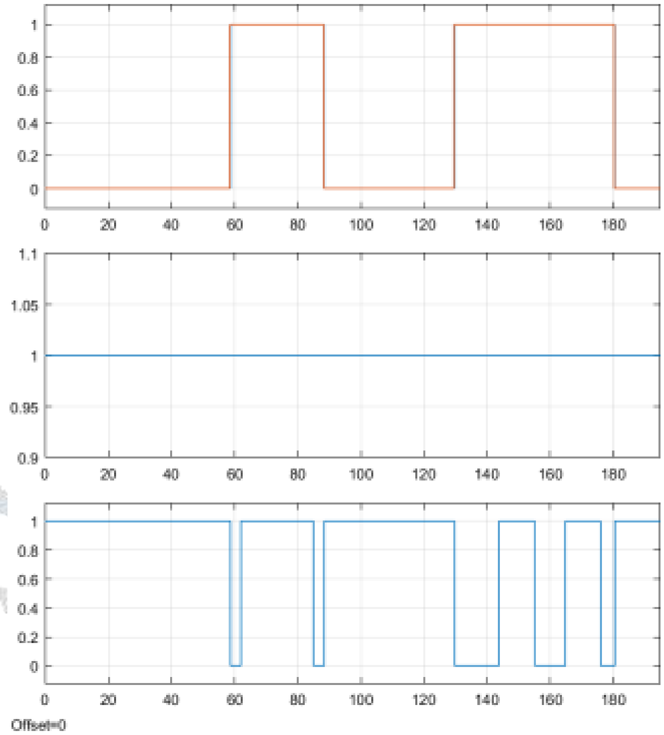


Figure 9: Model Control logic for Hybrid Electric Vehicle on Duty Cycle1.

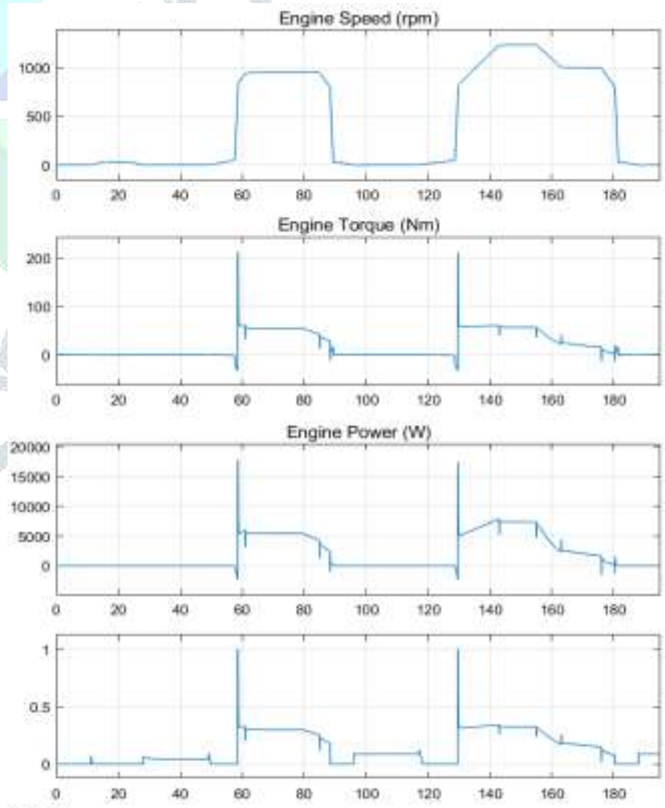


Figure 10: Internal Combustion Engine (ICE) performance for Hybrid Electric Vehicle on Duty Cycle1.

VI. Conclusion

Displaying of electric vehicle framework makes it simple to decide how much battery limit is needed by an electric vehicle with specific details to accomplish a specific distance too. This model can be utilized to appraise how long the battery can be utilized in electric vehicles. The model can likewise be utilized to decide the exhibition of electric vehicles, for example, the beginning processor running with consistent speed.

Here first portrayed a commonplace HEV plan and gave an outline of the key difficulties. We examined how the multidomain confusions emerge from the intricate communication between different mechanical and electrical segments—motor, battery, electric machines, regulators, and vehicle mechanics. This intricacy, joined with an enormous number of subsystem boundaries, makes HEV plan an imposing designing issue.

We picked Model-Based Design as a feasible methodology for taking care of the issue due for its various potential benefits, including the utilization of a solitary climate for overseeing multidomain intricacy, the help of iterative displaying, and plan elaboration. Consistent approval and check of necessities all through the plan cycle decreased blunders and advancement time.

Our initial phase in the improvement interaction was the acknowledgment of a framework level model of the whole HEV. The subsystem segments were found the middle value of models, which went through model elaboration with necessities refinement and adjustments in equal. We showed how state charts can be utilized to imagine the working methods of the vehicle. After every segment model was expounded, we coordinated it into the framework level model, thought about recreation aftereffects of the arrived at the midpoint of and nitty gritty models, and noticed the impact of model elaboration on the yields.

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