MODELING AND SIMULATION OF BATTERY OF ELECTRIC VEHICLE BY USING MATLAB SIMULATION

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ABSTRACT

The aim of this work 'Design of electric vehicle including different power train components'. Is to design an energy model of electric vehicle including different power train components. With the application of a design and simulation tool, in this work would be MATLAB Simulink software. With this design and simulation, we expect to find the energy consumption by a vehicle by virtue of different types of forces acting on vehicle when subjected to different standard driving cycles. This work also includes a different vehicle which runs on electric propulsion either only or in assisted mode in the present market.

I. INTRODUCTION

The only electric and low-emissions hybrid vehicles can meet the criteria outlined in the California Air Regulatory Board (CARB) regulations which require a progressively increasing percentage of automobiles to be ultralow or zero emissions beginning in the year 1998. Though purely electric vehicles (EV's) are a promising technology for the long-range goal of energy efficiency and reduced atmospheric pollution, their limited range and lack of supporting infrastructure may hinder their public acceptance. Hybrid vehicles offer the promise of higher energy efficiency and reduced emissions when compared with conventional automobiles, but they can also be designed to overcome the range limitations inherent in a purely electric automobile by utilizing two distinct energy sources for propulsion. With hybrid vehicles, energy is stored as a petroleum fuel and in an electrical storage device, such as a battery pack, and is converted to mechanical energy by an internal combustion engine (ICE) and electric motor, respectively. The electric motor is used to improve energy efficiency and vehicle emissions while the ICE provides extended range capability. Though many different arrangements of power sources and converters are possible in a hybrid power plant, the two generally accepted classifications are series and parallel. Computer modeling and simulation can be used to reduce the expense and length of the design cycle of hybrid vehicles by testing configurations and energy management strategies before prototype construction begins. Interest in hybrid vehicle simulation grew in the 1970's with the development of several prototypes that were used to collect a considerable amount of test data on the performance of hybrid drive trains. Studies were also conducted to analyze hybrid electric vehicle (HEV) concepts. Several computer programs have since been developed to describe the operation of hybrid electric power trains, including: simple EV simulation (SIMPLEV) from the DOE's Idaho National Laboratory, MARVEL from Argonne National Laboratory, CarSim from AeroVironment Inc., JANUS from Durham University, ADVISOR from the DOE's National Renewable Energy Laboratory, Vehicle Mission Simulator, and others. A previous simulation model (ELPH) developed at Texas A&M University was used to study the viability of an electrically peaking control scheme and to determine the applicability of computer modelling to hybrid vehicle design, but was essentially limited to a single vehicle architecture. Other work conducted by the hybrid vehicle design team at Texas A&M University is reported in papers.

II. LITERATURE REVIEW

Hybrid Electric Vehicle is defined as the technology in which there are more than one energy source used in which at least one source will be electricity. There are three main types of HEVs. All HEV systems are equipped with an electric motor, an ICE and a generator. They may be considered either series, parallel, or series-parallel depending on how the system is configured. Series hybrid is very similar to an EV, in that the electric motor moves the vehicle. The gasoline engine is there only to provide added power to the motor via the inverter, and acts as a range extender. A parallel hybrid is where the power to the drivetrain is shared by ICE and the motor. The concept of using the parallel hybrid system is successfully implemented in the new Honda Insight improved model and in Honda Civic Hybrid. The advantages of using Parallel hybrid source are that if any of the source of power fails. Other source will be automatically available for moving the vehicle. The direct connect of the ICE shaft to wheels enables less power transformation and thus achieves higher efficiency. The differential, torque converter and combination of transmission is more efficient than the series HEV's ICE-to-wheel path. Thus, the size of parallel hybrid's electric traction motor is less than what is required in series hybrid. There can be various other combinations and configurations of the two subsystems as well. However, discussion of these is beyond the scope of this work. Finally, a series-parallel hybrid is where the vehicle can be powered by gasoline engine alone, the electric motor by itself, or by both. Toyota Prius is configured for a series parallel drive. The HEV system is equipped with an electric motor, an ICE and a generator. A power splitting planetary gear is used to integrate these systems which provides the functionality of power flow structure for different modes of operation. There are two kinds of motors in this system; the primary electric motor (MG2) is used for providing the mechanical drive power for moving the car through ICE and this (MG2) is also used for recharging the battery during the process if regenerative braking. The secondary electric motor (MG1) is responsible to act as generator which transfer the power from the ICE to recharge battery and also acts as a power source to supply MG2 which assists in propulsion of vehicle.

III. OBJECTIVES

- To develop a simulation model of electric vehicle car with functional blocks.
- To study the different concept of electric vehicle used in the car with hybrid concept of electric and petrol engine.
- To study the drive cycle of electric vehicle as well as longitudinal driver system for actual representation of car.

PROBLEM STATEMENT

Internal Combustion Engine (ICE) vehicles emit carbon dioxide, hydrocarbon, sulphur oxides, carbon monoxide and hydrocarbon through their tailpipes. These gases result in global warming through greenhouse gas effects and pollution which are harmful to both environment and lives. By the way, the prices of fossil fuels keep rising from time to time. There is a growing scientific consensus that increasing levels of greenhouse gas emissions are changing the earth's climate. Oil prices continue to sky rocket while tougher regulations and policies on permitted exhaust gases are being instituted in major cities of the world. These and some other related issues are compelling vehicle manufacturers to come up with fuel efficient vehicles. These types of vehicles are known as hybrid electric vehicles.

EV namely Mahindra e2o from a leading automobile manufacturer of India, Mahindra and Mahindra has been simulated and analysed in MATLAB platform. The simulation model is equipped with recuperation capability of EV. its performance has been investigated by simulation results for various vehicle velocity inputs and summarized in term of vehicle range and battery state of charge. Furthermore, vehicle range and SOC are evaluated and summarized with variation of input parameters at the end of this paper. This summery can give significant insight to improve the range of this EV. (Here in my dissertation project, I will improve the drive cycle and battery charging representation using MATLAB)

It gives an outstanding strategy for assessment which is effectively checked, passed on and acknowledged. In thispaper dynamic model of electric vehicle is made with the help ofMATLAB SIMULINK. The energy consumption estimation of electric vehicle is resolved, compared to the drive cycle related. the impact of various drive cycle on utilization of energy by vehicle and its consequences for other vehicle boundaries are discussed. (Here in my dissertation project, I will analysis the drive cycles a longitudinal behaviour of car with Simulink).

MATLAB

MATLAB (an abbreviation of "matrix laboratory") is a proprietarymulti-paradigmprogramming language and numeric computing environment developed by MathWorks. MATLAB allows matrix manipulations, plotting of functions and data, implementation of algorithms, creation of user interfaces, and interfacing with programs written in other languages.

Although MATLAB is intended primarily for numeric computing, an optional toolbox uses the symbolic engine allowing access to symbolic computing abilities. An additional package, Simulink, adds graphical multi-domain simulation and model-based design for dynamic and embedded systems.

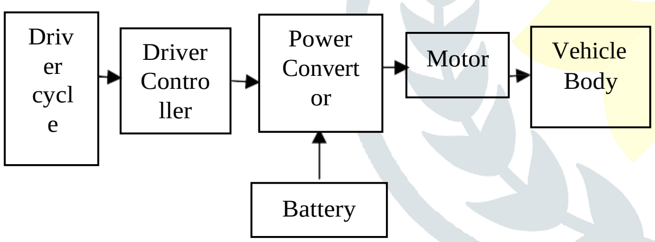
As of 2020, MATLAB has more than 4 million users worldwide. MATLAB users come from various backgrounds of engineering, science, and economics. MATLAB was invented by mathematician and computer programmer CleveMoler. The idea for MATLAB was based on his 1960s PhD thesis. Moler became a math professor at the UniversityofNewMexico and started developing MATLAB for his students as a hobby. He developed MATLAB's initial linear algebra programming in 1967 with his one-time thesis advisor, GeorgeForsythe. This was followed by Fortran code for linear equations in 1971.

The first early version of MATLAB was completed in the late 1970s. The software was disclosed to the public for the first time in

February 1979 at the NavalPostgraduateSchool in California. Early versions of MATLAB were simple matrix calculators with 71 pre-built functions. At the time, MATLAB was distributed for free to universities. Moler would leave copies at universities he visited and the software developed a strong following in the math departments of university campuses.

In the 1980s, Cleve Moler met John N. Little. They decided to reprogram MATLAB in C and market it for the IBM desktops that were replacing mainframe computers at the time. John Little and programmer SteveBangert re-programmed MATLAB in C, created the MATLAB programming language, and developed features for toolboxes.

IV. Block Diagram:



1) Drive Cycle Source

The Drive Cycle Source block generates a target vehicle velocity for a selected or specified drive cycle. The reference application has these options.

Timing	Variant	Description
Output sample time	Continuous (default)	Continuous operator commands

	Discrete	Discrete operator commands

2) The Longitudinal Driver subsystem generates normalized acceleration and braking commands.

3) The reference application has these variants,

Block	Variants		Description	
Longitudinal Driver (default)	Control	Mapped	PI control with tracking windup and feed-forward gains that are a function of vehicle velocity.	
		Predictive	Optimal single-point preview (look ahead) control.	
		Scalar (default)	Proportional-integral (PI) control with tracking windup and feed-forward gains.	
	Low-pass filter (LPF)	LPF	Use an LPF on target velocity error for smoother driving.	
		pass	Do not use a filter on velocity error.	
	Shift	Basic	State flow chart models reverse, neutral, and drive gear shift	

		scheduling.
	External	Input gear, vehicle state, and velocity feedback generates acceleration and braking commands to track forward and reverse vehicle motion.
	None (default)	No transmission.
	Scheduled	State flow chart models reverse, neutral, park, andN-speed gear shift scheduling.
Open Loop		Open-loop control subsystem. In the subsystem, you can configure the acceleration, deceleration, gear, and clutch commands with constant or signal-based inputs.

4) Controllers

To determine the motor torque and brake pressure commands, the reference application implements a supervisory controller. Specifically, the controller subsystem includes a powertrain control module (PCM) with:

1. Regenerative braking control

Motor torque arbitration and power management

Converts the driver accelerator pedal signal to a torque request.

2. Converts the driver brake pedal signal to a brake pressure request. The algorithm multiplies the brake pedal signal by a maximum brake pressure.

3. Implements a regenerative braking algorithm for the traction motor to recover the maximum amount of kinetic energy from the vehicle.

4. Implements a virtual battery management system. The algorithm outputs the dynamic discharge and charge power limits as functions of battery state of charge (SOC).

5. Implements a power management algorithm that ensures the battery dynamic discharge and charge power limits are not exceeded.

You can run this simulation using one of the following modeling techniques:

1. Switching Devices: Converters are modeled using standard SPS power switches and diodes controlled by firing pulses which are produced by the PWM generators.
2. Switching Function: Converters are modeled using a switching-function model controlled by firing pulses which are produced by the PWM generators.
3. Switching Function (PWM averaging): Converters are modeled using a switching-function model controlled by averaging the firing pulses produced by the PWM generators over a specified period.
4. Reference-Voltage (Uref or D-Controlled): Converters are modeled using a switching-function model directly controlled by the reference voltage (Uref) or the duty-cycle (D). PWM generators are not required.

Technique 1 is the most accurate modelling technique, while technique 4 yields to the fastest simulation. Techniques 2 and 3 are well-suited for real-time simulation.

5) Power Converters Description

The simulation allows you to observe operation of several types of power electronics converters:

1. 1-MVA Active Rectifier: This active rectifier will produce the main DC supply (+/-500V) used by several other converters. The rectifier consists of a three-phase, 3-level NPC converter and a closed-loop control system. It can take or give back power to the grid in order to maintain the specified DC level.
2. 60-Hz Load: The load is modelled using a half-bridge converter controlled by a PWM generator having a carrier frequency of 33*60.
3. DC Variable Load: The load variation is achieved using a buck converter and a

variable DC source at the converter output.

4. DC Supply: A boost converter transfers power (125 kW) from a 500V DC source to the main DC supply.
5. DC Motor Drive: The drive consists of a speed-regulated 200-HP motor, a Two-Quadrant DC-DC Converter and a control system.
6. 50-Hz Load: The load is modelled using a full-bridge converter controlled by a PWM generator having a carrier frequency of 1650 Hz and a modulation index of 0.9.
7. 2-MVA STATCOM: This distribution STATCOM consists of two three-phase, 2-level converters (twin topology) and a closed-loop control system. It can generate or absorb 2 mars from the grid.

Simulating Precision Control

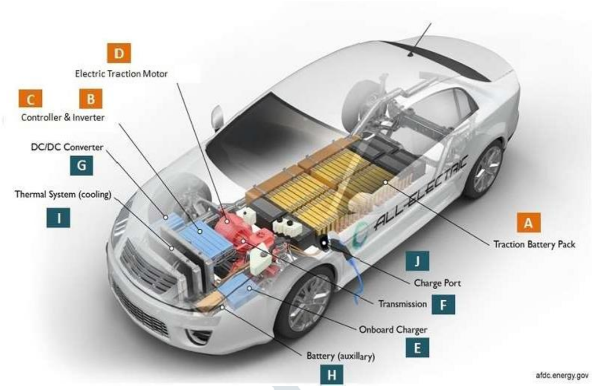
Mechatronic systems rely upon multiple controllers, often interacting with one another. Closed-loop control is often necessary to achieve the precision that these systems require. Hybrid actuators that involve two different technologies as well two different controllers can create a significant challenge for an engineer. For example, pneumatic actuators with a series piezoelectric motors offer both large stroke and control. However, the control systems for fine each system must work together to achieve the precise positioning required by the design. Here again, simulation is key to making sure that the control structure and parameters are optimized for thisdesign.

V. System Methodology

Several levels of depth are available to allow users to take advantage of the features that interest them. At the most basic level, a user can run simulation studies by selecting an EV, series, or parallel hybrid vehicle, or conventional vehicle drive train model provided and display the results using the graphical plotting tools. In addition to being able to change the drive cycle and the conditions under which the vehicle operates, the user can switch components in and out of a vehicle model to try different types of engines, motors, and battery models. The user can also change vehicle characteristics such as size and weight, gear ratios, and the size of the components that make up the drive train.

Electric car or vehicle component and function depend on the car type. There are at least four types of electric cars (Please read the article "types of electric cars, Architecture and working principles") currently sold commercially and operates in the world. This article will discuss various common main electric car components or parts or elements and their function such as traction batteries, inverts (DC-DC converters), traction motors, on board chargers and controllers.

The different types of electric car component determine how the car works. Electric cars (vehicles) components and functions can be explained by means of picture below.



VIII. Result

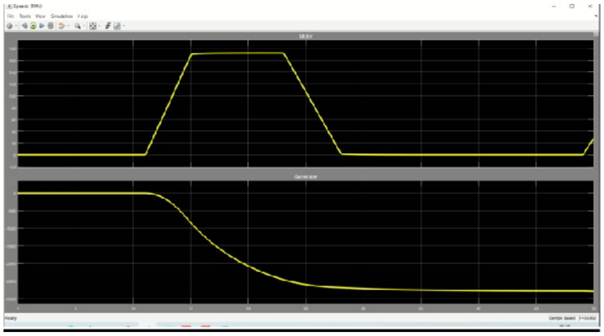
1) Voltages

HEV voltage shows that, in the first wave DC bus voltage is shown & in second wave battery level is shown. In which x-axis shows time and y-axis carries voltage.

In the destination work the graph is States the voltage value of DC bus and battery. DC bus provides small spikes over charging and discharging the constant value of 500 voltage at a point of consumption in system start consuming battery at second of 15 and give 550 in voltage pulse. Main system starts charging system then it gives negative also 490 voltages at 12 second. In this graph where is sitting time at x axis success. Innova access we are using voltage value.

The battery voltage value will give that in system is on the mode of discharging in the voltage drop is directly goes into the 185.Where is my battery voltage start charging maintain the level of 210v till discharging starts.

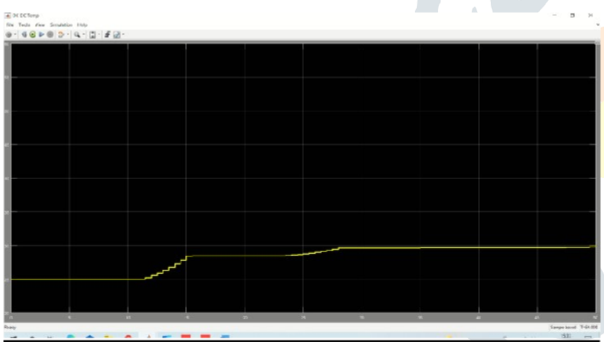
2) Speeds (RPM)



As the hybrid electricity vehicle assembly used to consume energy from battery as well as generate energy for battery from rotation of weeds so this process is container sly working as regenerative power supply. In this is scurvy that at X Axis it's a time in second speed of rotation of motor that is RPM.

Motor starts 160 in 3 second one time maintain accordingly. For the generator with the net electricity for the concept of regenerative braking system and system is of Internet is also goes to the of a system starts speaking after on at 10 second the net is generating energy by 3000RPM.

3) DC-DC Temp



In this scope we can see the temperature of battery as always temperature of particular cell which made by the material of Lithium polymer ions. Lithium polymer battery are used for very low maintenance you give thetemperature of 25 which is room temperature.

This is because by the 12 second regular is not started once the vehicle is started battery start consuming and temperature start increasing their maximum limit achieved 30° c. Time is an accessories and degree Celsius temperature at y Axis

VI. Conclusion

From the plot of State of Charge isobserve that after the vehicle has startedrunning, after sometime due toregenerative system the graph hasincreased in terms of charge stored in thebattery. Further from the engine speed andMotor Speed, shows smooth functioningof vehicle without any distortions.

Theflow of simulation was observed andvarious factors are involved in modellingof an electric vehicle

VII. References

[1]A. Nouh, M. Chami, A. Djerdir, M. El Bagdouri, Eleves: a new software tool for electric vehicle modelling and simulation, The World Electric Vehicle Association (WEVA) journal, ISSN 2032-6653, vol.1, pp.236-243, 2007

[2] University of California Berkeley, MATLAB software, [Online], Available: https://software.berkeley.edu/matlab%C2%AE

[3]Washington University Saint-Louis, MATLAB – students license,

[Online], Available: https://sts.wustl.edu/matlab-free-for-students/

[4] Quora digest, how do I get MATLAB software for free? [Online], Available: https://www.quora.com/How-do-I-get-MATLAB software-for-free

[5]Wikipedia.org, GNU Octave, [Online], Available: https://en.m.wikipedia.org/wiki/GNU_Octave

[6] Wikibooks.org, Octave FAQ: Programming differences between Octave and Matlab, [Online], Available: https://en.m.wikibooks.org/wiki/MATLAB_Programming /Differencebetween_Octave_and_MATLAB

[7] Daniel Frey, Modelling the performance of an electric car, [Online], Available:

[8]https://www.mathworks.com/matlabcentral/fileexchang e/60498- modeling-the-performance-of-an-electric-car

[9] A. Kiyakli, H. Solmaz, Modelling of an electric vehicle with Matlab/Simulink, International journal of automotive science and technology, vol.2, no.4, pp. 9-15, 2018, Doi:

[10]Range Estimation of Electric Vehicle using MATLAB. Netra Lokhande MIT World Peace University Pune, Maharashtra, INDIA Apr 02-04, 2021

[11]Planning and Application of Electric Vehicle with MATLAB Simulink. Alok Bhatt, Hitachi Hi-Ri Power Electronics Pvt. Ltd. 2016 IEEE.