Review on Modelling and Simulation of Hybrid Electric Vehicle Based on MATLAB/ Simulink

Avinash Banduji Raut
PG Student, Department of Electrical Engineering
Abha Gaikwad-Patil College of Engineering, Nagpur

Dr. Pratik Ghutke
Project Guide, Department of Electrical Engineering
Abha Gaikwad-Patil College of Engineering, Nagpur

Abstract**—** Due to the more vigorous regulations on carbon gas emissions and fuel economy, Fuel Cell Electric Vehicles (FCEV) are becoming more popular in the automobile industry. This paper presents a neural network based Maximum Power Point Tracking (MPPT) controller for 1.26 kW Proton Exchange Membrane Fuel Cell (PEMFC), supplying electric vehicle powertrain through a high voltage-gain DC-DC boost converter. The proposed neural network MPPT controller uses Radial Basis Function Network (RBFN) algorithm for tracking the Maximum Power Point (MPP) of the PEMFC. High switching frequency and high voltage gain DC-DC converters are essential for the propulsion of FCEV. In order to attain high voltage gain, a three-phase high voltage gain Interleaved Boost Converter (IBC) is also designed for FCEV system. The interleaving technique reduces the input current ripple and voltage stress on the power semiconductor devices. The performance analysis of the FCEV system with RBFN based MPPT controller is compared with the Fuzzy Logic Controller (FLC) in MATLAB/Simulink platform.
Keywords: Fuel cell electric vehicle, high voltage gain IBC, PEMFC, MPPT, RBFN etc.

I. Introduction

As the green movement will increase in quality, additional and additional electrical vehicles (EVs) of all kinds from electrical scooters to cars to buses and product trucks can grace the roads. Power designers are challenged to produce systems which will be tailored to a good type of differing types of batteries and vehicles with immensely numerous performance needs. This report examines the key issues that square measure best suited to meeting the challenges of as well as battery performance, lifespan and, of course, safety whereas coming up with intelligent battery management and charging systems EV battery packs are created of multiple cell modules organized nonparallel and in parallel. organized round the battery pack and throughout the vehicle, the battery management system (BMS) is comprised of many elements, including observance elements close to the battery cells themselves, one or additional power-conversion stages dictated by the requirements of the vehicle, and intelligent controllers or embedded processors placed at strategic locations in the design to manage numerous aspects of the facility system.

This project introduces A battery observation computer circuit (BMIC) or cell-balancer device is often assigned to observe the voltage of every battery cell during a module, the temperature of varied points within the module and other conditions. This information is reportable to a cell management controller (CMC) and, counting on the quality of the system, on to higher-order processing parts, like one or a lot of battery management controllers (BMC). The exactitude of these measurements and also the frequency of the communications from the BMIC to the CMC and BMC is essential to detective work a condition of concern early on and taking corrective action before it becomes hazardous. for instance, the BMC may stop regenerative charging or scale back the ability draw from a pack to come individual cell temperatures to an appropriate vary or the driving force of the vehicle might be alerted to such a condition through a “check engine” light-weight on the dashboard. In any case, the BMICs should be capable of terribly correct measurements and strong communications with the CMCs so a BMC will take the correct corrective action during a timely fashion. associate degree electron volt is so terribly challenging in terms of planning a good communication network thanks to the abundance of electrical noise within the surroundings. Lithium-ion battery packs are the predominant energy storage systems in aircraft, electric vehicles, portable devices, and other equipment requiring a reliable, high-energy-density, low-weight power source.

II. Problem statement

1. The battery management system (BMS) is a critical component of electric and hybrid electric vehicles.
2. The purpose of the BMS is to guarantee safe and reliable battery operation. To maintain the safety and reliability of the battery, state monitoring and evaluation, charge control, and cell balancing are functionalities that have been implemented in BMS.
3. As an electrochemical product, a battery acts differently under different operational and environmental conditions.

The uncertainty of a battery's performance poses a challenge to the implementation of these functions.

III. Objective

The primary objectives of this study can be summarized as follows:

- Modeling battery packs using electrical networks whose topology mirrors that of the actual system and scales with the number of cells
- Parameterizing equivalent circuit elements using test data for accurate representation of cell chemistry
- Designing the power electronics circuit that connects the pack with the controls
- Developing closed-loop control algorithms for supervisory and fault detection logic
- Designing state observers for state-of-charge and state-of-health online estimation.

IV. Literature Review

Xu wang Yuan wang et. al. 2019, Battery management system (BMS) is the core component of new energy vehicle battery system. With the increase of energy density of new energy vehicle battery, its control algorithm becomes more and more complex, and the task of battery management system will be more and heavier. The hardware, software and control strategy model of battery management system are developed based on ARIX multi-core microcontroller. The minimal BMS system is developed by using AURIX265 + LTE35584 chip which meets the functional safety requirements. The dual-core processing of control strategy and individual information acquisition is realized, and the processing efficiency is improved. The three-tier software architecture of battery management system is developed based on the software hierarchical architecture. The graphical development of battery management system strategy model is realized by using MATLAB / Simulink. The results of bench test and real vehicle test show that the battery management system developed meets the application requirements of enterprises, and the batch matching is obtained in vehicle enterprises.

Yang Xu ; Shen Jiang a et. al. 2020, Compared with ordinary lead-acid batteries, lithium batteries are gradually favored by more electric bicycle manufacturers due to their high energy density, high charging and discharging efficiency and other properties. In order to ensure that the operating status of the rental battery pack applied to electric bicycles can be monitored by the operating units in real time during charging or discharging, a lithium battery management system for electric bicycles is designed. The battery management system can monitor the voltage, current, temperature, energy storage and location information of the battery pack in real time, and transmit information to the cloud management platform in real time. The system has been used in the leasing battery products of a battery leasing enterprise.

Fawad Ali Shah et. al. 2021, Batteries are extensively used to power electric vehicles (EVs), hybrid electric vehicles (HEVs), and for many other power demanding applications, where the modeling of a battery plays a vital role in their efficiency, safety, and reliability. In this paper, initially different types of batteries used in the EVs and HEVs are investigated, according to the latest battery management systems (BMS). Li-Ion batteries are a popular source of EVs and HEVs because of their long-life span, high energy and power density, and good charging and discharging performance. However, there remain some issues associated with the deployment of Li-ion batteries, such as complex electrochemistry, degradation, and inaccurate battery health estimation. The latest techniques for the estimation of the battery state of health (SOH) are reviewed in a comparative table. The table furthermore helps in concluding the best estimation technique so far with respect to the models/algorithms, estimation errors, pros, and cons as well as the cost of the system. The electrification of vehicles has been a global trend including Asia and Pakistan. Subsequently, the paper explores implications of the increasing use of the electrified vehicles on the economy, environment and the energy efficiency.

Federico Martin Ibanez et. al. 2022, Modeling of Lithium-Ion Battery (LIB) is essential for studying its behavior under different operating conditions like temperature, load current and state of charge. The parameters of a LIB such as capacity, open circuit voltage, impedance can be characterized by using a suitable model according to the application. This paper has proposed an impedance-based equivalent circuit modeling (ECM) approach for electric vehicles (EV) to estimate the aging of a LIB ($LiFePO_4$) and to prevent the system, where the battery is installed, from failure. The aging has been performed experimentally using a real electric motorcycle load profile and the impedance test results for the aged LIB at different cycles have been fitted and analyzed with a chosen ECM. In addition, the same ECM has been used to analyze and compare the aging for the same battery type with a profile achieved using a hybrid energy storage system (HESS) consisting of LIB and super capacitors. The ECM for HESS profile showed smaller impedance change and smaller capacity reduction with aging compared with the ECM for the battery profile. Therefore, it validates that HESS has a longer cycle life than battery energy storage system.

Chong Zhu et. al. 2022, The automotive lithium-ion batteries suffer severe capacity and power degradation at subzero temperatures, leading to serious "range anxiety" of the electric vehicles (EVs). Therefore, the onboard battery preheating equipment is essential for EVs at cold climates. In this study, an interleaved resonant onboard battery self-heater is developed for internally preheating the automotive batteries without external power supplies, thereby providing great flexibility for EVs at different parking areas. By properly adjusting the switching frequency, the self-heater can achieve the zero-current-switching (ZCS) to improve the energy consumption and eliminate the voltage spikes during the turn-off. Meanwhile, a detailed guideline for optimizing the resonant tank parameters is presented so that the efficiency of the self-heater can be further developed by reducing the circulating current. The experimental validation on 18650 cells demonstrates the proposed heater can preheat the battery from -20°C to 0°C within only 3.5 minutes, and only consumes 5% of the cell energy.

V. Block Diagram

The designed EV motor driver is comprised by four sections such as battery, bi-directional dc-dc converter, FLC and dc machine as shown in Fig. 3

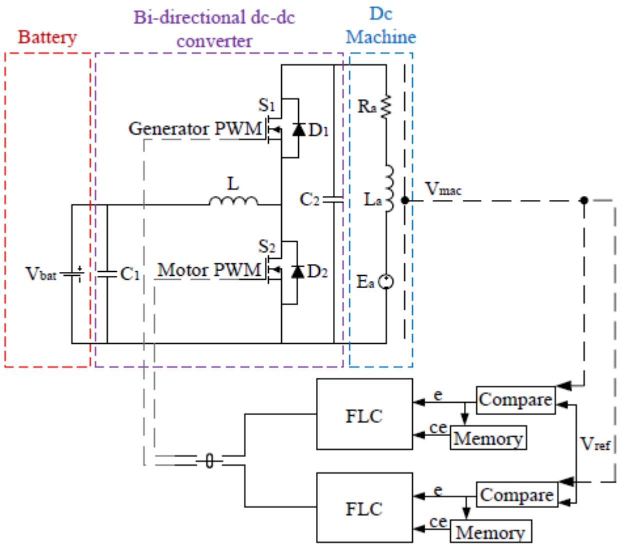

Fig. 1.Circuit diagram of EV machine driver with battery management

In this study, the starting voltage of battery is set to 378 V while the operating voltage of dc machine used in traction system is 500 V dc. The battery voltage is increased up to 500 V with bi-directional dc-dc converter in generator mode. The battery is discharged when dc machine is started acceleration. The motor mode simulation with various torque values are performed to observe battery parameters such as state of charge (SoC), current, voltage and voltage of the dc machine.

The voltage of the dc machine is decreased to 500 V with bidirectional dc-dc converter which is controlled with FLC. The battery is charged during the generator mode operation of dc machine. The FLC determines duty cycle of S_1 and S_2 to ensure charge and discharge of battery. The dc machine is comprised by brushes, armature core and windings, commutator, field core and windings. Armature circuit is comprised by series structure with inductor, resistance and counter-electromotive source.

VI. Conclusion

As batteries are the center fuel sources in EVs and HEVs, their presentation significantly impacts the attractiveness of EVs. Along these lines, producers are looking for advancements in both battery innovation and BMSs. Synthetic responses in the battery are liable to working conditions, and consequently, the corruption of a battery may shift in various conditions. Building up a complete and develop BMS is basic for makers who might want to expand the piece of the pie of their items. The significant worries of BMSs were examined in this paper. They incorporate battery state assessment, displaying, and cell adjusting, wherein the assessment strategies of battery status were seen as the pivotal issue.

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