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Impact Of Li-Ion Battery Using MATLAB/Simulink For Charging And Discharging

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Abstract: In EV and HEV applications, battery optimization has increased. Lithium-ion batteries, in particular, are increasingly used as an energy storage system in green technology applications because of their high power and energy density. Drawbacks are seen in electric car applications during the storage system's charging interval period. Multi-state charging is seen to be the best option in these circumstances. The state charging of lithium-ion batteries and their criteria for charging and discharging for long battery life are discussed in this study using the MATLAB Simulink tool. The state-of-charge (SOC), which is measured and used to assess charging and discharging characteristics, is a crucial factor in determining a battery's performance. Therefore, an accurate SOC estimate is required to safeguard the battery and avoid overcharging and undercharging it. Additionally, by doing this, the battery's lifespan will be extended. Multi-state charging is used for applications that demand greater efficiency.

Keywords: MATLAB, Li-ion, state-of-charge, electric car

I.INTRODUCTION

Batteries are very useful in solar energy systems, EVs, HEVs, and other smart-grid systems. The "Primary Battery (PB)" and the "Secondary Battery (SB)" are the two most common battery kinds. Due to its chargeability, high energy to power ratio, and high power to energy ratio as compared to Lead acid and other Nickel Metal Hydride batteries, SB, especially Li-ion Battery, is highly used and preferred[1]. Designers consider battery behaviour for anticipating performance and optimising energy dispute. So, when building the circuit to achieve high power performance and efficiency, knowledge of the Li-ion battery's charging and discharging is crucial. Battery behaviour is influenced by a number of factors, one of which is the battery's state-of-charge (SOC). The stored charges (Q) and integrated current (I) flowing through the battery affect the battery's state of charge. The SOC of a battery is defined as the proportion of Current Capacity to Nominal Capacity[2]. As the battery's SOC information reveals how its charge/discharge regulation is managed, the accurate reporting of SOC is crucial for hybrid electric vehicle applications. There is no sensor to measure the SOC's value, hence it cannot be determined. For the purpose of determining the SOC, which is given by: C. Park suggested an approach based on physical measurements. “$SOC = 1 - (1 - 1/Q \int t0i(t)dt$”

II.LITERATURE REVIEW

The literature on Li-ion battery modeling and simulation using MATLAB/Simulink has demonstrated significant advancements in algorithm development, battery management strategies, and simulation accuracy. Researchers have developed comprehensive models to analyze the charging and discharging behavior under various operating conditions, with a focus on improving battery life, efficiency, and system safety. Sharma and Patidar presented a MATLAB/Simulink-based model for charging and discharging control of Li-ion batteries in electric vehicles. Their implementation utilized a Proportional-Integral (PI) controller to regulate current flow during charging and discharging cycles, thereby enhancing battery protection and improving system responsiveness. Accurate modeling of battery parameters was key to their control performance. Vinayaka and Katari developed a bidirectional buck-boost converter model in MATLAB/Simulink, specifically designed for managing charge/discharge cycles in EV applications. Their work emphasized SOC tracking and dynamic voltage regulation, demonstrating the converter's effectiveness in bidirectional power flow and safe battery operation. To improve the accuracy of state-of-charge (SOC) estimation, Zhang et al. implemented an Extended Kalman Filter (EKF) within a MATLAB/Simulink framework. Their approach addressed the nonlinear characteristics of Li-ion batteries, resulting in improved prediction accuracy and system stability during both charging and discharging cycles. Another study, Alavi et al., explored a thermal-electrical co-simulation approach using MATLAB/Simulink and Simscape to evaluate temperature effects on battery performance. Their results showed that thermal modeling is essential for preventing overheating and ensuring long-term battery reliability under varying load conditions. To address the challenge of high-current fast charging, Islam et al. [10] introduced a multi-stage charging algorithm modeled in MATLAB/Simulink. Their system dynamically adjusted current and voltage levels based on real-time feedback, reducing the risk of overcharging and minimizing energy losses. These studies collectively highlight the importance of robust simulation environments like MATLAB/Simulink in designing, testing, and optimizing Li-ion battery systems for electric vehicle and renewable energy applications. The body of work on bidirectional DC-DC converters, particularly in MATLAB/Simulink environments, has made significant strides across topology design, control methods, and real-world implementation: Soft-Switching Topologies with MATLAB/Simulink Modeling. Banu and Moses introduced a soft-switching bidirectional buck-boost converter using a simple auxiliary circuit, leveraging Zero-Voltage Switching (ZVS) to reduce switching losses and enhance efficiency during both step-up and step-down modes. His MATLAB/Simulink simulations validated superior performance compared to traditional hard-switching.

III.METHODOLOGY

1. **Steps for Charging Circuit** put Sims cape's electrical cord in there (this will be included in the library, it has components like battery, MOSFET, RLC unit, etc.) Additionally, add a DC power source and a Li-ion battery from the library. (Set your voltage and amp-hours.) Set the resistance and inductance values after inserting the RLC unit and choosing the RL type. Connect the RL unit's positive terminal to it. Put in two MOSFETs, connect them together, and connect them to the opposite end of the RL unit. An RC unit's values are set once a resistive load is added. Connect the MOSFET, RC circuit, and resistor in parallel. Add the perfect switch. (Join it with a constant block.) Set the charging voltage and connect the ideal switch at one end and the resistor at the other. SOC, current, and voltage can be selected using a bus selector. Connect it to the power source. Add three Go TO tags with the names SOC, Current, and Voltage to the Bus selection. Include tags for MOSFETs 1 and 2. Then, we must build a charging subsystem; therefore, we must first connect the PID controller and PWM generator. Using a NOT gate in between, the MOSFET 1 tag connects it to the PWD branch and the MOSFET 2 tag. Connect the PID controller to an add operator (change it to +-). Connect to the - of the add block's constant block (which is the reference current) and set the necessary value. Connect the + of the add block to the Current tag. (This is how we cry.) Make connections for SOC, current, and voltage to the scope and add it to the output-checking setup.

2. **Steps for Discharging Circuit** incorporate a continuous power GUI. Li-ion battery addition using the library option. Attach a bus selector to it. Choose the SOC (%) element there, link it to a GOTO tag, branch the connection, and add a display to the newly-branched link. Connect a scope to the SOC GOTO tag and use it. Connect two perfect switches to the battery's negative and positive ends (with initial state 0). To finish the circuit, add a DC source voltage and link it to the optimum switches. In order to link two distinct ideal switches, branch the connection between the battery terminals and the ideal switches (initial state 0). Complete the circuit by connecting a load resistance in series with the switches. Create two statement blocks in the chart, one for statement 1 (charge entry: pulse=1) and the other for statement 2 (discharge entry: pulse=0). Provide it with the conditions SOC>85 in condition 1 and the SOC tag as output to the chart in condition 2. We'll design a timer circuit right now. A relation operator (>) is connected to a clock and a constant block, both of which have the value 10. Next, include a second clock and a block of constants with the value 200, and connect them to the relation operator (). Connect a product1 block to both relation operators. Include one more product block. Connect the discharge tag to the product block after connecting the not gate and product 1 to it. Next, attach the two pulse tags to the ideal switch and ideal switch1, respectively, and two v discharge tags connected to ideal switches 2 and 3. Li-ion battery from the library, please. Select SOC, Current, and Voltage, and then connect a scope to the bus selector after connecting the battery. Branch the voltage connection and attach it directly to a unit.

IV.CONCLUSION

For determining battery limit, battery charge, and release time for its varied burdens, a battery test system based on MATLAB programming and a reliable current supply has been developed. In a dynamic load, the battery's releasing current is maintained constant while the heap decreases the battery voltage. After running the battery model through simulation, the output of the battery parameters is shown in Figs. 1 and 2 can be visualized by plotting the following graphs:

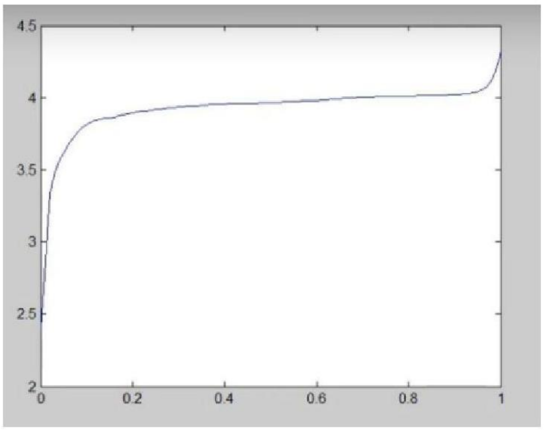

Figure: Output of the SOC with OCV.

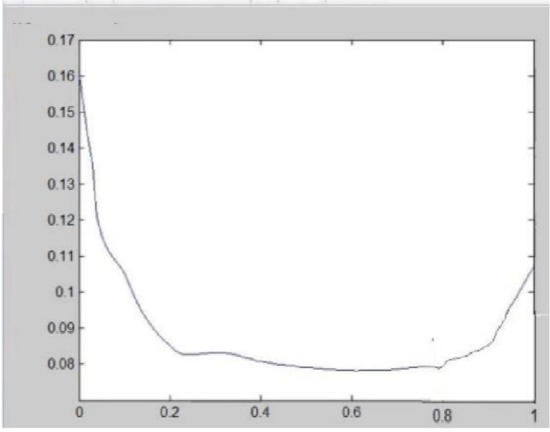

Figure: Output of the charge resistance of the battery.

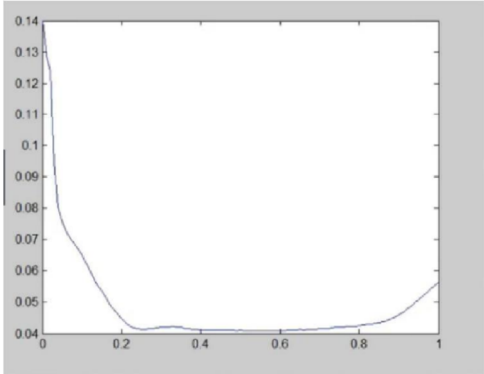

Figure: Output of the discharge resistance of the battery

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