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BATTERY MANAGEMENT SYSTEM IN ELECTRIC VEHICLES

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Abstract:- Battery management systems (BMS) is used in electric vehicle to monitor and control the charging and discharging of rechargeable batteries which makes the operation more economical. Battery management system keeps the battery safe, reliable and increases the senility without entering into damaging state. In order to maintain the state of the battery, voltage, current, ambient temperature different monitoring techniques are used. For monitoring purpose different analog/digital sensors with microcontrollers are used. This paper addresses state of charge, state of health, and state of life and also maximum capacity of a battery. By reviewing all these methodologies future challenges and possible solutions can be obtained.

Keywords: Battery management system, state of charge, state of health, state of life.

1.INTRODUCTION

Electric vehicles (EV) are playing a key role because of its zero-emission of harmful gases and use of efficient energy. Electric vehicles are equipped by a large number of battery cells which require a effective battery management system (BMS) while they are providing necessary power. The battery installed in a electric vehicle should not only provide long lasting energy but also provide high power. Lead-acid, Lithium-ion, -metal hydride are the most commonly used traction batteries, of all these traction batteries lithium-ion is most commonly used because of its advantages and its performance. The battery capacity range for a electric vehicle is about 30 to 100 KWHormore.Battery management system (BMS)makes decisions based on the battery charging and discharging rates, state of charge estimation, state of health estimation, cell voltage, temperature, current etc.Battery Management system (BMS) is the pivotal system in electric vehicle because batteries used in electric vehicle should not be get overcharged or over discharged.

If that happens, it leads to the damage of the battery, rise in temperature, reducing the life span of the battery, and occasionally also to the persons using it. It's also used to maximize the range of

vehicle by duly using the quantum of energy stored in it.

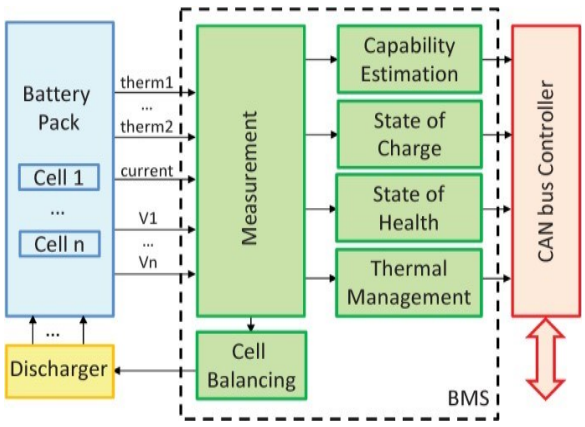

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Figure 1: BMS block diagram -1

Battery Management system is essential for following reasons:
1. Maintain the safety and the trustability of the battery.
2. Battery sate monitoring and evaluation.
3. To control the state of charge

2.PROBLEM FORMATION

1. Voltage Balancing: Ensuring that each cell in the battery pack has the same voltage, preventing overcharging or undercharging.
2. State of Charge (SOC) Estimation: Accurately estimating the remaining charge in the battery to avoid running out of power unexpectedly.
3. Thermal Management: Monitoring the temperature of the battery cells to prevent overheating, which could lead to battery degradation or failure.
4. Current Monitoring: Measuring the charging and discharging currents toprotect the system and optimize power usage.
5. Fault Detection: Identifying and mitigating faults such as short circuits,overvoltage, undervoltage, and temperature anomalies.

3.PROPOSED METHODOLOGY

Energy and environmental problems are the most dangerous problems faced by the world automotive industry.to overcome these problems world has accelerated to the new energy development.Booster converter maintains battery SOC between 95%-70%.MATLAB/SIMULINK simulation optimizes power distribution.Fuel cell + battery hybrid system enhances range & efficiency. Hybrid control strategies ensure efficiency & performance stability.

3.1.BATTERYMANAGEMENT SYSTEM(BMS)

Battery management system (BMS) is the crucial system in electric vehicle because batteries used in electric vehicle should not be get overcharged or over discharged. If that happens, it leads to the damage of the battery, rise in temperature, reducing the life span of the battery, and sometimes also to the persons using it. It is also used to maximize the range of vehicle by properly using the amount of energy stored in it.
Battery management system is essential for following reasons

1. Maintain the safety and the reliability of the battery
2. Battery sate monitoring and evaluation
3. To control the state of charge
4. For balancing cells and controlling the operating temperature
5. Management of regenerative energy

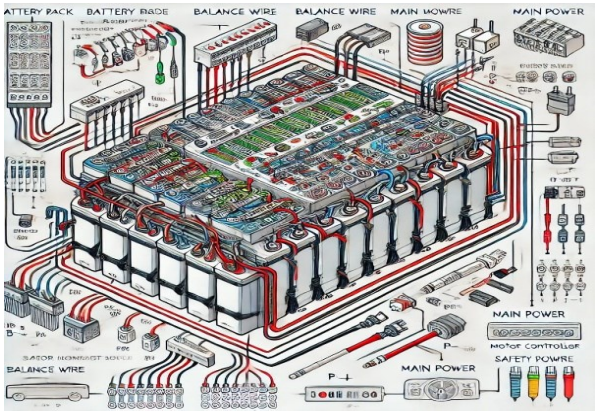

Figure 2: BMS connections diagram:

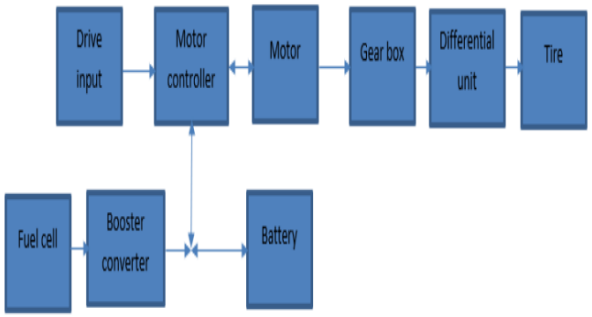

Figure 3: BMS block diagram -2(proposed method)

3.2 STATE OF CHARGE ESTIMATION

State of charge is defined as the available amount of battery as the percentage of rated capacity of the battery. State of charge gives a crucial support

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Vol 13, Issue 2, 2025

to battery management system to assess the state of the battery which helps the battery to operate within the safe operating range by controlling charging and discharging. It also increases the life span of the battery. State of charge cannot be estimated directly. It is calculated by using the equation

$$SOC = 1 - \frac{\int idt}{C_n}$$

Where I =current and

C_n= maximum capacity that the battery can hold

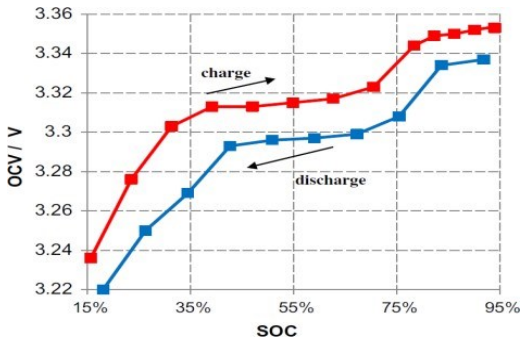

Figure 4:SOC during charging and discharging

There are various methods to estimate the state of charge. Following are the list of state of charge estimation method

1. Coulomb counting SOC estimation method
2. Fuzzy logic SOC estimation method
3. Impedance spectroscopy SOC estimation method
4. Kalman filtering SOC estimation method
5. Open circuit voltage SOC estimation method

- Among all these various methods Kalman filtering method has been successful for the estimation of SOC for EV'S.

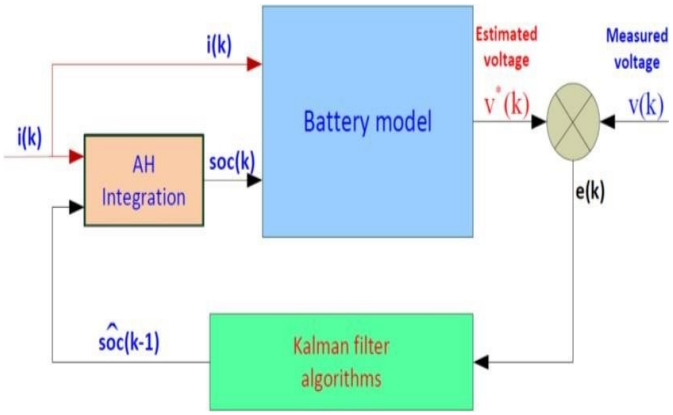

Figure5: Kalman filtering SOC estimation model

Temperature Monitoring & Control: During operations of battery because of chemical reactions it produces heat in batteries. as load varies there is chances of temperature rise or drop, damage the chemical property of cells and it can lead to explosion in worst cases. The temperature monitoring and control is essential for safer and smooth operation of batteries. The higher temperature of batteries can lead abnormal behavior like fire catch up and lower temperature can affect the charging and discharging parameter (current or voltage) of battery, may it can also reduce the power handling capability of batteries. Cell Balancing: In order to meet the requirements of energy storage rechargeable batteries are widely used in electric vehicle and other areas also. in various applications because of low terminal voltage of individual battery cells, they all are normally connected in series to create battery pack to reach required voltage level. however, the imbalances between individual cells of a battery pack are a common phenomenon. a well- known imbalances is SOC (State of charge) differences between all cells [4] This imbalance is caused by both intrinsic and extrinsic difference among battery cell [5] The soc differences between cells are because of energy consumption of each cell is different. A li-ion battery pack is having safety issue if overcharging and undercharging occurs, at the time of discharging the cell with lowest soc will reach the lower limit of safe operation voltage first thus the BMS has to turn of the operation. Same things (similar situation) happen during charging of battery. the cell with highest soc will reach upper limit of safe operation voltage first. This overcharge and undercharge cause on SOH (state of health) of battery. In order to maintain a balanced battery bank two methods are there: 1. Passive cell balancing 2. Active cell balancing

3.3STATE OF HEALTH ESTIMATION

State of health estimation describes the state of the battery with respect to the newly manufactured battery. It gives information regarding the available amount of discharging capacity during its lifetime. The SOH in EV use

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Vol 13, Issue 2, 2025

to describe the ability to drive the specific distance.

3.4STATE OF LIFE (SOL)

The remaining useful life of a battery is known as SOL. RUL of a battery using a for different thresholds of capacity fade C (i) and power fade P(i) is given by equation RUL(k)=h({$P(i)$, $C(i)$}i=1 k) where k is thekth week, approximately for an end-of-life criterion 23% power fade and 30% capacity fade is the RUL

3.5 BATTERY CAPACITY ESTIMATION USINGVARYINGLOADS AND ENVIRONMENTAL TEMPERATURES

Degradation of a battery depends upon charge and discharge cycle, environmental conditions and specific materials. The status of the battery is predicted when discharging at constant current and constant temperature. Here are few experimental factors of a lithium ion battery at different discharge rates and temperatures.

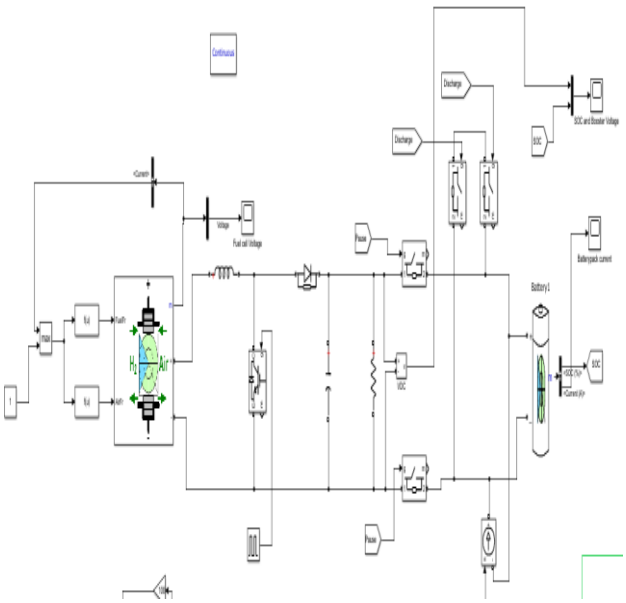

Fig 6: Simulation Diagram of BMS

Discharge Rate	Temperature
0.5C (350 mA)	25 °C
0.5C (350 mA)	50 °C
1C (700 mA)	25 °C
1C (700 mA)	50 °C

Table1:Experimentfactorsdifferent discharge rates and temperatures.

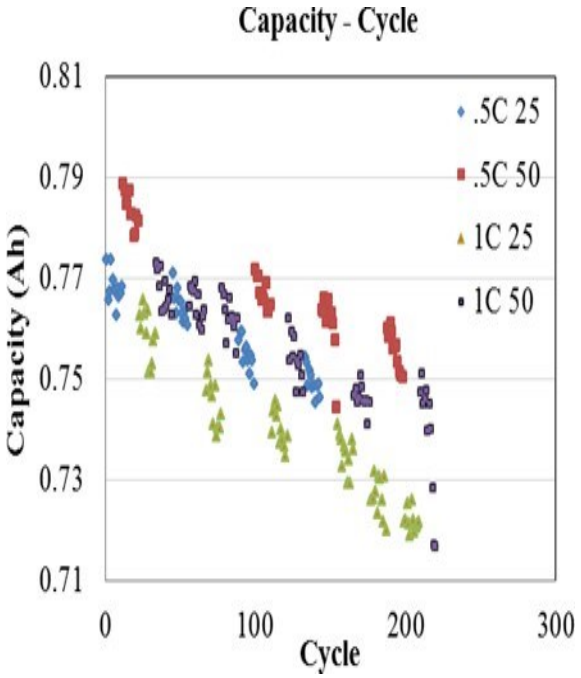

Figure7:Discharging capability alternating atdifferentdischarge rates and at different temperatures

3.6 CHARGING AND DISCHARGING OF LI-ION CELL USING BMS

Lithium-ion batteries are highly reactive, smaller in weight and has the highest energy. Charging and discharging of lithium-ion batteries are very faster than the other batteries. Lithium-ion cells should be operated beyond its safe operating voltage range to avoid combination of many chemical reactions, rise in temperature which leads to cell venting and generation of fire. Hence, Battery management system (BMS) is used which allows the battery to operate with in their safety zone.

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Vol 13, Issue 2, 2025

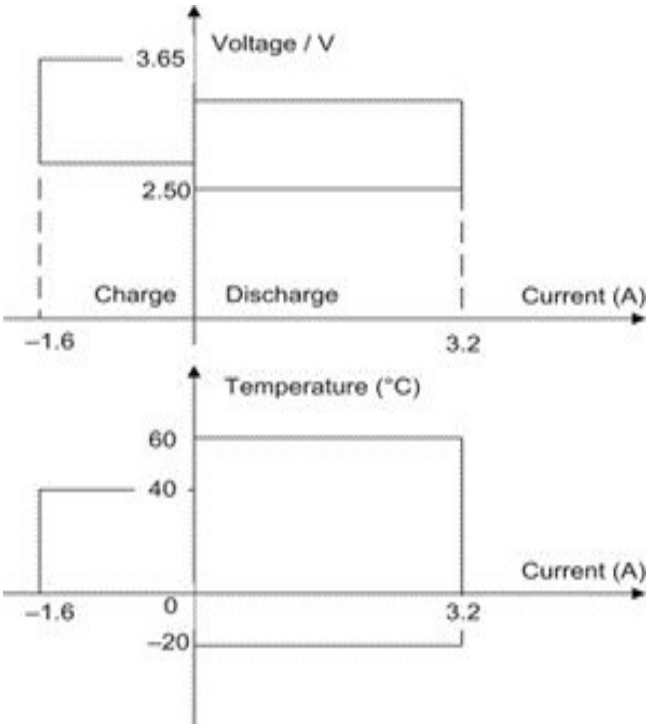

Fig 8: Wave forms of voltage and temperature control

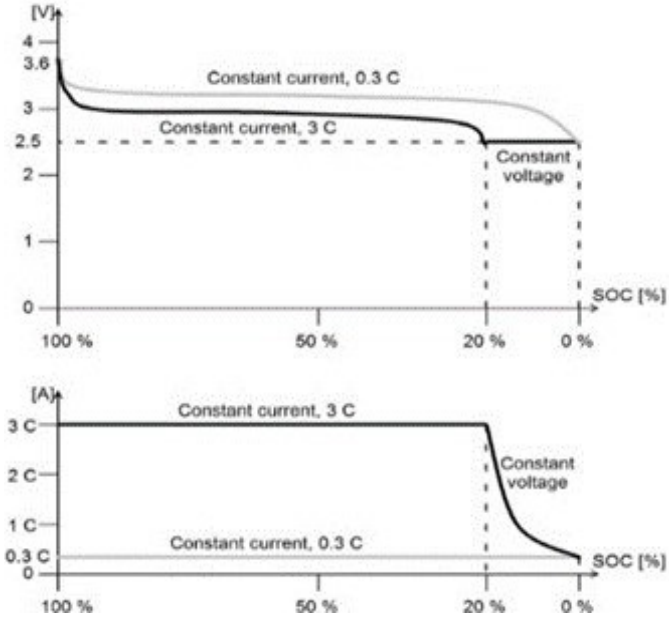

Fig 9: Wave form of current control

3.7ADVANTAGES

1. It improves the battery performance
2. It enhances the life span of battery
3. It controls the charging, discharging and temperature ranges and keeps them with in their range.
4. It predicts the batteries capabilities in near future

4.RESULTS & DISCUSSIONS

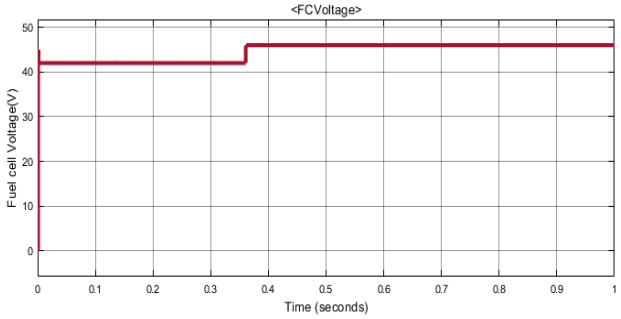

Figure 10:Fuel cell output wave form simulation

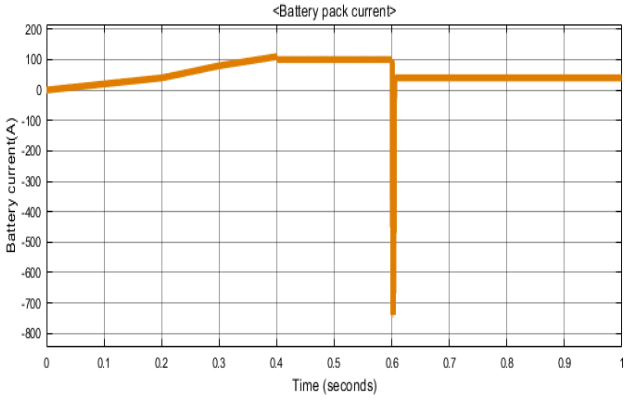

Figure 11: Li-ion cell output wave form simulation

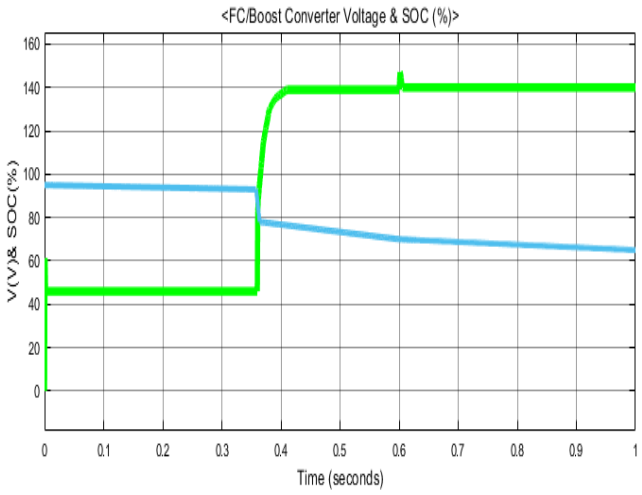

Figure 12: State of charge (SOC) output wave form simulation

Based on this work, specific challenges faced by BMS and their solutions were presented as a foundation for future research. Based on the particular situation,different strategies can be applied to upgrade and optimize the performance of BMS in EVS.

5.CONCLUSION

In this way we are developing the system model for battery management in electric vehicle by controlling the crucial parameters such as voltage, current, state of charge, state of health, state of life, temperature. It is every important that the BMS should be well maintained with battery reliability and safety. This present paper focusses on the study of BMS and optimizes the power performances of electric vehicles. Moreover, the target of reducing the greenhouse gases can greatly be achieved by using battery management system.

The observation from this fuel cell/battery hybrid electric vehicle simulation is that the total distance travelled by the vehicle is only limited by the amount of hydrogen supplied to the fuel cell to produce 140V to charge the 120V battery pack, the traction motor is able to propel the vehicle to the pre-determined destination.As the weight of the weight exceeds the optimum weight of 600kg the vehicle speed is struggling to follow the reference speed from the signal builder block, hence missing the reference speed trajectory. Therefore, as long as the fuel cell is producing the voltage to charge the battery pack, it would maintain the soc between 70%-95% depending on the speed and the load of the electric vehicle. The fuel cell/battery hybrid electric vehicle is able to cover any distance in zambia as long as hydrogen is on board.

In this way we are developing the model for battery management system in electric vehicle by controlling key parameters like current, voltage, temperature, and SOC (State of Charge). It is an important that the BMS should be well maintained with battery credibility & security. this paper mainly focusses on the study of battery management system and enhance the power performances of electric vehicles. Besides, the goal of reducing the greenhouse gas can greatly be achieved by using battery management system.

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