Battery Management System in Electrical Vehicles

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Abstract— Battery Management Systems (BMS) are used in many industrial and commercial systems to make the battery operation more efficient and for the estimation to keep the battery state, as long as possible, away from destructive state, to increase battery life time. For this purpose, many monitoring techniques are used to monitor the battery state of charge, temperature and current. In the current paper, the monitoring system for battery powered Electric Vehicles (EV) has been implemented and tested. This system evaluates and displays the battery temperature, charging/discharging current and State Of Charge (SOC) for the considered model battery. For monitoring purpose, digital and analog sensors with microcontrollers are used. The battery information and the obtained results explaining the main characteristics of the system are presented by photographs and some experimental results are given by the LCD screen .

Keywords— Battery management systems, Electric vehicles, Monitoring techniques, microcontroller and State of charge

I. INTRODUCTION

A battery management system (BMS) is a combination of hardware and software that extends the battery's lifetime by increasing the number of discharge cycles [1]. There are two factors that need to be taken into account while attempting to explain battery management systems (BMS). Battery State Of Charge (SOC), which describes the amount of charge present in a battery during a charge or discharge cycle, is the first variable. The battery's performance in relation to its past and anticipated future is represented by the second variable, the Battery State Of Health (SOH). The Battery Control Unit (BCU), the CAN bus vehicle communication network, and the Battery Monitoring Unit (BMU) are the three primary components of the basic BMS, as depicted in Figure 1. Additionally, it is obvious how BMS building blocks connect to the other vehicle energy management systems. The alternative variants, however, have dispersed BMS integrated into the battery cell to cell interconnections.

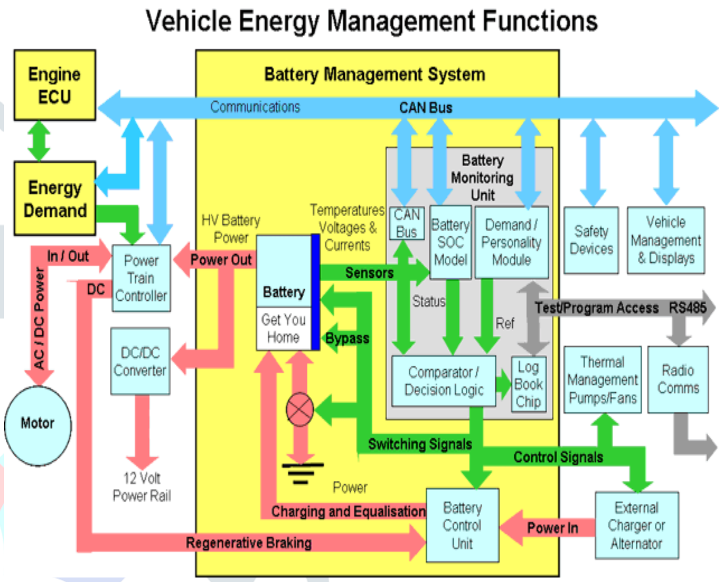


Figure 1: Vehicle Energy management

II. SOC DETERMINATION

A good SOC calculation has various benefits for EVs, including greater battery performance, longer battery life, and battery pack failure warning. The density of the battery's chemical components can be measured in order to determine the remaining battery capacity, although this is not a workable solution. As a result, numerous techniques based on the measuring of battery voltage and current have been presented. Most of these techniques don't account for the impact of temperature when calculating battery SOC.

Particularly for applications involving electrical cars, the SOC should be precisely calculated to forecast the remaining trip distance. There are now three fundamental interrogation techniques available to determine a battery's SOC. Coulomb counting is the initial technique, followed by voltage delay and impedance approaches, respectively. Other approaches, including monitoring the electrolyte specific gravity, are impractical for use in a fuel gauge or battery management system for an electric car.

The most popular method for measuring battery fuel in EVs is the coulomb counting method. When SOC calculations are adjusted for temperature and discharge rate fluctuations, this approach is fairly accurate. Coulomb counting, however, does not offer any diagnostic capabilities that could be utilized to assess the state of health (SOH) of batteries.

Battery tests carried out outside of a vehicle are frequently conducted using the voltage delay method. In this scenario, the battery is discharged under a transient load while the battery's voltage response is tracked. The battery's SOC is then determined using the voltage recovery transient. Again, the applicability of this technique as an in-vehicle battery SOC/SOH instrument is constrained.

The impedance approach monitors the voltage/current response of the battery while applying a current/voltage excitation waveform to it. The applied signal in electrochemical impedance spectroscopy (EIS) is a low-amplitude, ac waveform, which disturbs the battery system's equilibrium condition.

III. SOH DETERMINATION

Estimated state of health describes the battery's condition in relation to a battery that has just been produced. It provides details on the quantity of available discharge capacity over the course of its lifetime. The term "ability to drive the specified distance" (SOH) is used in electric vehicles (EV).

Pattipati et al classified capacity deterioration and power decline as health characteristics. With a fully charged battery, capacity fade refers to decreased driving range, and power fade refers to decreased acceleration capability. Power fading happens when a cell's resistance rises with ageing. Total impedance is as a result (RHF+Rtc=R). where the transfer resistance and frequency resistance, respectively, are RHF and Rtc.

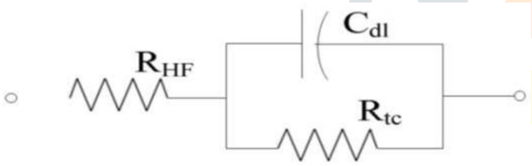


Figure 4 circuit model for a lithium-ion battery

$$P=\frac{V^2}{R}$$

$$\text{Power Fade}=1-\frac{power(K)}{power(0)}=1-\frac{R(0)}{R(k)}$$

$$\text{Capacity Fade (\%)}=1-\left(1-\left(\frac{capacity(k)}{capacity(0)}\right)\right)*100$$

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

$$RUL(k) = h(\{P(i), C(i)\}_{i=1}^{k} k)$$

where k is the k th week, approximately for an end-of-life criterion 23% power fade and 30% capacity fade is the RUL. The maximum capacity of the battery describes the performance and future life of the battery. The maximum capacity of a battery is calculated by:

$$\text{Capacity}=\int I dt$$

IV. CHARGING AND DISCHARGING OF LI-ION CELL USING BMS

High energy density, low weight, and high reactivity are all characteristics of lithium-ion batteries. Lithium-ion batteries charge and discharge much more quickly than traditional batteries.

To prevent a chain reaction of numerous chemical reactions, a rise in temperature that causes cell venting, and the ignition of fire, lithium-ion batteries should not be operated within their safe operating voltage range. As a result, the battery can run within its safety zone thanks to the Battery Management System (BMS).

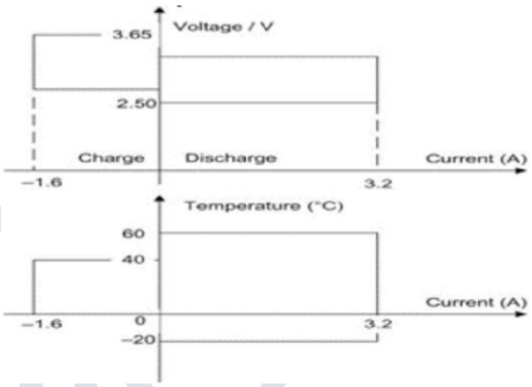


Figure 2: Safe operating area charging and discharging

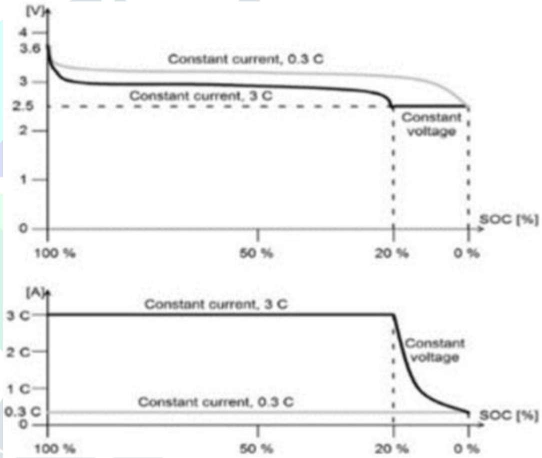
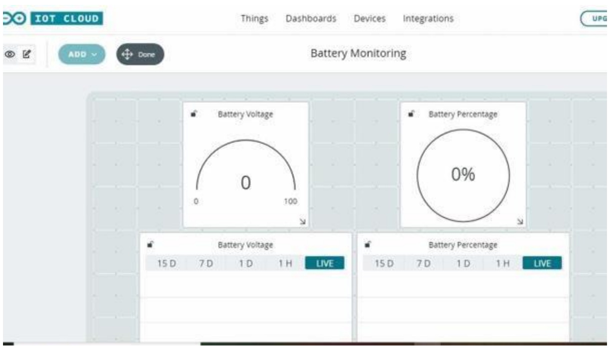


Figure 3: Charging and discharging of lithium-ion batteries

V. BATTERY MONITORING SYSTEM USER INTERFACE

An app-based user interface is another component of the designed battery monitoring system. The user interface may track the health of batteries and the battery monitoring device. As a result, the concept for the user interface has taken location independence into account when there is a need to check battery conditions from anywhere

Figure 4: The main page for the app-based user interface



First, a dashboard must be created to display the data. The First Gauge is used to check the voltage of the batteries. Therefore, we will set it up as "Battery Voltage" and link a voltage variable from earlier creations. Similarly, we will link a bat_percentage variable from objects for "Battery Percentage". One chart widget will be set up for Battery Voltage, and the other for Battery Percentage, as a final step. We have finally finished creating our dashboard. Let's now programme the NodeMCU ESP8266 to transmit data to the IoT Cloud.

After the programme has successfully been uploaded, we will launch the Serial Monitor at a 9600 baud rate. The ESP8266 NodeMCU will attempt to connect to the WiFi network. It will show the Analogue voltage Value, Battery Voltage, and Percentage once it successfully connects to your WiFi network. Similar to this, we can easily process and observe the same values in extremely attractive widgets on the dashboard.

VI. CONCLUSION

By adjusting the vital characteristics such as voltage, current, status of charge, state of health, state of life, and temperature, we are able to construct the system model for battery management in electric vehicles. It is crucial that the BMS is kept up to date to ensure battery dependability and safety. This research optimises the power performances of electric vehicles while concentrating on the study of BMS. Additionally, the use of a battery management system can significantly help achieve the goal of reducing greenhouse gases.

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