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# Prototype Design of GSM Based Monitoring of Battery Management System for Electric Vehicles

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**ABSTRACT:** This study presents a comprehensive overview of this relatively revolutionary and gratifying solution for battery difficulties in electric vehicles, as well as an in depth investigation of it. In this new battery management system, we divide the battery in two halves. One half is for charging and the other half is for discharging. For charging, we use renewable energy sources such as solar panels, regenerative braking, regenerative suspension, and so on. While one half is charging, the other half is discharging simultaneously. When the other half is discharged completely, we use the charged portion of the battery and a discharged portion is kept for charging. Due to this management we don't require external charging and the vehicles becomes autonomous itself for charging and we are not using two different batteries, so there will be no space problem. This system evaluates and displays the battery temperature, charging/discharging current and state of charge (SOC) for the considered model batteries. For monitoring purpose, digital and analog sensors with microcontrollers are used.

**KEYWORDS:** Battery management system, renewable energy, Electric vehicles, State of charge, solar panel, regenerative braking, evaluate, monitoring, charging, discharging.

## I. INTRODUCTION

In Electric vehicles, battery management systems monitor and control the charging and discharging rechargeable batteries, making the operation more cost- effective. The battery management system keeps the battery safe and reliable while also increasing senility without harming it. Different monitoring techniques are employed to maintain the state of the battery, including voltage, current and ambient temperature. This addresses the state of charge, health, life, and also the maximum capacity of a battery. Electric vehicles play an important role because they emit no hazardous emissions and use energy efficiently electric vehicles are equipped with a large number of battery cells which require an effective battery management system while they are providing necessary power. The battery installed in electric vehicles should not only provide high power. In practice the BMS may also be couples to other vehicles which communicate with the BMS. Thermal management system or to anti-theft devices which disable the battery.

### A. Need of this method

Nowadays the modern world demands high technology which can solve our current and future problems. If we particularly see the problems in every country, then we can realize that scarcity of fossil fuel is the main problem. The rates of fuels (petrol & diesel) are increasing day by day. Because of fossil fuels, there is so much pollution produced all over the world. on 2030 all the sources of fuel will finish. so this method will helpful for also future improvement.

**B. Easy of Use**

We have to move towards Electric vehicles where we can use renewable energy sources instead of these conventional sources. By using renewable energy sources such as solar energy, wind energy we can get electrical energy for further use. In electric vehicles, battery management systems monitor and control the charging and discharging rechargeable batteries, making the operation more cost-effective. The battery management system keeps the battery safe and reliable while also increasing senility without harming it. Different monitoring techniques are employed to maintain the state of the battery, including voltage, current and ambient temperature. This addresses the

**C. Electric Vehicles**

According to research 18 % of suspended particulates, 27 % of organic compounds, 28 % of pb, 32% of nitrogen oxide and 62 % of carbon dioxide of air borne pollution in America are produced by vehicles with internal combustion engines. In addition 25% of energy related CO<sub>2</sub> in the atmosphere are released from traditional vehicles. As an increasing number of people use public and personal transportation, the amount of air pollution increases every single day. Consequently, electric vehicles becoming more and more popular. An electric vehicle generally contains the following major components. An electric motor and motor controller, a traction battery, a battery management system, a plug-in-charger that can be operated separately from the vehicle, a wiring system, a generating braking system a vehicle body and a frame. Z

**D. Lithium-Ion-Battery**

Lithium is the lightest with the greatest electro-chemical potential and the largest energy density per weight of all metals found in nature. Using lithium as the anode, rechargeable batteries could provide high voltage, excellent capacity and remarkable high energy density. Lithium ion battery requires almost no maintenance during its lifecycle, which is an advantage that other batteries do not have. No schedule cycling required and there is no memory effect in the battery. Further over this battery is suitable for electric vehicles because its self-discharge rate is less than half of discharge rate of lead acid and NiMH batteries.

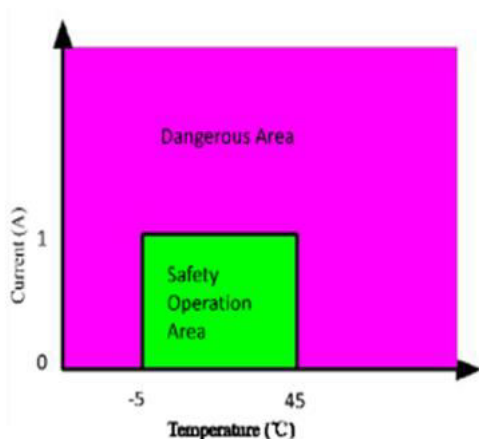


Figure 1-2 Lithium-ion cell operation window (Current)

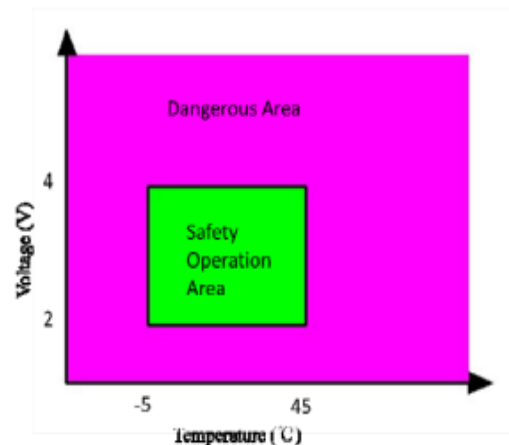


Figure 1-1 Lithium-ion cell operation window (Voltage)

**II. RELATED WORK****2.1 Why do we need a Battery Management System?**

In electric vehicle the BMS is a part of complex and fast acting power management system. In addition, it must interference with other on board systems such as a motor controller, the climate controller, the communication bus and the safety system and the vehicle controller. The lithium ion batteries have proved to be the battery of interest for electric vehicles. manufacturer because of its high change density and low weight even though these batteries pack in a

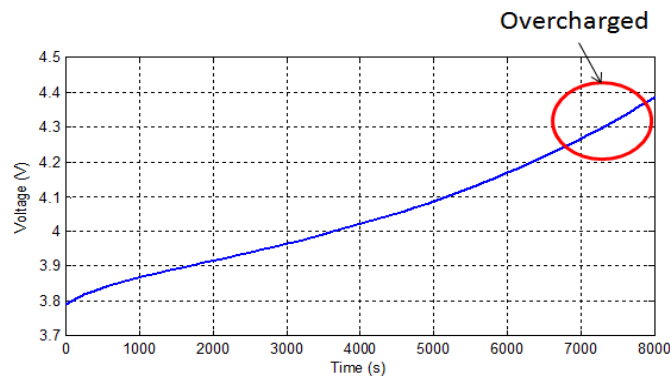
lot of punch for its size they are highly unstable in nature it is a very important that these batteries should never be overcharged or under discharged at any circumstances which brings in the need to monitor its voltage and current. These process gets a bit tougher since there are a lot of cells put together to form a battery pack in EV and every cell should be individually monitored for its safety and efficient operation which requires a special dedicated system called the battery management system.

## 2.2 Objectives of BMS:-

- 1.To protect the battery cells from abuse and damage.
- 2.It extends the battery life as long as possible.
- 3.It make sure the battery is always ready to be used.

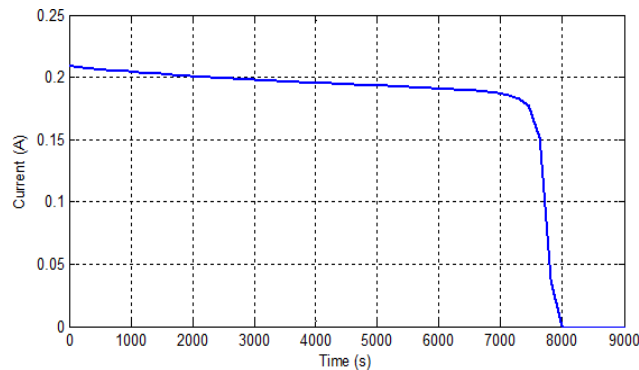
## 2.3 Charging control

A part from the discharging the charging process should also be monitored by BMS. Most batteries tend to get damaged or get reduced in lifespan when charged in appropriately. for lithium battery charger two stage charger is used. The first stage is called the constant current during which the constant current to charge the battery. When the battery gets nearly full. The second voltage called the constant voltage stage is used during which a constant voltage is supplied to the battery at a very low current. The BMS should make sure both the voltage and current. During charging does not exceed permissible limits so as to not overcharged or fast charge to the batteries. The maximum permissible limits charging voltage and charging current can be found in the datasheet of the battery. As shown in the figure below, the battery voltage exceeded the high voltage limit (4.2 V) when the battery was charged using a constant current power source, which was harmful for the battery.



## 2.4 Discharging control

The primary goal of a BMS is to keep the battery from operating out of its safety zone. The BMS must protect the cell from any eventuality during discharging. Otherwise, the cell could operate outside of its limitations. The primary function of BMS is to maintain the lithium cells within the safe operating region for ex. A typical lithium 18650 cell will have an under voltage rating of around 3 V. it is the responsibilities of the BMS to make sure that none of the cells in the pack get discharged below 3 V. As shown in the figure below, the battery voltage dropped below the low voltage limit (2.75 V) when the battery was discharged without protection. This was harmful for the battery.



### 2.5 SOC Determination

A good SOC calculation provides many advantages for EV such as longer battery life, better battery performance and failure warning of battery pack. The residual battery capacity can be determined by measurement of the density of the chemical components of the battery; however, it is not a practical solution. Accordingly, various methods have been proposed based on battery voltage and current measurement. Most of this method ignore the temperature effect in calculation of the battery SOC.

The SOC should be determined accurately especially for electric vehicles application to predict the travel remaining disturbance of the vehicles. These are basic interrogation methods existing of the determining of the SOC of a battery. The open-voltage source was calculated with a non-linear equation based on the actual SOC of the battery. The model assumed the same characteristics for the charge and discharge cycles

$$\text{The SOC is given by } SOC = 100\% * \left(1 - \frac{\int i dt}{Q}\right)$$

Where,

Q = battery capacity (Ah)

i = battery current (A)

t = time (h)

### 3.2 State-of-Charge Estimation Equation

The state of charge is estimated by reading the battery voltage  $v$  and comparing it to a series of values stored in a lookup table I0-I8. The threshold voltages are derived from the particular discharge curve shown below for the LG 18650 HE4 cells used in this,

The remaining capacity and charge duration are derived as follows:

$$Mah = c_{full} * (100 - soc) * 1.3$$

$$T_{max} = 3600 * c_{full} / i_{charge} (90 - soc) + 45 * 60$$

Where  $c_{full}/c_{max}$  is the battery design capacity and  $i_{charge}$  is the nominal charging current. Note that  $c_{max}$  is increased by 30% and  $t_{max}$  is increased by 45 minutes in order to account for resistive losses and SOC estimation inaccuracy.

The equation to be used to describe the battery in the electric circuit based model become:

The circuit voltage equation becomes,

$$V = E - (R + R_t) i$$

Where,

E = no load voltage (V)

i = battery current (A)

V = battery voltage (V)

R = internal resistance ( $\Omega$ )

$R_t$  = self discharging resistance ( $\Omega$ )

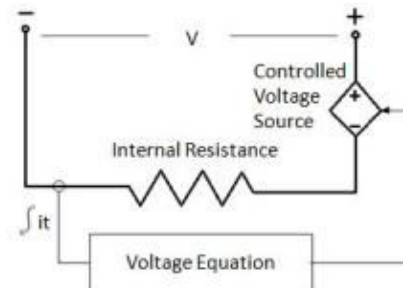
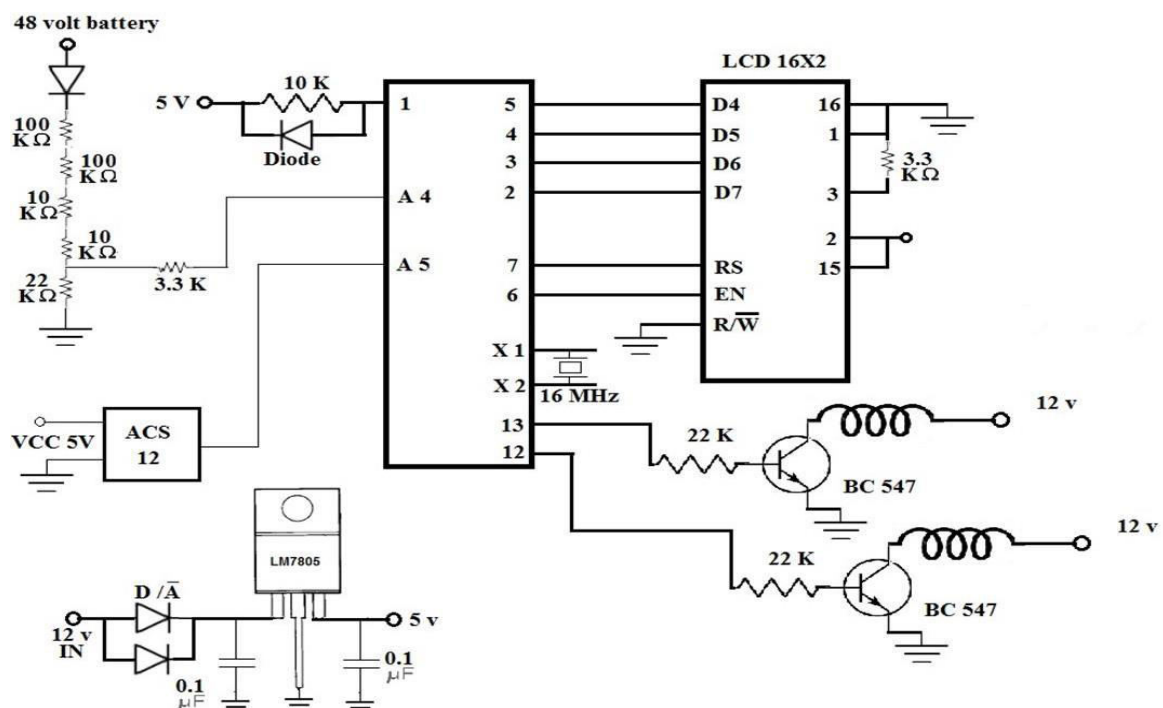


Figure 2-2 Electric circuit-based model

### III.METHODOLOGY

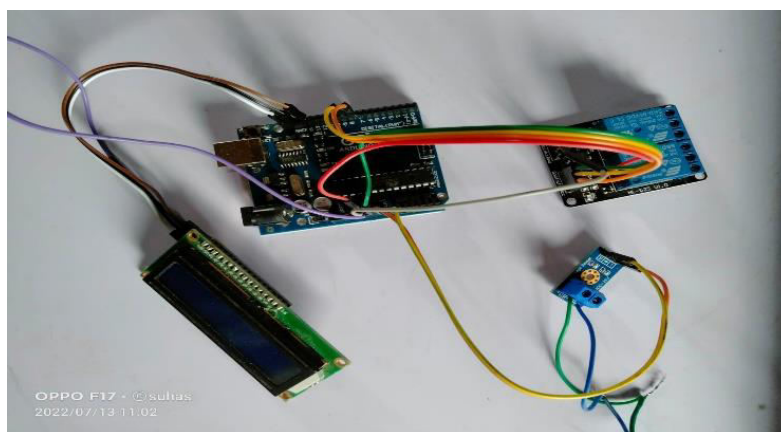
#### 3.1. Optimization Objectives of EV Charging/Discharging in Power System

The primary aim of connecting EVs to the power grid is to obtain enough charge for the next trip; however, with optimal EV charge/discharge management, other goals can be achieved in addition to the stated primary goal. The literature has considered various goals, such as minimizing losses, reducing voltage imbalances, frequency regulation, load flattening, minimizing the charging cost for the EV's owner, supporting the integration of renewable energy sources decreasing the cost of operating the distribution system, maximizing EV profits through market participation and reducing greenhouse gas emissions to optimize the EV charging/discharging process in the power grid. Additionally, some papers have examined multi-objective optimization of EV charging/discharging. In the objectives of minimizing the load variance and the EV charging cost are considered. According to the above-mentioned facts, the objectives pursued by charge and discharge management in the power network can be divided into three categories: the improvement of the power grid's operation, economic objectives, and environmental issues. A classification of the optimization objectives of EV charging/discharging in power systems is shown in fig.



In low-power applications that require only simple BMSs, such as cell phones and laptops, they could be designed from integrated circuits. However, electric vehicles require numerous large battery cells that are more problematic and more costly to repair. A lithium-ion BMS for electric vehicles based on CAN-bus was proposed. This BMS could sample battery information, estimate the SOC of the battery and communicate with the vehicle controller. The design structure is shown in Figure. The main advantage of that system compared with the existing systems was that it provided a fault-tolerant capability and battery protection. It consisted of a number of smart battery modules and each module provided the functions of battery equalization, monitoring, and battery protection to a string of battery cells. However, the reference did not specify the application of the BMS and was likely not designed for lithium-ion batteries.

### 3.2 Hardware Mounting: -



#### 3.2.1. Improved Battery Model

To simulate battery behaviours more accurately in the models, factors such as self-discharge, temperature, and fading capacity should be taken into consideration.

##### A. Self Discharging Effect: -

Even without any physical connections between the electrodes, the battery can self-discharge through internal chemical reactions and decreases the stored charge. This lowers the shelf life of the batteries and reduces the amount of available charge when they are put to use. The self-discharging speed of a battery depends on the battery type, and the effect is especially strong for nickel-based rechargeable batteries. For example, nickel cadmium batteries discharge by 15 – 20% per month, whereas NiMH batteries discharge by 30% per month. Because primary batteries cannot be recharged between manufacturing and use, they have a lower self-discharge rate. Nevertheless, lithium batteries still suffer from a 2 – 3% discharge per month, which is the smallest amount of self-discharge among rechargeable batteries.

##### B. Temperature Effect: -

Temperature and humidity could also affect battery performances. Batteries do not operate within their normal and designed specifications when the ambient temperature exceeds the appropriate operating range. This is not a manufacturing defect but a direct consequence of extreme weather. Therefore, a battery should not be used in an environment for which it was not designed. When the ambient temperature and relative humidity of a specific environment are altered beyond the norm, they are considered extreme weather conditions. These conditions may occur almost anywhere and at anytime

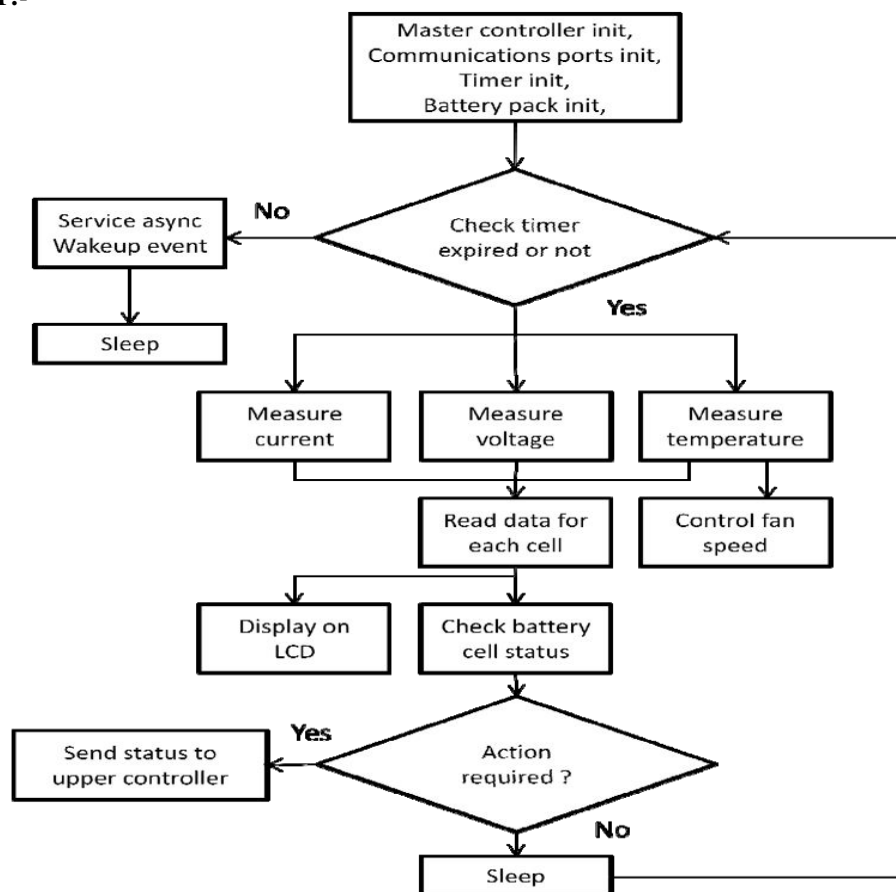
### C. Effect of fading capacity

It is known that lithium-ion batteries have a limited life because they gradually and irreversibly lose their capacity to hold a charge. As the battery loses its capacity, the length of time it can power a device (also called run time) decreases. As the system cycles through multiple iterations of charge and discharge, the overall performance of the battery deteriorates over time. The typical estimated life of a lithium-ion battery is approximately two to three years or 300 to 500 charge cycles. In high-performance applications such as electric vehicles, it is important to have an accurate knowledge of the present conditions of the battery and its remaining lifetime.

### D. Improved Battery Model

Because the operation of rechargeable batteries depends on factors such as temperature, the self-discharge rate and its capacity, it is necessary to carefully develop models that accurately describe the charging and discharging behavior of batteries.

#### FLOWCHART:-



**IV. EXPERIMENTAL RESULTS**

Parameters	Hardware
1.Voltage	$24 \times 2 = 48 \text{ V}$
2.Current	1.3 amp (per battery)
3.Time needed for charging	Normal condition – 118 minutes By using this project= 65 minutes

**V. CONCLUSION**

The detection of Hydrogen gas emitted from the batteries. It aims at providing a very safe atmosphere around the battery, which can help in having harmless environment. Also, the basic battery parameters help in monitoring the battery conditions. Incorporating Cloud and IoT into the Battery Management System will help in analysing the data. This BMS is also equipped with the GPS tracker that will enable tracking of vehicles and hence immediate attention can be provided. And also by using this project we can reduce the charging system time and improve the life of the batteries. Thus, a prototype model will develop based on all these and will successfully implement and test.

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