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A Review Paper on "BMS for Electric Vehicles with Charge Monitor and Fire Protection"

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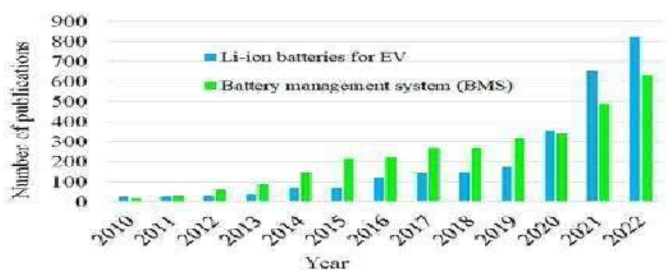
Abstract: Lithium batteries are the most commonly used energy storage devices in items such as electric vehicles, portable devices, and energy storage systems. However, if lithium batteries will not continuously monitored, their performance could be degraded, their lifetime becomes shortened, or severe damage or explosion could be happen. To prevent such types of accidents, we propose a lithium battery state of health(SoH) monitoring method and state of charge estimation algorithm based on the state of health results. And also speed control in electric vehicles is mandatory Because it is used to influence the rotational speed of motors and machinery. This has a direct effect on the operation of the machine and is crucial for the quality and overall outcome of the work. Li-ion batteries having a lot of energy into them, and thermal runaway accelerates quicker the more power present in the battery itself. If a battery is fully charged and something is happened inside it, then thermal runaway would happen really quickly. To overcome this problem, fire protection of electric vehicle is necessary.
Keywords: Battery; BMS; Fire Protection; Charge Monitoring; Safety; EVs.

I. INTRODUCTION

An electric vehicles EVs is a type of vehicle that uses one or more electric motors to its drive. Instead of using a combustion engine (ICE), the EV uses a battery to store electrical energy in the form of electrical current to supply electricity to the electric motor and turn the wheels. Compared to traditional IC Engine cars, EVs offers many advantages, including: Reduced emissions, quiet operation, and overall sustainability. Electricity is often cheaper than gasoline or electric motors, so it usually has an lower operating cost. Li-ion Battery is extremely sensitive and responsive to overload and deep discharge, damaging the battery, shortening its lifespan and causing dangerous situations. This requires the installation of a proper Battery Management system (BMS) to maintain all cells of the battery in a safe and reliable operating area [1]. In this regard, one aspect faced is the battery monitoring system. If you want your FEV to be reliable, you need to be able to control the battery condition under load, indicating whether the car needs to be stopped and charged, and whether it indicates the health of the battery. In FEVs, the battery management system (BMS) controls battery usage [2]. One of the most important features of a BMS is that the battery will not expire or work overtime, which can cause permanent damage to the battery and lifespan. The BMS does this by controlling the load and discharge process, and the battery turns off when abnormal conditions are determined. Another important feature of the BMS is to ensure that the battery will operates in a safe temperature range. If the battery gets very hot, the BMS can be either slow down the load speed or it will shut down the battery to avoid damage. If the battery gets very cool, the BMS can increase the charging speed and heat the battery. It is important to remember that overloading of the Li-ion battery can cause to malfunctions, leading to fires and explosions. As a result, it is very important to carefully observe the charging process and prevent the battery from remaining alone during charging [3].

Overload, overcharge and short circuits are common electrical errors in LIBS [4] [5].In comparision to overcharge/overload defects, the battery short circle is more destructive. This is more destructive as gas production (increased internal pressure) and fractures of the cell vessel lead to dramatic temperatures that increase in internal chemical processes (SEI layer separation, anodel electrolyte reaction). Notable BMS explorations are outlined below. The number of distributions was given in 2010. Looking at this type of modeling [17].



II. BATTERY TYPES AND KEY TECHNOLOGIES FOR BMS

Many battery types can be used as power sources in EV applications. BMS has the many function modules. This article analyses and summarizes some common types of batteries and key technologies in the BMS.

A. *Battery types in EVs*

Batteries are usually divided into two categories on the basis of their charging capabilities: primary battery and secondary battery. The primary battery can only be used once after a full discharge, and the secondary battery can be charged after being removed. Long cycle secondary batteries, small energy losses, high performance density and large safety levels are essential for EV and HEV applications. Some of the popular batteries used in EVs include lithium ion (lithium), lead acid, nickel cadmium (NICD), and nickel metal hydride (NIMH). Li-ion batteries are significantly better than other types of batteries, especially in lifetimes. This is extremely important for long EV services (e.g. 6°C lifespan). Plus, Li-ion batteries are made up of environmental friendly materials that do not have any toxic hiking issues, making them safer. Therefore, the Li-ion battery is the most popular power source for EVs.

B. *Key technologies for BMS*

On the other hand, the battery needs to be given special attention in the EV applications. Incorrect processes such as temperatures too high or too low, overload or discharge dramatically accelerate the battery disassembly process. Additionally, Electric Vehicle batteries are consist of hundreds of battery cells connected in series or parallel configurations to operate at the vehicle's high performance and high voltage requirements. You will also need to ensure that these complex batteries are operated. Therefore, a proper BMS is extremely important to protect the battery from damage that needs to be carefully designed [4,5]. In this article, several key technologies such as battery modelling, battery status estimation, battery charging, etc. are required for the development of effective BMSs in EVs. With EV application, battery current and voltage canbe detected by on-board current sensor and voltage sensor directly, and surface temperature of battery pack can be also detected by temperature sensor or thermocouple conveniently. Then the well-trained battery models together with suitable estimation methods can be adopted to achieve the independent or joint state estimations of battery SOC or the internal temperature. After capturing battery electric and thermal behaviours, battery charging approaches can be optimized by proper optimization algorithms, and further to charge battery from initialstate to final state target with the equilibration of various charging objectives such as fast charging, high efficiency of energy conversion and low temperature rise. If there is any abnormal situations of battery states occur in the operation process, then the alarm module and safety control module will operate to record or eliminate these cases accordingly.

Therefore, battery modelling, state estimation and battery control are the vital technologies in the BMS. And these technologies become the thriving areas of research inthe applications of BMS/EVs.

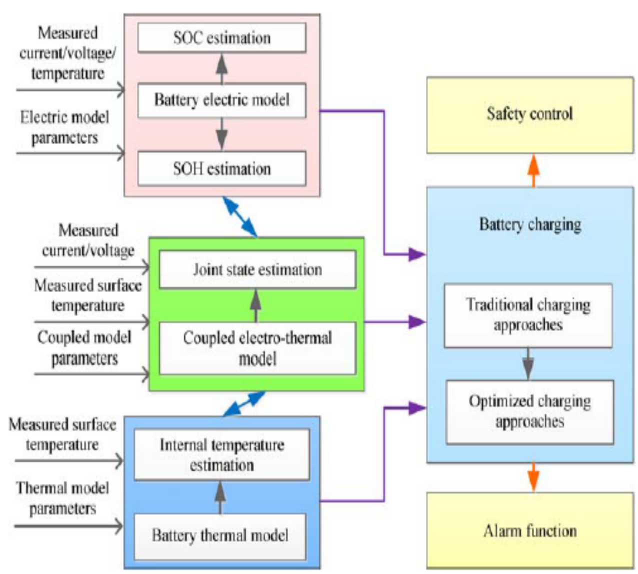


Fig. 1 The relation of key technologies in the BMS

III. BMS MODEL

The Battery management system (BMS) is the most important part of the any FEV. The BMS must control and confirm the operation of the energy vehicle and report to all relevant information about the battery to the user. The duration and number of lifecycles per discharge must be maximized. Typically, The BMS is connected to the remaining electronic systems via a can bus.

- The BMS performs the following actions:
- Monitoring battery voltage, electricity, temperature, load condition (SOC), health condition (SOH).

Battery Management Systems (BMS) monitor a variety of functions such as energy storage, transmission, control, and [18] management facilities in electric vehicles. It Tasks such as load compensation, battery cell voltage rules, input/output voltage control, protection, and diagnosing and assessing errors.Fig. 2 reports the block diagram of a BMS.In this work, the BMS was modelled in SystemC. I mainly made this choice because the SystemC simulation is fast and the BMS parameters can be easily changed. Furthermore, to simulate the more complex systems, BMS models are connected using SystemC with already developed bus models. Individual blocks are shown in detail below.

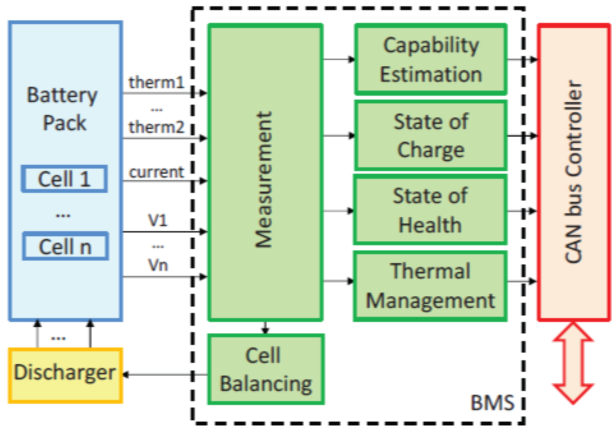


Fig.2 BMS Block Diagram[2]

A. Requirements And Standards For Battery Monitoring And Management

Battery management is a must for Li-Ion batteries to ensure energy availability, service life and safety of energy storage systems. Battery flow, voltage and temperature progression are the main inputs of electronic battery management systems. This is responsible for battery protection and estimates of State of Charge (SOC), Health System (SOH), and State Offunction (SOF). Additional tasks include controlling the heating/cooling subsystem and mains switch, ensuring the separation of high voltages from the vehicle, and separating communication with the network within the vehicle from an electronic perspective, synchronizing the battery measurement challenges and voltage demand triggers, and triggering the voltage and voltage measurements for domestic measurements. Tensions in the sync and voltage domains. Typical accuracy goals are 0.5-1% for streams up to 450 A and 1-2 mV, or 0.1% for tension at cell or packing levels. This strict demand for voltage accuracy is driven primarily by LifePO4 chemistry. This is one of the priority technologies for automotive applications as it offers a good compromise between energy density, cost, security properties, lifetime and cycle resistance. The extremely flat feature of open circuit tension compared to cutting-edge fees stands for this battery technology. This makes it extremely difficult to accurately view the load estimates from voltage measurements, especially within the 20% to 80% range. Other automobile-ion chemicals such as Li-titanate (better cycle resistance, fast loading characteristics, but lower energy density) or Li-Mangan are less demanding in terms of voltage measurement accuracy than LifePO4 cells. From a semiconductor component perspective, it is important to follow the ISO26262 design flow to design for integrated error compensation technology. Furthermore, accurate evaluation of product parameters requires accurate evaluation of product parameters.

B. Battery Monitoring

The core Parameter of themonitoring circuit is the battery monitoring IC. Inthis case the newly developed AS8505 by Austria microsystems was used. It is the first IC thatfeatures an integrated active cell balancing method,which has been described as the Module-to-Cellmethod in Section IV. This monitoring IC is directlycommunicates with a microcontroller by SPI busand various digital I/O lines. The main role of themicrocontroller is to enable the communicationbetween the monitoring IC and the PMU via CANbus, control cell data acquisition and monitoring thebalancing process.

Therefore, it is sufficient to usean 8-bit microcontroller, an ATMEL AT90CAN128in this case, The functions demanding morecalculation power (e.g. SoC, SoH and SoF) areimplemented at the PMU board, which uses a 32-bitInfineon TriCore TC1797 microcontroller. ThePMU gathers the information from all the MMUs andthe current sensor in order to generate a precisedestimation of the battery status.Thebatterymanagement circuit can be seen at the front,whereas two modules with their monitoring circuitare visible in the back.

C. Temperature Management

distribution in electric vehicles is indeed a critical challenge inthe industry. Efficient power distribution is extremely important in minimizing power losses and preventing abuse without proper power sources. The total system power can be significantly reduced.Furthermore, the utilization ofdifferent electronic devices, inconsistent functioning ofmachinery, and an unstable power source. can all contribute toreduced effectiveness to the battery energy storage system(BESS). Therefore, effective power management is crucial toensuring reliable and stable power distribution in electricvehicles. Efficiently managing the supply and power controlwhile charging Electric Vehicles (EVs) is a smart andadvantageous approach. It involves precise power regulationand management, considering variables like State of Charge(SOC), State of Health (SOH), and aging to enhance systemprotection, lifespan, and effectiveness. This strategy proves tobe successful in minimizing power wastage and upkeeprequirements by implementing automated control andsupervision of EV systems. Additionally, it is important tokeep the Lithium-Ion Battery (LIB) within a safe temperaturerange to avoid explosions.

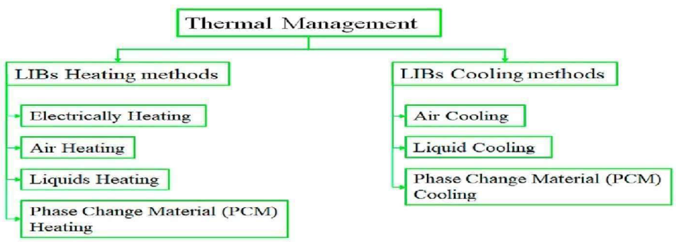


Fig. 3 Thermal Management

IV. SAFETY CHARACTERISTICS ANALYSIS OF CHARGING EQUIPMENT

A. Charging Equipment Structure

Electric vehicle batteries can be divided into the batteries and fuel cells. Among them, fuel cells are very rarely used to supply the power for the electric vehicles. Most electric vehicles usesthe batteries to supply the power into the load. It has the advantages of high power density, high energy and long life. In this paper, from the battery charging safety point of view, electric vehicle charging safety can be divided into four aspects: power grid side safety, charging equipment side safety, vehicle side safety and platform side system safety. Through the power grid side and charging side two angles are to carry on the detailed analysis, which makes the charging safe and faster. Among them, the charging of electric vehicles affect the power quality of the power network, and produce about 6K of harmonics, which lead toloss of the power network, affect the life of the equipment and interfere with the circuit, and then it affect the normal operation of the equipments. Therefore, only through avoiding these type effects for the impact of electric vehicles on the power grid is minimized.

B. Analysis on the Safety Scheme of New Energy Vehicle Charging

The problem that electric vehicle should be needed to notice and solving in the process of development is the charging safety. The quality, operation standard and management of charging equipment during charging are the main factors in affecting the charging safety. From the charging equipment point of view, the fire treatment of charging equipment itself cause the charging vehicle to catch fire in the time. In this paper, the battery charging safety of electric vehicle is analyzed. The statistical examples of public data show that most of the charging accidents of electric vehicles are universal and involve various aspects, including the accidents caused by many of the reasons, such as power grid side, charging equipment side, vehicle side and platform system "Fig. 4". It correctly analyzes and finds responses. It has become a serious problem for electric vehicle users. If it is not handled properly within a specified time, it will threaten the life and property safety of users. Figure 4. Out of control protection model According to the typical values of power cell voltage, current, battery temperature, the threshold upper and lower limits of its normal working range which is set in the fault index.

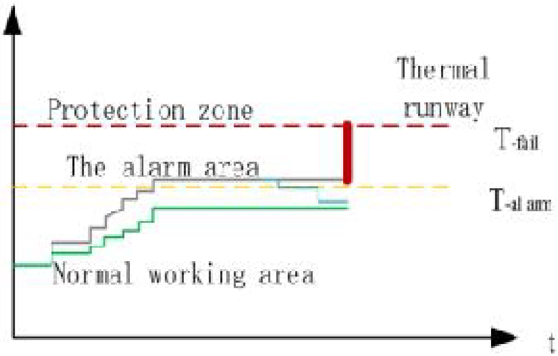


Fig. 4Out of control protection model

C. Charging Safety Response

As a special electric load, electric vehicle battery chargingshould be consider the safety factors of charging. Thelarge-scale charging of electric vehicles is concentrated inthe distribution network, and its impact on the power systemis mainly reflected in the distribution network. Differentregions having different loads, and its impact on distributionnetwork is different.

Battery state detection by measuring the different parameters suchas single voltage, total voltage, current, temperature,insulation resistance of the battery system.the measurementaccuracy and frequency should meet the nationalstandardrequirements under both conventional and severe extremeconditions (Table 1)

Parameters	Performance indicators	Remarks
Single voltage	±0.5% FS	±10mV Max
Battery temperature	±2℃	-20℃~60℃
Total pressure	±2% FS	±5V Max
Current	±2% FS	Lithium ion
Insulation detection	±20%	More than 400V

TABLE I. VARIOUS PERFORMANCE INDEXES OF ELECTRIC VEHICLEBATTERY

V. LITERATURE SURVEY

A. Battery Energy Storage System (BESS) and BatteryManagement System (BMS) for Grid- Scale Applications

Due to the discrepancy between the quantity of energy consuming users and the amount of energy generated by the generation sources, the current electric grid is an inefficient system that wasted a considerable amounts of the power it generates. In order to assured to the adequate power quality, power plants are often produces maximum energy than is required. Many of these inefficiencies can be eliminated by making the use of the energy storage that is already exists inside any grid. To accurate monitor and regulate the storage system while using battery energy storage systems (BESS) for grid storage, comprehensively modelling is needed. The storage system is controlled by a battery management system (BMS), and a BMS that makes use of sophisticated physics-based models will enable considerably more reliable operation of storage system.

B. A Battery Modular Multilevel Management System (BMS) For Electric Vehicles and Stationary Energy Storage Systems.

Although the many of energy systems on batterystorage systems are constantly growing, there are stillmany number of issues that are need to be resolved. Currentbattery systems are rigid; only cells with the sameelectrical characteristics may be coupled; and cellflaws significantly shorten the lifespan of the entirebattery or even triggering a system blackout. Additionally, system’s weakest cell restricts thesystem's maximum useful and maximumcharging current. Current Battery ManagementSystems (BMS) are able to enhance the maximumuseful charging current as well as the useablebattery capacity tosome extent.

A very adaptable,fault-tolerant, and economical battery system can bedeveloped with the help of the Battery ModularMultilevel Management System (BM3) described inthe workWith the current setup.

C. A Battery Modular Multilevel ManagementSystem (BMS) For Electric Vehicles AndStationary Energy Storage Systems

The dependency of the energy systems on batterystorage systems is constantly increasing, but thereare still many unsolved problems. Current batterysystems are unflexible, only cells with the sameelectrical parameters can be combined, and celldefects causes a high reduction of the overall batterylifetime or even a system blacked out. In additionally, themaximum usable capacity and the maximumcharging currents are limited to the weakest cell inthat system. Current Battery Management Systems(BMS) can increasesd the usable battery capacity tosome extend and are abled to enlargen the maximumusable charging current. With the Battery ModularMultilevel Management System (BM3) presented inthe paper, a more flexible, fault tolerant, and costefficientedbattery system can be implemented. Withthe system it is possible to established either serial orparallel connections between neighbouring cells orto bypasses a cell. Thus, the cells are operatedaccording to their needs and their state of charge(SoC). Separate balancing means for balance thecells SOC, however, its become obsolete.

D. Battery Management System Via BusNetwork For Multi Battery Electric Vehicle

This paper proposes multi-battery design of batterymanagement control using bus communicationmethod based on loop shaping. The experiment ofproposed method showing that the capacity dynamicsof batteries has been improved. The multiples ofbattery controlling system are implemented in electricvehicle's modelling, and we modified the origin controlsystem by using buscommunication method autotuning based on loop shaping. The result of themodified control system using bus method based onloop shaping are shown in the implementation of designresponse of the battery management that the price of reliability are improved. However, this methodcan maintain the error steady state to be zero.

E. Traditional battery charging approaches

There are several traditional stress approaches to solve the battery charging problems at many destinations and termination conditions. Figure 5 showing the four traditional charging approaches where the battery are loaded into the electric vehicles. These typical approaches can be categorized primarily as CC loads (constant power), constant voltage (CV), constant power loads with constant power and loads (CC-CV), and multi-stage level (MCC) MCC loads. Below we focus on the loading approaches of CCCV and MCC. The CC will be end when the time reaches at a predefined threshold. This loading approach was first introduced to load NICD or NIMH batteries [10] and is also commonly used in Li-ion batteries [11]. However, batteries behaviour are highly dependent on the current rate of the CC shop. Therefore, the very biggest challenge of the CC charging approach is to look for a corresponding charge current that can be compensated for the use of battery load speed and the capacity. For large power rates in CC stores, charging speeds will be improved, but the age of the battery is vary accordingly. The less power speed of the CC load reaches at the load rate at high capacity, but the battery lighting speed slows down to the low current speeds, continuing to affect the convenience of using Electric Vehicles.

Battery type	Charging performance
Li-ion	1) High temperature can improve charging speed but damage to battery lifetime; 2) charging is dangerous at pretty low temperature, well below freezing
Lead acid	1) Higher temperature leads to lower V-threshold by 3 mV/°C; 2) charging at 0.3 C or less below freezing
NiMH, NiCd	1) Charging acceptance decreases from 70% at 45 °C to 45% at 60 °C, respectively; 2) 0.1 C charging rate between −17 °C and 0 °C; 3) 0.3 C charging between 0 °C and 6 °C

Fig. 5 Charging Performance for the Various Batteries

The battery charging speed of the CC-CV approach is primarily determined by the constant power speed, but the capacity utilized of the battery wheel is primarily influenced by a constant tension and the final value. The constant speed of the CC-CV is allow a high electric speed values to reduce the efficiency of lithium coatings in the energy conversion, allowing the battery temperatures to exceeds acceptable values, especially in the high-performance applications. On the other hand, a less charging current are reduces the battery load speed and reduces the convenience of using an EVs. Therefore, it is highly important to design a very suitable CC-CV approach to improve total charging capacity and to ensure battery safety. This approach was successfully developed to load many battery types, including lead acid batteries [12], NIMH batteries [13], and Li-ion batteries [14].

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F. Optimization of battery charging approach

Based on the traditional standard loads, many optimized charging approaches have been recently developed to improved the charging capacity of the EV batteries. The optimization of these load approaches can be divided into four main fields, as explained in Figure 6. The first field is CV shop optimization. Several approaches continue to improve the charging capacity of standard CV loads. These approaches take into their account targets such as load speed and temperature fluctuations in the battery. By adapting the power and speed of the proposed approach, a less rise in the battery temperature of the overall load process is achieved. Lee and Park [16] proposed a fast charging control scheme at the CV level, based on their internal battery frame. Compared to the standard resume transactions, developed testingprovides the faster battery charging speeds.

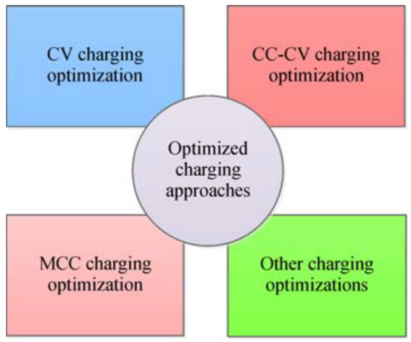

Fig. 6Optimizing the battery load approach for EVs

For CC-CV charging optimization, the key optimalelements are current rate in CC phase and constantvoltage value in CV phase. A number of researches is toimprove the CC-CV charging approach have beendeveloped recently. In Ref. [19], a cycle of controlling algorithmassociated with zero computational method are proposedto optimize the CC-CV profile of the Lithium-ion battery. Thisimproved battery charger is validated is to drive the CC-CVprocess accurately and smoothly. In Ref. [20], a closedformapproach to search the optimal charging strategy for aLi-ion battery is to proposed. Afunction which considersthe charging time, energy loss and temperature rise is usedto acquire the optimal CC-CVcharging profile. Hsieh et al.[21] designed a controller to improve the performance of theLi-ion battery in the CC-CV charging. The general CV modeis is to replaced by two modes: Sensing and charging. Then thefaster charging trajectory can beachieved. In Ref. [22], abattery charging function with three objectivesincluding charging time, energy loss and temperature riseespecially the battery internal temperature is presentedon the basis of a coupled thermoelectric model. Then theTeaching learning-based optimization (TLBO) method isapplied to balance The three conflicting objectives, further toobtain an optimal CC-CV pattern for the Lithium-ion battery.

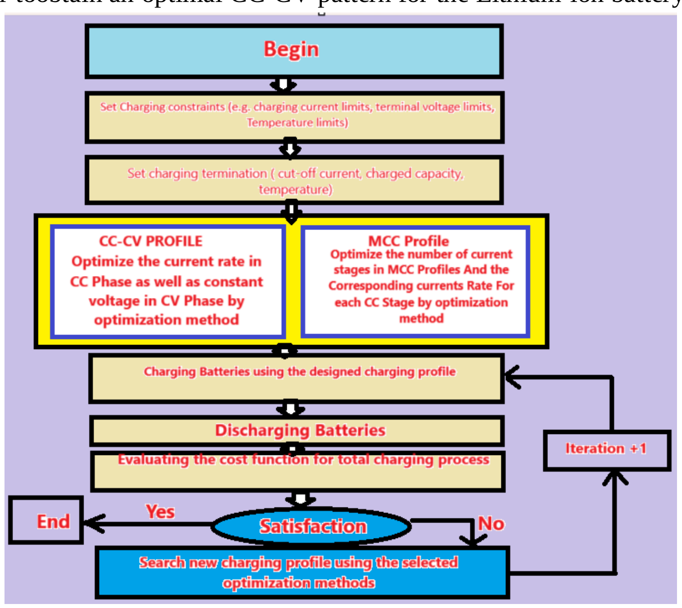

Fig.7 Summary of improvements to the CC-CV/MCC charging approach

In Ref.[23], a model-based strategy was proposed to optimizeCC-CV charging pattern for the Lithium-ion battery management.The desirable trade-offs among the charging speed,energy conversion efficiency and temperature variation canbe achieved based upon the multiple-objective bio-geographybasedoptimization (M-BBO) approaches. Then the currentregions is to efficiently equilibrate these key objectives arealso identified.

For MCC charging optimization, the main and challengingtargets is to determine the number of current stages inMCC profile and the corresponding current rates for eachCC stage. One popular approach to improve MCCcharging performance is the fuzzy logic technology. InRefs. [24,25], the fuzzy logic controller is utilized toconvert their charging quality characteristics into a single layer fuzzydual-response performance indexed, and a five-stage MCCcharging pattern is optimized to improve the chargingefficiency. In Refs. [26,27], the fuzzy logic control isadopted to regulate the weights within the functionsof Lithium-ion charging process.

G. Outcomes

The BMS serves a significant function inmonitoring the battery's condition and guaranteedsafely charging and discharging phenomenon in the electric car batterysystems.BMS should have temperature monitoring, cellbalancing, overcurrent protection, fire suppressionsystems, and containment systems in order toprevent the potential risks like thermal runaway, inefficiency andfire.

Using the automatic fire extinguishers and coveringthe battery cells with fire-resistant materials are twoexamples of the fire safety strategies that canincorporated into the BMS design.By preventing overcharging, undercharging, or overdischarging, which can damage the battery and shortenits lifespan, the BMS should also be made toincrease battery life.Different types of designs and tactics for BMS with chargemonitor and fire protection measures, such as firedetection and suppression systems, over currentprotection, cell balancing, and temperaturemonitoring, have been offered in various research.

VI. METHODOLOGY

The methodology can be structured as follows:

1) System Design and its Architecture
2) Charge Monitoring Implementation by Voltageand Current Sensing
3) Fire Protection Strategies and Early DetectionSystems.

Two buttons for selecting fast and slow charging ofbattery. Based on selection, battery will charge fastand slow by current controlling. If more current are allowed with fasat charging switch,then battery will chargefast and vice versa. Thirdbutton is for discharging battery by enabling the load.Here we used a motor as load. If battery getsfullycharged then charging will be disconnectedautomatically. While charging or discharging ifbattery temperature increased a preset valuethen load willdisconnected automatically. All this operationinformation like voltage, current and temperaturevalues willbe displayed on 16x4 LCD display.

The Block Diagram for Proposed system is shownin Figure 8.

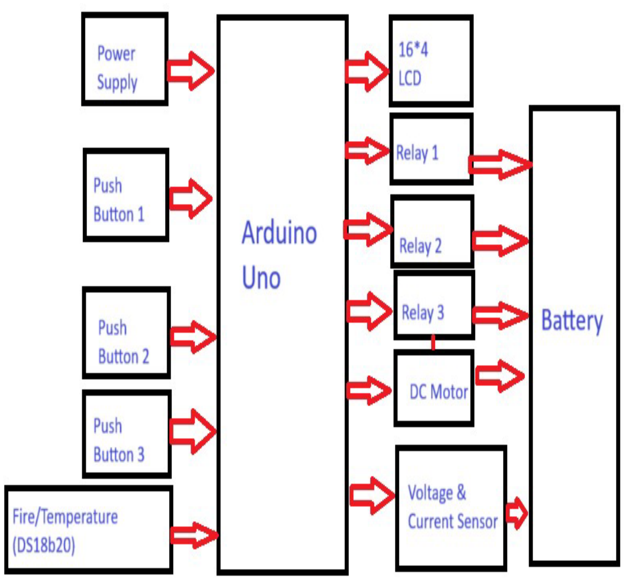

Fig. 8

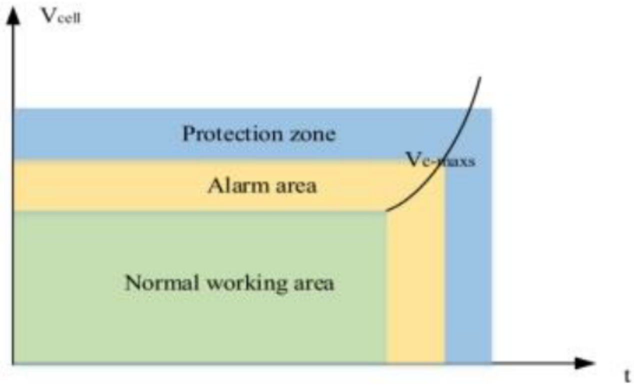

Fig. 9Battery Overvoltage Protection model

VII.CONCLUSION

Key technologies in the BMS of EVs have beenreviewed and defined in this paper, especially in the fields ofbattery modelling, state estimation and batterycharging. In conclusion, an essential part of electricvehicles that guarantees the security, dependability,and longevity of the battery pack is the EV BMSwith charge monitor and fire protection. Bysupplying the crucial safety features like temperaturecontrol, fault detection, cell balancing, and fireprotection, the system reduces the possibility ofbattery fires and enhances the overall efficiency ofelectric vehicles. In order to improve the featuresand capabilities of EV BMS with charge monitorand fireprevention, more research and developmentis still possible. A few potential future work areasinclude enhancing theprecision and dependabilityof battery monitoring systems is to deliver moreacerated and timely data regarding the charge,health, and function of the battery pack.

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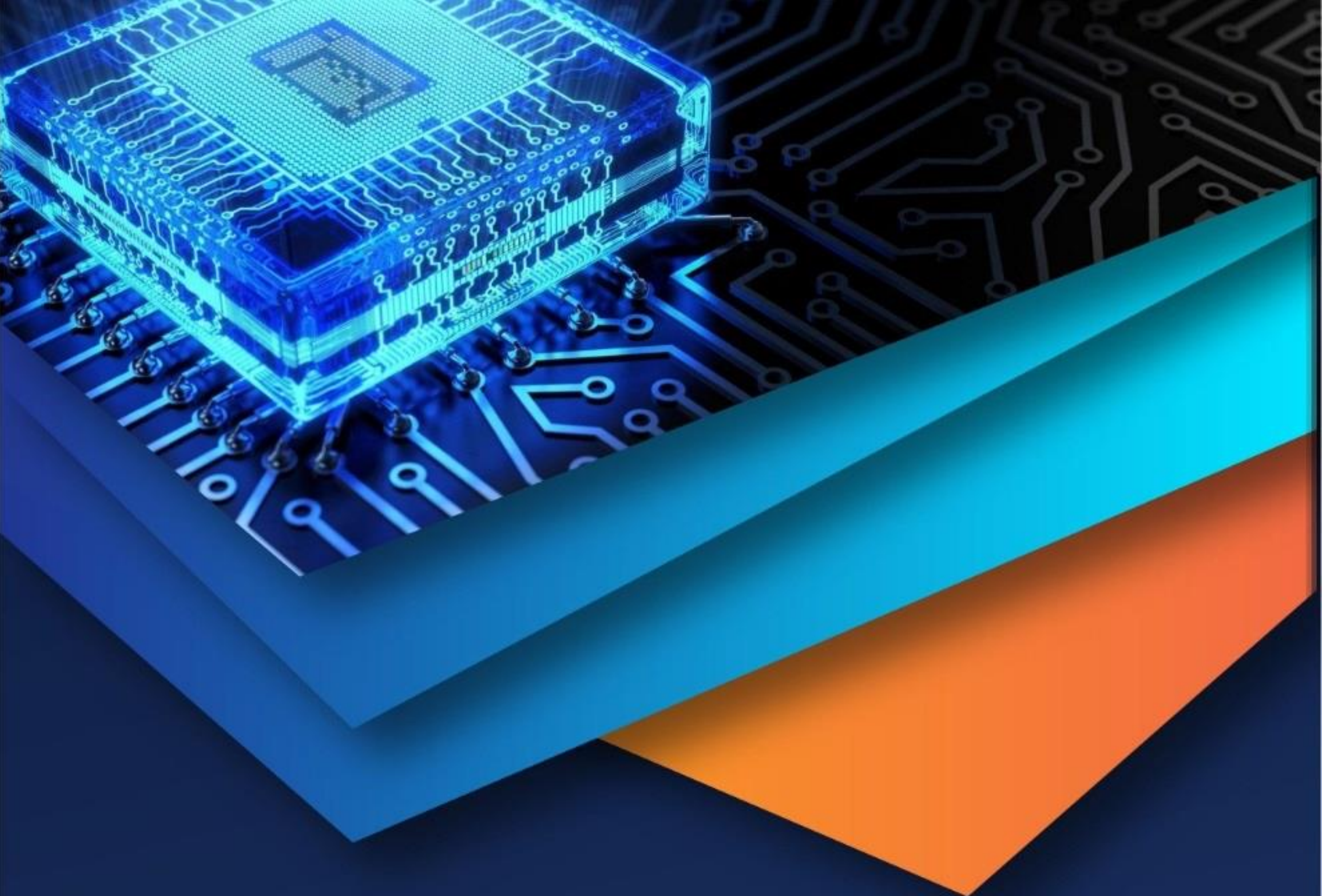

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