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Design and Analysis of IoT-Based Battery Management and Monitoring System for Electric Vehicle

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Abstract

The growing popularity of electric vehicles (EVs) on a worldwide scale led to further research to monitor their performance. The use of internet of things (IoT) technology will make it easier to integrate the automated real-time monitoring system with the current EV technology. The great majority of EVs use rechargeable lithium-ion batteries. Use of lithium-ion batteries creates an overcharging situation in the battery, which significantly decreases battery life. It also increases the possibilityof disastrous safety risks due to fire. This paper develops an IoT- based battery management system (BMS) to minimize hazardous situations. The proposed BMS notifies the user about the condition of the battery in real time.

Key words— *Internet of Things (IoT), Battery life, EV user interface*

I. INTRODUCTION

In today's world, utilizing green vitality is getting to be increasingly significant. As a result, a few producers are looking for elective vitality sources to gasoline when it comes to both individual and open transportation. Less contamination may result from the utilization of electrical vitality sources, hence improving the environment. In expansion, EVs offer considerable benefits in terms of vitality preservation and natural security.

EVs are presently the foremost naturally neighborly alternative. EVs are being created as a potential way to achieve this driven objective of making a cleaner environment and empowering better modes of transportation. Employing a BMS and cell adjusting in each lithium-ion battery cell can resolve this issue. When an EV's battery is exhausted, it is about inconceivable to find the closest charging station. To coordinate a GPS framework into us extend to transmit the closest area by means of a versatile gadget interface [1]. Each battery cell is followed and overseen to dodge any cheating or over-discharging of the batteries. Control BMSs, both equipment and computer program, have been created. A suitable BMS is fundamental for guaranteeing the secure and reliable operation of batteries in a few tall- control applications, such as electric cars (EVs) and half-breed electric vehicles (HEVs) [2]. A battery's cells may be lopsided in several ways, including state of charge (SOC), self-discharge current, inside resistance, and capacity. Inactive and dynamic adjusting topologies can be utilized to broadly classify adjusting topologies [3]. Li-ion batteries are the foremost reasonable alternative for accomplishing evenhanded and proficient transportation for economical worldwide improvement. Due to the changed battery charge-discharge behaviors at diverse temperatures and the truth that battery temperature. It is fundamental to identify and control the temperature of the battery pack [4]. BMS has checked and controlled the charging and releasing forms of the battery pack. Within the charging prepare, the BMS sets the charging parameters and charging mode, and within the releasing handle, the battery BMS controller gets the voltage and state of charge of the battery pack [5]. The battery pack of EVs frequently comprises of hundreds of battery cells coupled in arrangement or parallel to meet the tall control and tall voltage necessities of the vehicles [6]. Utilizing remote communication, analysts made a battery observing framework for UPS to distinguish dead battery cells [7].

A BMS is basic for guaranteeing security and expanding the valuable life of Li-ion battery packs [8]. The charging of EVs ought to be done in a adjusted way, taking into thought earlier encounter, data-mined meteorological data, and reenactment methods. To put through electric vehicles and renewable energy sources to savvy networks, this proposed savvy electric vehicle charging system leverages vehicle-to-grid (V2G) innovation [9]. Considering the foremost potential substitutions for bringing down CO2 outflows and the around the world natural challenges, EVs have as of now gotten broad acknowledgment in the car industry. Lithium-ion batteries have pulled in extraordinary intrigued for utilize in EVs due to their invaluable characteristics, which include their light weight, rapid charging, tall vitality thickness, moo self-discharge, and amplified life expectancy [10]. Utilizing IoT, a system can effectively be observed and controlled remotely [11- 16]. IoT based brilliantly battery administration arrangement for electric vehicles Lithium-ion batteries have found far reaching utilize in shopper gadgets due to their predominant vitality thickness, control thickness, benefit life, and natural invitingness in comparison to other routinely utilized batteries. Be that as it may, lithium-ion batteries for vehicles have high capacities and huge serial and parallel numbers, which, in conjunction with security, solidness, and fetched issues, confine their broad sending within the vehicle industry [17–20].

The most objective of this paper is to plan and screen BMSs of EVs. It'll be utilized to improve the vehicle's battery wellbeing. Checking frameworks will routinely screen distinctive wellbeing parameters, e.g., voltage, current, and temperature. The microcontroller will control frameworks, and a GSM module will help send data to the backend server. An LCD show is associated to the device to appear the status of the sensors. A portable application is created to check the status remotely.

Section II portrays the proposed show of BMS; Segment III appears the equipment and computer program execution models. The result and examination are displayed in Segment IV. Area V concludes the paper.

2.PROPOSED MODEL

The proposed framework engineering is displayed in Fig. 1. It is composed of photovoltaic (PV) board, charging framework, proposed BMS framework and IoT-interfaced app. The PV board produces DC voltages within the nearness of daylight and transmits vitality to the framework. The vehicle's Lithium-ion battery is charged by an EV charging station and controller as appeared in Fig. 1. For the PV source, to begin with vitality must be put away in a battery. PV isn't as effective as characteristic powers, so it must be stored when sunshine produces electricity. So, it'll be put away within the battery to be utilized amid the request [21]. In electric vehicles, the essential work of the BMS is to identify the battery sort, voltage, temperature, capacity, state of charge, control utilization, remaining operational time, and charging cycles. Through a committed interface, the created framework can give real-time data to EV clients with respect to the closest charging station with the briefest holding up time and the least charging taken a toll, as well as a secure online get to component for getting to the EV's State of Charge.

Fig. 1. Block Diagram of Proposed Battery Management System for Electric Vehicle.

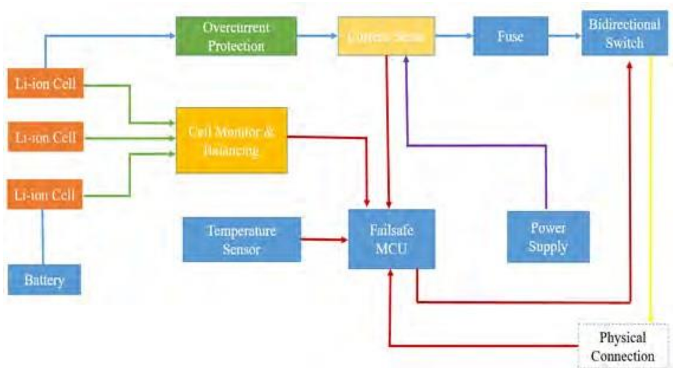


Fig. 2. Flowchart of BMS in EV

EVs are fueled by high-voltage batteries. To guarantee the safe operation of the battery, the BMS screens variables such as temperature, input and yield current, and voltage over the battery packs as appeared in Fig. 2. Checking the current streaming towards the battery pack anticipates cheating. The BMS is additionally dependable for calculating the State of Wellbeing (SoH), which shows the battery's remaining capacity. BMS continuously screens temperature and conducts warm administration obligations. It measures characteristics such as normal, admissions, yield, and person cell temperatures. In BMS actuates cooling framework to the gadgets when the battery gets to be overheated. BMS can interface with the vehicle's Electronic Control Units. The central controller of the BMS interfaces with the cell well's inner equipment or with outside equipment.

It transmits data approximately the battery parameters to the engine controller so that the vehicle can work productively.

A flowchart of the battery charging unit is appeared in Fig. 3. To begin with, Initialize and set the voltage esteem on the Arduino. At that point Arrange the baud rate to empower communication between the Arduino and the computer. After setting up the Amp hour of the Li-ion battery that will be associated to the analog stick of the Arduino, the comparing computerized esteem (ADC Esteem) is recorded in the analog-to-digital converter (ADC). The remaining battery utilization hours will be decided based on the upgraded battery status. The fetched of charging will shift based on charging separate and length.

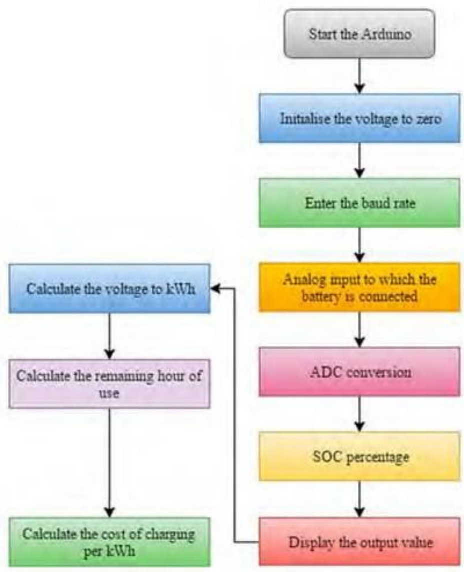


Fig. 3. Battery State of Charge estimation flowchart

II. SIMULATION AND HARDWARE PROTOTYPE ANALYSIS

A schematic recreation of the proposed demonstration for battery administration and observing frameworks for EVs appears in Fig 4.

Concurring to the show circuit, it is being actualized in Proteus computer program. The reenactment demonstration combines all the electronic components, counting a voltage and current sensor, a temperature sensor, a gas sensor, and a hand-off security, to distinguish the battery's wellbeing state. In any case, the IoT integration was actualized autonomously in this equipment. The sun-based framework was physically modified into the program, and the DC supply of the framework was changed to an AC source. the Sun oriented Framework taken after. Voltage sensors are handcrafted, and three current sensors (ACS712 30A models) are utilized to demonstrate or show the voltage and current at whatever point a disappointment of any sort happens.

current level and maximizes the battery pack capacity. The temperature sensor fulfills the part of warm administration by persistently checking the temperature. It measures parameters such as the cruel temperature. When a warming issue is created and the normal temperature constraint is surpassed, an caution will sound to diminish the temperature. To diminish the temperature, interface the 5V colling fan to the battery and enact the hand-off to turn it on consequently. The fan will turn off consequently when the temperature is ordinary or normal. Utilize the 16x2 LCD show that demonstrates the rate of charge within the battery and the greatest run that can be accomplished with this charge.

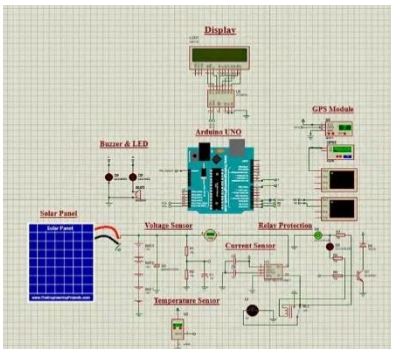


Fig. 4. Simulation Schematic for proposed design

Display the actual voltage and charging station location in this study, cell balancing is used to utilise these sensors,a technique that extends the battery's life, creates an equal voltage and when charging is required.

All the Sensors collect information and transmit it to the Arduino Uno. This Arduino UNO transmits Framework Information to ESP3266 through the Wi-Fi module utilizing serial association. In this framework, ESP8266 and Arduino IoT Cloud are utilized to make a Battery Status Observing Framework utilizing the Web of Things, this venture can specifically inform individuals. The client can too remotely check the battery status of their smartphone or computer. And this Arduino Uno serves as the project's brain. With a pin that's clarified within the coding area. Within the reenactment stage, the whole operation will run by uploading the hex record to the mega.

The selection We create a recreation demonstration to assess the proposed IoT-based BMS beneath different working conditions and usage scenarios. The reenactment permits us to survey the system's execution, vitality productivity, and unwavering quality in virtual situations. By analyzing information collected from the recreation, we are able to refine the plan parameters and optimize the calculations utilized for battery administration.

Hardware Prototype:

Electric vehicles (EVs) is developing quickly, emphasizing the requirement for productive battery administration and checking frameworks. In this think about, we propose an IoT-based arrangement for overseeing and observing EV batteries, combining reenactment and equipment model examination. The framework points to optimizing battery execution, amplify battery life, and improve client security by giving real-time information on battery status and wellbeing.

The move to EVs is pivotal for reducing greenhouse gas outflows and reliance on fossil fills. In any case, the execution and life span of EV batteries are basic components affecting customer acknowledgment and advertise development. Conventional battery administration frameworks (BMS) need real-time observing capabilities and may not completely utilize the potential of IoT technology. Hence, there is a requirement for an integrated approach that combines IoT network with progressed battery administration methods.

Simulation Model:

To approve the viability of the proposed framework, we implement a equipment model for real-world testing. The model joins sensors for measuring key battery parameters such as voltage, current, temperature, and state of charge (SoC). These sensors are associated to a microcontroller unit (MCU), which processes the information and communicates with the IoT stage by means of remote network (e.g., Wi-Fi).

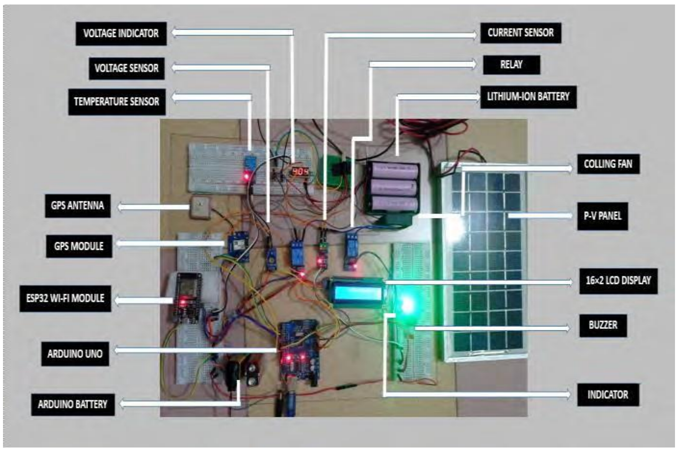


Fig. 5. Implemented Testing Hardware

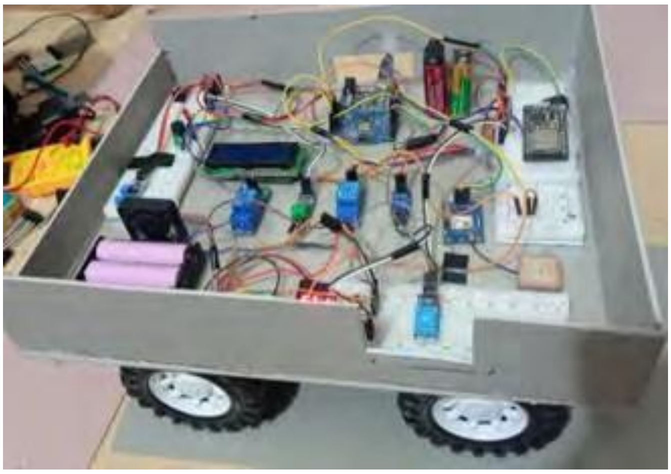


Fig. 6. Proposed hardware design (Exterior)

III. RESULT ANALYSIS

Initialization of the EV is appeared in Fig. 7. The method of beginning the framework when the EV State and other values are shown on the show. There will be no caution on the take note location when the Arduino Uno is powered on, but it'll be shown on the LCD display.1

Fig. 7. Reading from hardware at initial stage

An outline of the battery administration framework for electric vehicles where each information component has its claim noteworthiness, such as battery data, PV data, and the sending out of sun-oriented vitality to the lattice as appeared in Fig. 8. After the framework has been introduced and associated to the battery and sun powered board, the battery's charge rate will be displayed on the LCD show for the whole framework. The real voltage supply of the vehicle can be decided by interfacing the voltage sensor to the battery. The voltage sensor synchronizes the voltage in each battery cell and measures the transmission voltage. The real current of the battery can be measured. The current sensor measures the current stream and equalizes the current in each battery cell. when the temperature sensor was associated to the battery. This temperature sensor screens the temperature ceaselessly and performs the function of warm administration. This framework will educate the client and show the adjacent area on the LCD show.

TABLE I

BATTERY VOLTAGE MESUREMENT

SN	Voltage Sensor	Multimeter	Accuracy
1	3.79	3.70	94%
2	3.68	3.67	99%
3	3.68	3.62	93%

TABLE II

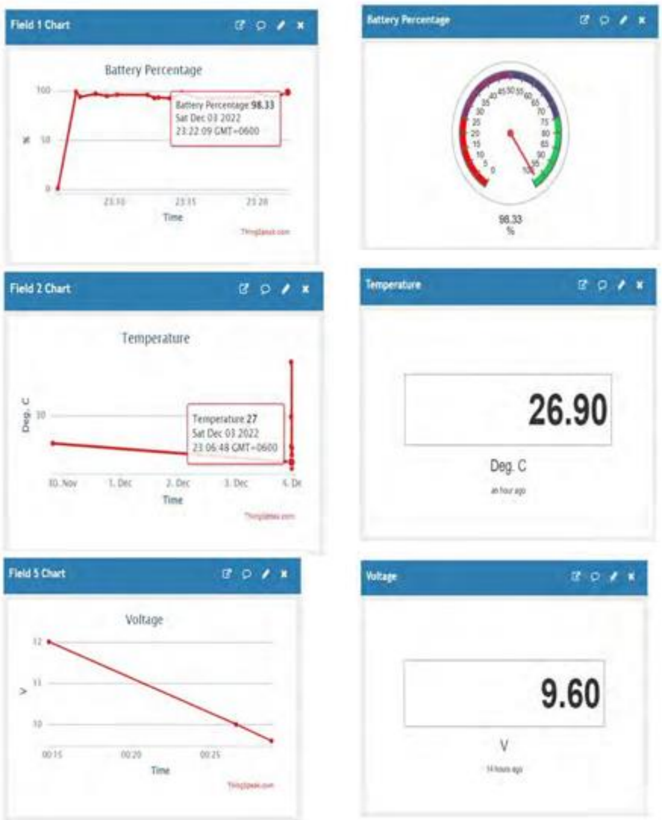
BATTERY CURRENT MESUREMENT

SN	Current Sensor	Multimeter	Accuracy
1	0.48	0.37	88%
2	0.42	0.34	91%
3	0.10	0.9	99%

when the modified ac supply is utilized. The measured voltage and precision of the framework amid the testing period is appeared in Table I. Battery life requires uncommon thought in EV applications. Inaccurate operations, such as current stream, too much tall or moo temperatures, cheating, or releasing, will drastically quicken the battery's degeneration. Table II speaks to the lithium-ion battery stack current passing through the proposed circuit passing through the proposed circuit.

Fig.8. Data of battery charge, voltage, current temperature in LCD Display

A.IoT Interface for battery monitoring



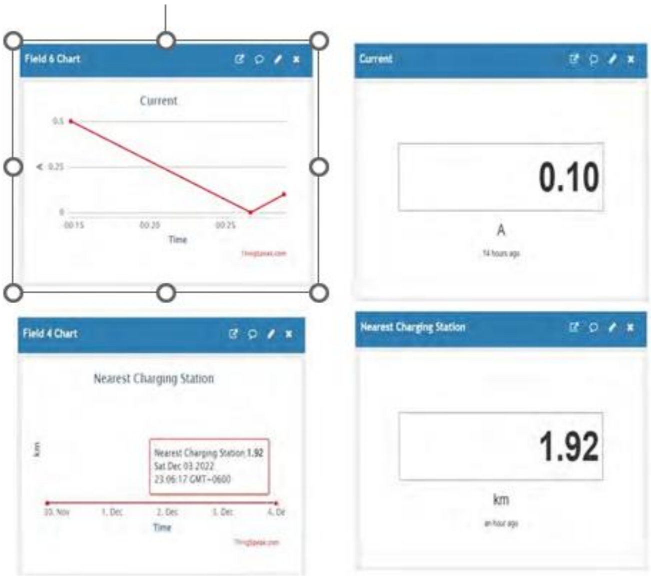


Fig. 9. Battery monitoring interface in Mobile Applications

The proposed framework can screen the battery condition expressed within the proposed show utilizing an Android smartphone appeared in Fig. 9. Client can screen the charge, voltage, current, closest charging station in a graphical client interface both in chart and numerical see.

B. Electric Vehicle User Interface

Also, the battery checking framework incorporates a web- based client interface. The client interface can screen the areas and conditions of numerous batteries observing gadgets. interfacing batteries In this manner, the plan of the client interface has considered the prerequisite to screen the conditions of different batteries.

The login page of the versatile applications permits clients to get to the applications by entering their username and watchword appeared in Fig. 10. It can too be available by verifying with a social login. In expansion, the apps permit us to enter both authorized clients and login work which will be utilized to form substance lightness.

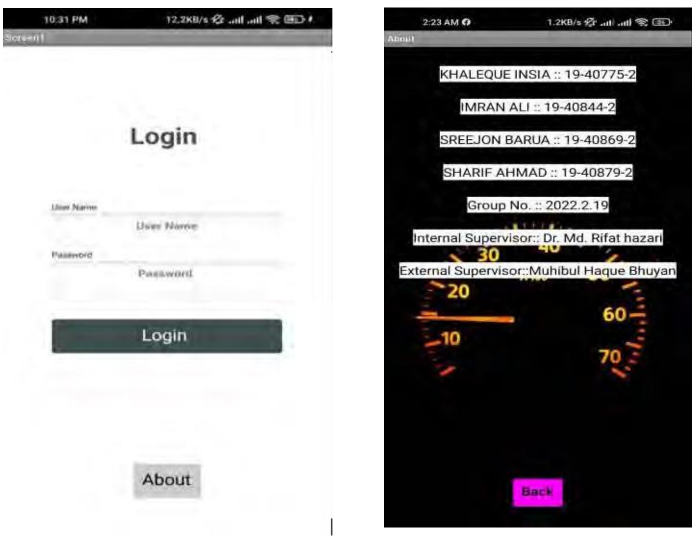


Fig. 10. Login interface and home page of the apps

Fig. 11 appears that when a charge is required and the battery charge is mood, the shrewd electric vehicle will give the surmised location of any charging stations. This framework can be utilized to form installments in numerous ways for battery charging costs, counting through the versatile keeping money framework utilizing their client ID on the portal, and they moreover have the choice to utilize charge or credit cards appeared in Fig. 12. Within the past few a long time, there has been a noteworthy distinction between customary electric vehicles and more current models. The electric vehicle framework has been making strides from routine to present day. Advanced frameworks permit clients to see the comes about by means of smartphone applications.

Fig. 11. Low Charge alert in mobile app

In this framework, Android application appears the rate of charge and battery status of electric vehicles, as well as some alerts and a chart of expended units. Since this intelligent electric car is directional, the meter can screen both PV and framework voltage and consumed and traded units. In this manner, IoT highlights were connected to move forward this extend.

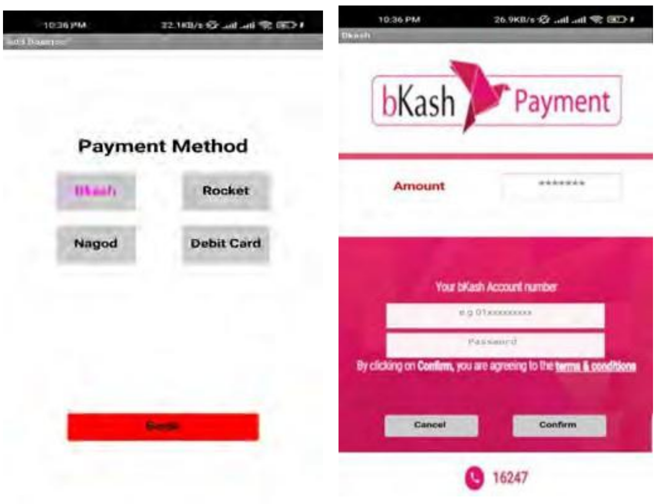


Fig. 12. Charging cost payment system via mobile app

The key work of a Lithium-ion battery is to supply power when other producing sources are inaccessible; thus, batteries in frameworks will encounter persistent charging and releasing cycles. All battery parameters are influenced by battery charging and reviving cycle. The well-known condition underneath is utilized to calculate the control.

Power (W) = Voltage (V) x *Current (A)*

In In this paper, three lithium-ion batteries with 3.7V, 2000mAh or 2 Ah packs are in arrangement association and get 12V and working current 6 Ah for this framework. charging current ought to be 10% of the Ok rating of battery. So, 12V, 6Ah battery = 10% of 6Ah = 6 Ah x (10 ÷ 100) = 0.6 A. Considering 0.12A for charging misfortune. So, add up to charging current= 0.72A Battery charging time (hour) = Battery capacity /Charging Current.

Battery releasing current = 10% of 6 Ah = 6 Ah x (10 ÷ 100) = 0.6 Ah. So, add up to releasing current = 0.6 A. So, the battery charging and releasing misfortunes are 0.12 or 20%.

The SOC of lithium-ion batteries is between and 1. Beneath perfect conditions, when the charge runs out, the SOC = 0; for a completely charged unused battery, the SOC = 1. In case the initial charge within the battery is known, from at that point on "Coulomb Tallying" can be utilized to calculate its SOC. For 6A current into a battery, for 2 hours, will include 2 * 2 = 4 Ah to the battery charge. The full battery capacity is 6 Ok, that will increment its SOC by 4/6 = 0.67.

Lithium-ion batteries are profound cycle batteries, so they have profundity of release (DoD) around 95%. It demonstrates the rate of the battery that has been released relative to the general capacity of the battery. The charging effectiveness is the proportion between the vitality expended by the charging handle and the energy spared by the battery. Greenhorn completely charged battery features a DOD of 100%; a maturing battery, even if completely charged, cannot reach 100% beneath diverse charge and discharge conditions.

The entire process takes a sometime and amid this time there is an electric current through the interfacing wires and the battery. Lithium batteries charge at about 100% efficiency, compared to the 85% efficiency of most lead acid batteries. This can be particularly important when charging through sun oriented once you are attempting to press as much proficiency out of each amp as conceivable some time recently the sun goes down or gets secured up by clouds.

IV. CONCLUSION

The proposed method can reduce user discomfort and increase user awareness of inefficient energy usage and environmental degradation. Reduced pollution may result from the utilization of electrical energy sources, thus improving the environment. In addition, EVs offer substantial energy conservation and environmental protection benefits. The battery management system in an electric vehicle, which manages the electronics of a rechargeable battery, whether a cell or a battery pack, is thus a critical element in assuring the safety of electric vehicles. It protects the user as well as the battery by ensuring that the cell runs within its safe operating boundaries. Even though the system is operating as intended, it can be enhanced in the future by implementing an improved version of network communication to receive the data more precisely. A real-time data collection method can help in modeling a battery model as close to reality as possible for analysis, development, and performance enhancement.

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