ISSN: 2249-7196
IJMRR/Jan 2023/ Volume 13/Issue 1/Article No-1/01-15
K.Shivanagireddy/ International Journal of Management Research & Review

Advance Electric Vehicle Battery Protection And Monitoring System With Mobile Application

Dr.K.Shivanagireddy[1]
Aishwarya.Y[2], Lakshmi Harika.R[3], Manisha.A[4]
[1] Professor, Department of Electronics and Communication Engineering
[234]Student, Department of Electronics and Communication Engineering [1]
sivanagireddykalli@gmail.com
yaraaishwarya5829@gmail.com
rangisettiharika@gmail.com
manishaakula123@gmail.com

Abstract—The battery, which acts as the main source of powerand enables supportable mobility, is the essential component of an electric vehicle. Electric cars (EVs) are getting more andmore popular in the current world as petrol prices rise as new concepts have developed as global warming has become a bigissue. As a result of this circumstances, electric automobiles have come into action. Also, EVs have significant economic savings and safeguarding the environment advantages. Because of the safety and functioning of most battery powered vehicles battery monitoring and management arecritical. The main problem which we are facing is that battery is exploding in recent times. A technique for both internal and external battery monitoring is the Battery Management System (BMS).The goal of this proposed system is to prevent exploding EV battery. In this project, we use Node MCU ESP8266, DTH11 temperature and humidity sensors, MQ2smoke sensors, pressure sensors, AES, and binary search algorithms to track the electric car battery. These values are communicated with amobile application that can be accessed by both the vehicle owner and the vehicle manufacturer. When the data exceed thecritical point, a buzzer will sound to inform the vehicle user. The suggestedsystem's algorithm has been tested and verified

Keywords—Node MCU ESP866,DTH11 temperature and humiditysensors,MQ2smoke sensors,Buzzer

I. INTRODUCTION

Electric vehicles (EVs) and their batteries were launched as areplacement for regular gasoline-powered cars to reduce emissions of greenhouse gases and reliance on fossil fuels. Asthe general public's concern over climate change and airpollution grew, various governments around the world beganenacting laws and providing benefits to promote the use of electric cars (EVs) and aid in the advancement of EV battery technology. EV batteries can enable vehicle-to-grid (V2G) technology, in which EVs can hold additional power generated by solar and wind power before releasing it again to the grid during peak demandperiods. These can assist to balance the grid and enhance energy supply dependability. Overall, EV batteries have been created to solve the financial and ecological problems. connected to older petrol engines, as well as to offer a healthier, more effective, and durable method of transportation. As battery development continues and EV costs fall, the use of EVs driven by high- performance, dependable, and secure battery systems is likelyto grow. One of the most significant issues for EV batteries isrange anxiety, or the concern that thepack of batteries may run out of power before reaching its destination. To deal withthis difficulty, electric car makers arealways attempting to enhance vehicle range by boosting battery density and improving aerodynamics as well as engine performance. The need for proper maintenance and security is another problem EV batteries encounter. Complex battery management systems (BMS), which monitor the battery's current charging level, health status, and other crucial data, are installed in EV batteries to ensure reliable and secure operation. The BMS also protects the battery against excessive charging, undercharging, and thermal overload, every single one of which can cause harm to the battery or loss. Despite these obstacles, electric vehicles (EVs) have significant benefits over classic gasoline-powered vehicles, including cheaper running costs, lower pollutants, and improved overallefficiency. As battery technology advances and the need for electric automobiles develops, the future looks bright for broad usage of EVs due to high-performance, dependable, aswell as secure battery systems.

A vehicle that is an electric vehicle (EV) is one that is drivenby a number of battery-operated engines. This could be supplied by a collector system, extravehicular forms of energy, or through a battery (often recharged by sunlight, or through the conversion of fuel to power by fuel cells or a generator). EVs, along with additional upcoming automotive technologies that include self-driving cars, linked vehicles, and shared transportation, comprise the next-generation mobility vision known as connected, Autonomous, Shared, and Electric (CASE) Mobility for highway vehicles. In general, electric cars have come into the world to solve financial, environmental, and technological difficulties, as well as to offera less polluted, more environmentally friendly method oftransportation in future years.

Electric car batteries are bursting for many kinds of causes, including Thermal runaway, failures in manufacturing,battery cell damage, excessive charging, outside heat sources, battery life and degradation. To reduce these risks, Electric vehicle makers use several security measures, including as battery management techniques, thermal control systems, and physicalobstacles to avoid thermal overload as well as other safety hazards. Moreover, industry norms and laws are continually improving to guarantee that EV batteries satisfy the greatest safety requirements.

This proposal is being introduced to avoid the bursting of an electric car battery. In this research, we use sensors for temperature, sensors for humidity, smoke sensors, as well as pressure sensors to keep track of the electric car battery. The results are sent along with a smartphone app that can be accessed by both the person who owns the car and the maker ofthe car. When the data exceed the critical point, an alarm will sound to inform the vehicle user.

II. LITERATURE REVIEW

[1] For the majority of electric vehicles (EVs), battery monitoring is essential because the battery system is in charge of the occupant's safety, functionality, and even life. To circumvent the drawbacks of the solo Coulomb counting approach, the estimate of state of charge (SOC) applying Coulomb measuring and voltage measurement in open circuits methods was developed. To determine SOC, model the batterywith SOC being a single of the state variables, which is then adjusted using the Kalman filtering approach. [2] For most battery-powered vehicles (BOVs), proper battery monitoring and management are essential for operation, safety, and even to increase the lead acid battery's lifespan. In order to maximise BOV utilisation and health, this article aims to investigate battery discharge, specifically for TOTOs in the countryside Bengal, and its relationship with projected km runs. [3] This paper describes a unique adaptive battery model that is based on a remapped version of Randle's well-known lead-acid model. When paired with subdomain estimator approaches, model remapping allows for increased modelling capabilities and exact predictions of dynamic circuit parameters.[4] The state of charge of the closed lead-acid battery has been estimated using a variety of methods. Whereas no technique can anticipate the remaining capacity with certainty. For calculating a sealed lead-acid battery's remaining capacity, a novel equation is offered. The experiments were conducted tosupport the proposal evaluation.

Many topics related to "Extension of battery life via charge equalisation control" are covered in this book. The charging process control method is defined as a two-level approach. An extensive description, the introduction of a unique looping charge equitable distribution approach that improves the even distribution of batteries formed up of long serial strings of cells is followed by a discussion of batteries and charging problems.
[5] Results from simulations and experiments support theapplicability of the equalisation control technique. [6] In orderto conduct cutting-edge research on battery State-of-Health and State-of-Charge, this paper offers a revolutionary battery testing and quantification method. The factors that contribute to decreasing lifetime and the causes of inaccurate SoC predictions must be fully understood in order to improve leadacid batteries. By utilising a versatile, one-of-a-kind testing tool to evaluate lifetime and performance, current methods forextracting State-of-Charge and State-of-Health could be improved and managed more effectively. This might be done by utilising a better battery lifespan and frequency analysis tool, like the one suggested in this study, to identify and improve current models.

[7] This project's main objective is to build an integrated observation system that can predict errors. Error detection, error diagnosis, and integrated prognosis are the three components that make up this system. The reliability of the battery management system in an electric car will be evaluatedin this study using a Big Data analytics platform. [8] One suchdevice is a battery management system ,which gives tracking of the battery's internal and external temperatures as well asits current and voltage and regulates its charging and discharging processes. In this work, various intriguing batterymanagement methods and systems are investigated. The fundamental structure of a cutting-edge system for optimum battery performance is also covered.

[9] A full wireless temperature monitoring system for EV battery charging surveillance is offered in this study. The created detecting gadget is portable, entirely passive, compact in size, and inexpensive, allowing it to be extensively employed for cell- level temperature of batteries measurement. The device's maximal detection range in the surrounding air is larger than 5 m, with a sensor accuracy of 1.5 °C (3 from 20 to 80 °C). Measuring the internal temperature variation of a lithium-ion 18650-36V-4.4A cell battery while it is charged at various C- rates, the entire system is internally validated. This article contains different forms of newly developed battery tracking designs to be utilized with applications involving electric vehicles. Batteries made from lithium ion are projected to be thekey source of power for the foreseeable future of vehicle systems. [10] The Co-Estimation technique is mentioned initially in this publication. The conceptualization of an electrical electronics testbed is next built, and the choice of critical components such as a microprocessor and voltage/current monitors is described. The efficiency of the physical experimentation and the outcomes of the simulation performed in MATLAB have been contrasted utilizing the precise same Co-Estimation approach, demonstrating the identical effectiveness of both platforms.

This article [11] suggested to ensure A actual time Android- based surveillance system is being created to ensure that the lithium-ion batteries that are employed by electric vehicles (EVs) function effectively and consistently. We created a real- world test scenario to evaluate the feasibility of the proposed continuous monitoring technology. According to the outcomes of the tests, information gathered about the power source is communicated to the user's smartphone and shown there, making it easier for users to remain in updated on how it's doing.

[12] The proposal for this work includes An electric vehicle's lithium-ion battery management system's diagnostic feature thatguards against overcharging and more discharging. The study provides a diagnostic feature to avoid lithium ion batteries from excess charging and discharged while still keeping them connected to the motors and generators of electric vehicles. The regular and extraordinary condition of operations are taken into account while discussing communications. Influencing factors like sensor accuracy and estimation error are taken into accountthroughout the computing process to apply this estimating logicto the industrial automobile field in the real world ,The simulation results are displayed in order to highlight the effectiveness of the diagnostic feature, and the calculated cell voltages are contrasted with actual cell voltages in order to highlight the modelling precision. MATLAB/App Designer is used in this research to discuss the Electric Vehicle Monitoring System. The development of a graphical interface that enables the user to keep an eye on an electric car's most important attributes is the main topic of this article. The signal from the sensors is appropriate for measuring a variety of variables within the voltage range of the data collectioncard. So many adapters are needed in the circuits as a result [13]. The impact of numerous factors (environmental, traffic-related) on the performance, dependability, and battery wear/health of the vehicle is examined in this study, as well as how these automobiles may be electronically monitored. The hardware, software, and operational concepts of the testing devices are described in general. We also recommend a low-cost monitoring system for electric and hybrid vehicles in light of the new information. A 2018 Mitsubishi Outlander PHEV was used as a test vehicle for experimentation, parameter monitoring, and system testing. [14]. The battery management system (BMS) modelling environment for electric vehicles is the subject of this work.[15] The report also includes real-world telemetry data acquired from tests utilising an entirely electrically driven vehicle, a portable electric car prototype. Students can test and evaluate complicated algorithms and models for the best energyconsumption using this electric car and the provided system, extending the range of the vehicle.

[16] The article suggests rechargeable management solutions that are versatile and sophisticated for electric cars and fixed battery banks. Charging & discharging electrical converters via an unified energy management framework, as well as other incorporated conversions and processors. The total endurance as well as effectiveness of the system was a critical project requirement. Each battery cell module's mechanism for controlling proved eventually combined onto a use specified circuitry , that was critical in terms of price and effectiveness. The present paper presents an in-depth examination of the cutting-edge in lithium-ion battery including the basics, buildings, and general performance evaluations of several batteries with lithium varieties. The research presented here looks at the numerous elements, obstacles, and problems and makes recommendations to improve EV battery growth. [17].

[18] To find the variables linked to SOC, the technique employs an a square-root cyclical minimum squares technique. The current state of charge of the power source is then determined utilising an estimate approach known to as the smoothed varied

Filters, The proposed method's efficiency is demonstrated by

applying it on data from experiments from an extended ageing test. [19] An Electrical Bus Survey—Energy Distribution, This article is about managing electricity and recharge schedules. In the past few years, the auto sector, higher education, and transit agencies have all expressed an intense curiosity in journey electrical power, which includes electric bikes and electric school buses, in the goal of decreasing the quantity of urban airpollution created by cars that run on fossil fuels. Recent EB study subjects covered included storing electricity equipment dimension, power/energy administration, spectrum repair techniques, charger design/scheduling, and pilot projects. Based on the corpus of existing the written word, we continue by describing possible topics for further investigation andcurrent concerns, such as expanding EV-related research to EBs, calculating EB recharging consumer demand, and EB effect on power networks. Traditional ICE-powered buses are mostly to fault with current congestion.

[20] Systems for controlling and monitoring battery performance. This analysis focuses on three essential elements of Charge capacity for retention, power control structures, and cell monitoring devices are all distinct types of electric cars. It additionally contains a synopsis of recent research endeavors. Abattery administration system is a piece of technology that monitors how battery packs are powered up and drained in orderto prevent charging too much or burning. The battery management system is an essential component of any electric automobile. At the conclusion of the review, it has been suggested that additional research be conducted on the issues associated with solar PV integrated electric cars in order to run the system independently of EB or grid supplies.

III.EV SMART BATTERY

The Electric Vehicle (EV) block diagram represents an IOT (Internet of Things) system that gathers data from temperature, pressure, humidity, and smoke sensors. The data is sent to Node MCU, a small Wi-Fi enabled microcontroller. The data is then transferred to Google Firebase, a cloud-based database, using the Node MCU. The data is saved in the Firebase database and maybe analysed and visualised. There is also a mobile app with location tracking so you may review the data collected by your phone's sensors. Temperature, humidity, smoke, and pressure are among the environmental characteristics monitored by the sensors. The Node MCU reads the data and sends it to Google Firebase.The mobile app may retrieve and display data from Firebase.

A. Node MCU ESP8266:

Based on The device known as the (Node Microcontroller Unit)is an open-source hardware as well as software programming framework based on the ESP8266, a cheap System-on-a-Chip . RAM, central processing unit (CPU), wireless connectivity (Wi-

Fi), a contemporary software package, and an applicationdevelopment kit (SDK) are all required computer components. are present in the Espressif Systems ESP8266. The result is thatit is a superb solution for all IoT (Internet of Things)applications.

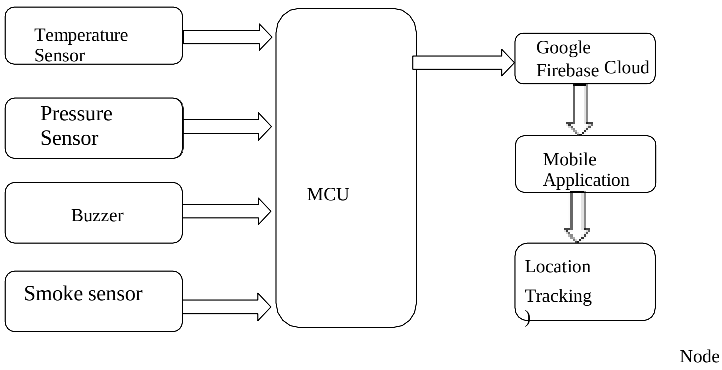

Fig: Block diagram of electric vehicle

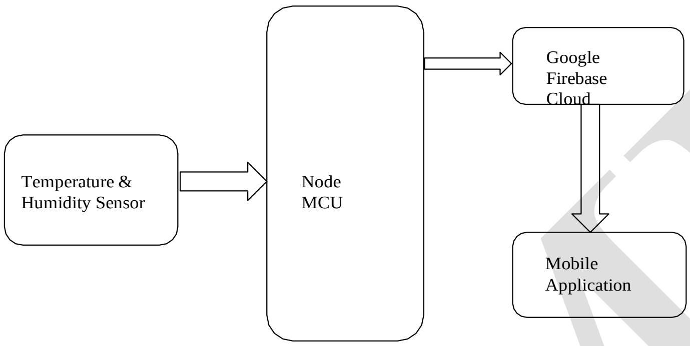

Fig: Block diagram for EV and Traffic signal

DHT11- Temperature and Humidity sensor:

The DHT11, which stands for DHT11, serves as a computerised temperature as well as humidity sensor which isboth simple and inexpensive. The detector is an electronic temperature and moisture detector with just one cable which transmits moisture and temperature readings serially. Heat is measured in Fahrenheit (0 to 50 °C) whereas humidity is recorded in proportion (from 20% to 90% RH).There includesa resistance moisture measuring part as well as an NTC temperature gauge component.

B. BMP180 - ATMOSPHERIC PRESSURE SENSOR:

The BMP180 sensor belongs to the BMP XXX family. These are all of them are intended to measure environmental or pressure atthe barometric level. For customers, the high-precision biosensor BMP180 was designed. The quantity of air applied toeverything is known as barometric pressure. Where there is air, pressure can be felt since the air has weight. Pressure is detectedand digitally sent by the BMP180 sensor.

C. MQ2 Smoke Sensor:

Within the MQ sensor family, the MQ2 sensor has grown to be the most well-liked. It makes use of a MOS (Metal Oxide Semiconductor) sensor. Due to the detecting material's fluctuating resistance when exposed to specific gases, metal oxide sensors are also known as chemiresistors. 800mW or more are consumed by the 5V DC gas sensor MQ2. For LPG,smoke smell, alcohol, propane, hydrogen, methane, and carbon monoxide, it has a detection range of 200 to 10000 parts per million.

D. Buzzer:

For instance, a beeper or buzzer may be mechanical, piezoelectric, or electromechanical. The conversion of the audio signal to sound is the major goal here. It is typically used in clocks, warning devices, printers, alarms, computers, and other electronic equipment that run on DC voltage. Depending on thedesign, it may produce a variety of sounds, including alert, melody, bell, and siren.

E. Firebase Cloud:

Google's Firebase is a smartphone application building framework. Its benefits comprise a from beginning to end growth and development environment, a shorter time to market for developing applications, and expandable infrastructure. Database operation, storage of files, cloud coding, analytics, scalable hosting, and machine learning are among the key features.

Advanced Encryption Standard (AES) Algorithm:
The Advanced Encryption Standard, also known as the AES is the most widespread and commonly used symmetrical method of encryption which is probably to be encountered presently. It has been found to be six times more rapid than treble DES. Because the key that made up DES had become tiny, an alternative were required. It was anticipated that since its computational capacity increased, it was going to become vulnerable to assaults employing extensive keyboard searching.This disadvantage was thought to be partially offset alongside quadruple DES, however it was shown to be sluggish. AES stands for improved security.

The following are AES's characteristics:

- Symmetric key symmetric block cypher with 128-bitdata and keys of 128/192/256 bits
- Triple-DES is more powerful and faster, and it provides fullspecs and design details.
- C and Java-based applications.

Here, we limit to describing a typical round of AES encryption. Each cycle is divided into four sub-processes. The first round ofthe procedure is shown below.

Since AES uses the same key for both encryption and decryption, it must be kept a secret and known only to those withthe proper authorization. Based on the size of the key, AES usesa set number of encryption cycles. AES-128 runs for ten rounds, AES-192 for twelve rounds, and AES-256 for fourteen.. Each round transforms the data block numerous times. When used appropriately with suitable key sizes, AES is considered safe against all known practical threats. It has been thoroughly examined by cryptography specialists all around the world and has achieved general acceptance.

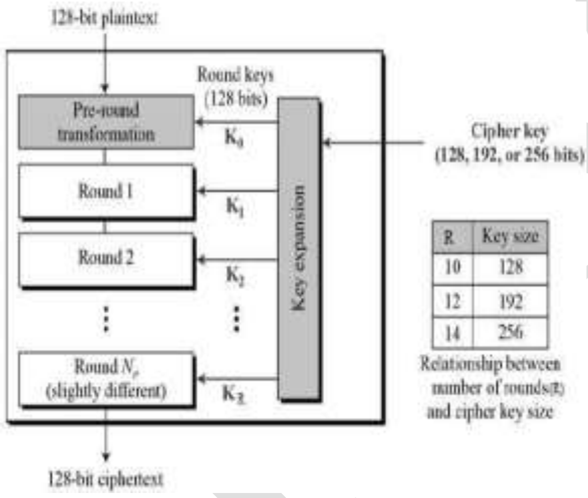

Fig: Schematic structure of AES

Binary search algorithm:

An effective way to quickly locate a particular member in a sorted array is to do a binary search. The centre member of thearray must be compared to the goal value as the initial task of this method. A successful search is one in which the target value is located in the middle element. If the goal value is lessthan the centre element, the algorithm will search the left halfof the array. The script will traverse the array's right side if thegoal value is greater than the centre element. The process is repeated until the desired value or the search range have beenfound.

IV. RESULTS AND DISCUSSION

The values of temperature, humidity, smoke, pressure and surrounding temperature are displayed in both firebase cloud and mobile application. The values in mobile application are viewed by logging into the app in mobile phones by using login credentials. There are separate login credentials for user and admin that is for driver and owner of the vehicle. These values communicated with a mobile application that can be accessed by both the vehicle owner and the vehicle manufacturer. When the data exceed the critical point, a buzzer will sound to inform the vehicle user.

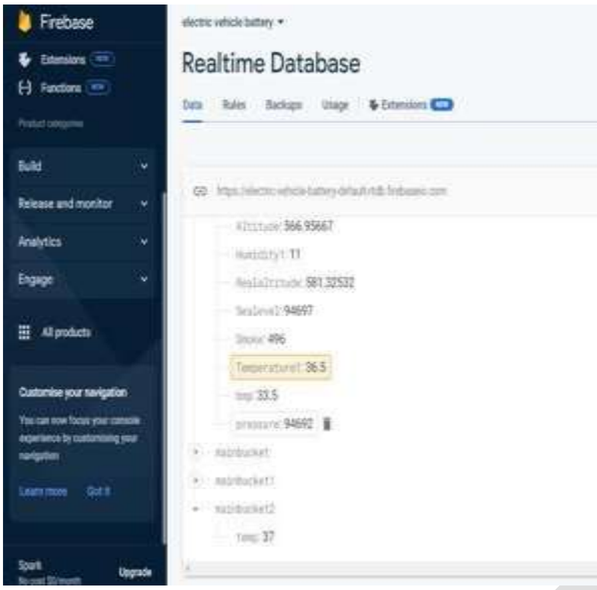

Fig: Values displayed in firebase

Fig : Login page for the mobile app

fig : Admin’s Login

When admin is log in into the mobile application the app showsthe above map in it for owner of electric vehicle.

Fig : user’s Login

When admin is log in into the mobile application the app shows the above map in it for owner of electric vehicle.

When we use the provided User credentials to access thesystem, you will retrieve the parameter values for the ElectricVehicle as well as the surrounding conditions as shownin above figure.

Different output values:

The below table shows the different output values of humidity, Smoke, pressure, temperature, BMP, surrounding temperature. Hence we can show that the results are estimated practically.

Humidity (%)	Smoke (AQI)	Pressure (Pa)	Temperature (°C)	BMP (°C)	Surrounding Temperature (°C)
7	510	94166	24.6	32.6	34
9	528	94161	32.1	32	48
22	569	94164	35.4	32.6	45
14	601	94165	40.2	32.7	43
16	638	94157	45.4	32.3	32
18	629	94161	48	32.4	32

Fig: Different output values

IV. CONCLUSION

The paper is described about the protection of battery of EVthrough a firebase cloud and mobile application using temperature sensor, humidity sensor, pressure sensor and buzzer. Before an electric car explodes for a variety of causes, it is necessary to provide instructions to the user. As a portion of the overall expansion, including the smartphone app and the physical components for the power source monitoring gadget were created. The equipment may show information such as battery temperature, pressure, humidity,and position of such electric vehicles on a map.The primarygoal of this research is to discover a solution to the explosion of batteries for electric vehicles. Because our nation experiences major climatic variations, the temperature

fluctuates from place to place. Explosions can occur as a result of the use of low-quality components or the escape ofgases from batteries. To solve this issue, we created a mobile application and database that the user can access from anywhere. His app provides information on theEV Battery and its operation. It warns the user if any danger is expected.

REFERENCES

[1] K. W. E. Cheng, B. P. Divakar, H. Wu, K. Ding and H. *F*. Ho, "Battery-Management System (BMS) and SOC Development for Electrical Vehicles," in IEEE Transactions on Vehicular Technology, vol. 60, no. 1, pp. 76-88, Jan. 2011, doi: 10.1109/TVT.2010.2089647.

[2] S. Haldar, S. Mondal, A. Mondal and R. Banerjee, "Battery Management System Using State of Charge Estimation: An IOT Based Approach," 2020 National Conference on Emerging Trends on Sustainable Technologyand Engineering Applications (NCETSTEA), Durgapur, India, 2020, pp. 1-5, doi:10.1109/NCETSTEA48365.2020.9119945.

[3] C. R. Gould, C. M. Bingham, D. A. Stone and P. Bentley, "New Battery Model and State-of-Health Determination Through Subspace Parameter Estimation and State- Observer Techniques," in IEEE Transactions on Vehicular Technology, vol. 58, no. 8, pp. 3905-3916, Oct. 2009, doi: 10.1109/TVT.2009.2028348.

[4] A. Kawamura and T. Yanagihara, "State of charge estimation of sealed lead-acid batteries used for electric vehicles," PESC 98 Record. 29th Annual IEEE Power Electronics Specialists Conference (Cat. No.98CH36196), Fukuoka, Japan, 1998, pp. 583-587 vol.1, doi: 10.1109/PESC.1998.701957.

[5] S. T. Hung, D. C. Hopkins and C. R. Mosling, "Extension of battery life via charge equalization control," in IEEE Transactions on Industrial Electronics, vol. 40, no.1, pp. 96-104, Feb. 1993, doi: 10.1109/41.184826.

[6] A test system for advanced lead acid battery state-of- charge and state-of-health research Christopher R. Lashway, Peter Idowu Pennsylvania State – Harrisburg, 777.
Harrisburg Pike, Middletown, PA 17057, USA

[7] M. I. Karmawijaya, I. Nashirul Haq, E. Leksono and A. Widyotriatmo, "Development of Big Data Analytics Platform for Electric Vehicle Battery Management System," 2019 6th International Conference on Electric Vehicular Technology (ICEVT), Bali, Indonesia, 2019, pp. 151-155, doi: 10.1109/ICEVT48285.2019.8994013.

[8] J. S. Lokhande, P. M. Daigavhane and M. Sarkar, "A Critical Approach Towards a Smarter Battery Management System for Electric Vehicle," 2020 4th International Conference on Trends in Electronics and Informatics (ICOEI)(48184), Tirunelveli, India, 2020, pp. 232-235, doi:10.1109/ICOEI48184.2020.9142869.

[9] B. Wang, J. Hernandez Fernandez and A. Massoud, "A Wireless Battery Temperature Monitoring System for Electric Vehicle Charging," 2019 IEEE SENSORS, Montreal, QC, Canada, 2019, pp. 1-4, doi: 10.1109/SENSORS43011.2019.8956733.

[10] S. M. Salamati, C. S. Huang, B. Balagopal and M. -Y.Chow, "Experimental battery monitoring system design for electric vehicle applications," 2018 IEEE International Conference on Industrial Electronics for Sustainable Energy Systems (IESES), Hamilton, New Zealand, 2018, pp. 38-43,doi: 10.1109/IESES.2018.8349847.

[11] W. Menghua and X. Bing, "A Real-Time Android- Based Monitoring System for the Power Lithium-Ion Battery Used on EVs," 2017 10th International Conference on Intelligent Computation Technology and Automation (ICICTA), Changsha, China, 2017, pp. 245-249, doi: 10.1109/ICICTA.2017.62.

[12] M. Ha, H. -C. Song and J. -J. Lee, "A diagnostic function preventing over charging and discharging for a lithium-ion battery management system of electric vehicles," 2017 17th International Conference on Control, Automation and Systems (ICCAS), Jeju, Korea (South), 2017, pp. 1309-1312, doi: 10.23919/ICCAS.2017.8204409.

[13] J. M. G. Valle, J. C. C. García and E. R. Cadaval, "Electric vehicle monitoring system by using MATLAB/App Designer," 2017 International Young Engineers Forum (YEF-ECE), Costa da Caparica, Portugal, 2017, pp. 65-68, doi: 10.1109/YEF-ECE.2017.7935642.

[14] A. Drosu, G. Suciu, A. Scheianu and I. Petre, "An Analysis of Hybrid/Electric Vehicle Monitoring Systems and Parameters," 2019 Electric Vehicles International Conference (EV), Bucharest, Romania, 2019, pp. 1-5, doi: 10.1109/EV.2019.8892923.

[15] L. Buccolini, A. Ricci, C. Scavongelli, G. DeMaso- Gentile, S. Orcioni and M. Conti, "Battery Management System (BMS) simulation environment for electric vehicles," 2016 IEEE 16th International Conference on Environment and Electrical Engineering (EEEIC), Florence, Italy, 2016, pp. 1-6, doi:10.1109/EEEIC.2016.7555475.

[16] N. Grass, F. Ferner and F. Nickl, "Modular and intelligent battery control system for electric vehicles and stationary storage systems," 2016 IEEE International Telecommunications Energy Conference (INTELEC), Austin, TX, USA, 2016, pp. 1-7, doi: 10.1109/INTLEC.2016.7749093.

[17] M. A. Hannan, M. M. Hoque, A. Hussain, Y. Yusof and P. J. Ker, "State-of-the-Art and Energy Management System of Lithium-Ion Batteries in Electric Vehicle Applications: Issues and Recommendations," in IEEE Access, vol. 6, pp.19362-19378, 2018, doi: 10.1109/ACCESS.2018.2817655.

[18] S. Rahimifard, S. Habibi and J. Tjong, "Dual Estimation Strategy for New and Aged Electric Vehicles Batteries," 2020 IEEE Transportation Electrification Conference & Expo (ITEC), Chicago, IL, USA, 2020, pp. 579-583, doi: 10.1109/ITEC48692.2020.9161556.

[19] R. Deng, Y. Liu, W. Chen and H. Liang, "A Survey on Electric Buses—Energy Storage, Power Management, and Charging Scheduling," in IEEE Transactions on Intelligent Transportation Systems, vol. 22, no. 1, pp. 9-22, Jan. 2021, doi: 10.1109/TITS.2019.2956807.

[20] R. Balamurugan, P. RamKumar, B. Singaraj, C. Vasudev, K. K. Kumar and M. W. Iruthayarajan, "A Survey on various Electric Vehicle batteries – Battery power management and performance monitoring system," 2022 Second International Conference on Artificial Intelligence and Smart Energy (ICAIS), Coimbatore, India, 2022, pp. 1497-1503, doi: 10.1109/ICAIS53314.2022.9743050.