BATTERY MANAGEMENT SYSTEM AND STATE OF CHARGING(SOC) DEVELOPMENT FOR ELECTRIC VEHICLES

T.Sirisha[1] , A.Sai Venkata Sowmya[2] M.Vaishnavi[3] M.Katyayani[4] P.NaveenKumar[5]

Electrical and Electronics Engineering Hyderabad Institute of Technology and Management Hyderabad, India

Electrical and Electronics Engineering Hyderabad Institute of Technology and Management Hyderabad, India

Electrical and Electronics Engineering Hyderabad Institute of Technology and Management Hyderabad, India

Electrical and Electronics Engineering Hyderabad Institute of Technology and Management Hyderabad, India

Electrical and Electronics Engineering Hyderabad Institute of Technology and Management Hyderabad, India

thrilangi.sirisha55@gmail.com, saisowmyareddy27@gmail.com, vaishnavi0087@gmail.com , medurikatyayani25@gmail.com,navinnani2k@gmail.com

Article History: Received: 15.03.2023 Revised: 13.04.2023 Accepted: 22.05.2023

Abstract**—**Battery monitoring is vital for most electric vehicles(EbVs), because the safety, operation, and even the life of the passenger depend on the battery system. This attribute is exactly the major function of the battery-management system (BMS)—to check and control the status of batteries within their specified safe operating conditions. In this paper, A Battery Management System is introduced where this system is used to monitor the battery at every time and temperature is measured at each battery and analyze the battery temperature at charging and discharging time. BMS block diagrams have been proposed using various functional blocks. The State of charge (SOC) estimation has been implemented using Coulomb counting method and the State of health(SOH) of the battery by using CCCV.We employ IOT to automatically store the battery, temperature, and voltage data on the WEBSITE OF THINGSPEAK. Therefore, a thorough investigation of the Batteries is anticipated. Therefore, if a problem arises, we can address it quickly**.**

Keywords**—***Battery,EV,battery management system,state of charging,state of health,thingspeak*

DOI: 10.48047/ECB/2023.12.SI8.106

INTRODUCTION

Batteries are the most common electrical energy- storehouse bias in EVs. The performance of a battery when it's connected to a cargo or a source is grounded on the chemical responses inside the battery. The chemicals degrade with time and operation which reflects the gradual reduction in the energy storehouse capacity of the battery. The battery deprecation process needs to be reduced by conditioning the battery in a suitable manner by controlling its charging and discharging profile, indeed under colorful cargo conditions. In general, the battery continuance will be lowered when the battery is operated under a wide range of thermal conditions and frequent charge and deep discharge cycles, particularly at high- palpitation current conditions. Batteries are safe, despite reports of explosion or failure when used with a power- exertion system that incorporates safety features and automatic arrestment. Conventional low- cost battery dishes employ many defensive features intended for that battery, therefore lacking inflexibility and full- fledged protection. Hence, BMS, which is flexible to cover batteries of different types and can give all the safety features, has been the subject of recent development/ exploration in EV.

SOC is one of the crucial characteristics needed to guarantee secure charging and discharging. The battery's current capacity expressed in terms of its rated capacity is known as SOC. SOC provides the battery's present condition and enables batteries to be safely charged and discharged at a rate conducive to extending their life. SOC assists in managing battery voltage, current, temperature, and other data related to the battery under consideration.

By preventing inappropriate overcharging and over discharging, accurate SOC calculation prevents battery damage or accelerated aging. Error accumulation glitches affect the Coulomb counting method's traditional SOC estimation, resulting in enormous estimation. Additionally, because batteries have a finite efficiency and chemical reactions occur during charge and discharge conditions, temperature rise affects SOC estimation. As a result, the battery needs to be modeled accurately for SOC estimation. To match the load requirement for EVs, the number of batteries is connected in a series-parallel mix.

To reflect the actual and practical capability of the cell to match the various road conditions and driving patterns of EVs, precise computation of SOC must be combined with constant monitoring of the actual capacity of the cell through a number of measures of the cells.

HARDWARE COMPONENTS

EQUIPMENT NAME	TYPE
3 Battery packs	Lithium-ion
LCD display with driver	16*2
Buzzer	Piezo type
voltage sensor	Resistive Type
Three Relays	Electromagnet
Transformer	Step Down
Crystal oscillator	Electro mechanical
PIC microcontroller	16F72
LED indicator	Red LED
Temperature sensor	LM35
Rectifier	Bridge rectifier
ADC converter	Analog Digital
Wifi-Module	ESP8266
Reset button	-

1) BATTERIES

Lithium-ion batteries, also referred to as Li-ion batteries, are an example of rechargeable batteries that store energy by the reversible reduction of lithium ions. In ordinary lithium-ion batteries, the anode, or positive electrode, is often made of graphite. The negative electrode, or cathode, is often made of metal oxide. The electrolyte is typically a lithium salt in an organic solvent.

2) LCD DISPLAY WITH DRIVER

An interface function known as a display driver is carried out by an electronics/computer hardware component between a microprocessor, microcontroller, ASIC, or general-purpose peripheral interface and a specific type of display device, such as an LCD, LED, OLED, ePaper, CRT, Vacuum fluorescent, or Nixie. Display drivers are often state machines composed of discrete parts, though they can also be state machines.

3) LM35 TEMPERATURE SENSOR

The LM35 is a thermometer with a temperature-dependent analogue output voltage.It provides the output voltage in °C. (Celsius). There is no need for additional calibration circuitry.The LM35's temperature sensitivity is 10 mV/degree. Output voltage rises as temperature does.

4) TRANSFORMER

An electromagnetic device known as a transformer comprises the voltage produced by the magnetic field that exists between the primary and secondary windings.

5) VOLTAGE SENSOR

A voltage sensor is a sensor that measures and records the voltage level of an object. Voltage sensors can measure either AC or DC voltage levels. The sensor's input is voltage, and its outputs include switches, analogue voltage signals, and current signals.

6) BUZZER

An electronic device called a piezoelectric buzzer creates tones, alarms, or other sounds. It is typically inexpensive, lightweight, and of a straightforward design.

7) CRYSTAL OSCILLATOR

A piezoelectric crystal serves as the frequency-selective element in the electronic oscillator circuit known as a crystal oscillator. Inverse piezoelectricity, which occurs when quartz crystals are exposed to an electric field, is the foundation of crystal oscillators. A crystal changes shape when a voltage is supplied to its electrodes; when the voltage is removed, the crystal elastically returns to its previous shape and produces very little voltage.

8) RELAYS

A switch that is actuated by electricity is a relay. A set of functioning contact terminals plus a set of input terminals for one or more control signals make up this device.The concept of electromagnetic attraction is used to make it work.The electromagnetic field that creates the temporary magnetic field is created when the relay's circuit detects the fault current.

9) RECTIFIER

A circuit known as a rectifier transforms ac into dc.Full wave and half wave rectifiers are the two different varieties we have.Bridge rectifier and center-tapped full wave rectifier make into a full wave rectifier.

10) PIC MICROCONTROLLER

The PIC16F72 is an 8-bit, fully static, CMOS Flash-capable, low-cost, low-power microcontroller chip with 28 pins, 22 of which can be used as I/O pins. It features circuits for Power-on-Reset (POR), Power-up Timer (PWRT), and Oscillator Start-up Timer (OST).

11) LED INDICATOR

A frequent way to indicate that equipment is receiving electricity or is having a problem is via indicator lights, a sort of illuminating gadget.

12) ADC CONVERTER

An "analog to digital converter," or ADC, converts analogue signals into binary data, allowing digital circuits to communicate with the outside world.

13) ESP8266 WIFI MODULE

Any microcontroller with access to your wifi network can use the ESP8266 WIFI MODULE, a self-contained soc with an integrated TCP/IP Protocol stack.Each ESP8266 module comes pre-programmed with an at command set firmware, enabling the ESP8266 to either host an application or offload all wifi networking functionality to another application processor.With a large and constantly expanding community, the ESP8266 module is a very affordable board.

14) RESET BUTTON

A device can be reset by pressing the reset button.

STATE OF CHARGING(SOC):

SOC stands for the battery's state of charge. SOC is a measurement of the remaining energy in a battery in relation to the total amount of energy present when the battery is fully charged. A user can calculate how much energy he can extract from a battery at a given moment and when to charge or stop charging a battery with the help of SOC. The coulomb counting method's SOC estimation.

$$SOC(t) = SOC(t-1) \cdot \int_{t-1}^{t} \frac{I_t \cdot \eta}{Q_n} \cdot dt$$

SOC(t-1) = SOC at previous time step

η = efficiency

t = current time step

t-1 = previous time step

Q = Charge capacity of the battery

STATE OF HEALTH(SOH):

The state-of-health (SoH) of a battery indicates how a battery under study differs from a brand-new battery and takes cell aging into account.

It is described as the proportion of a battery's maximum charge to its rated capacity.

The following shows how it is expressed as a percentage.

SOH/%=100*Qmax/Cr

Qmax/mAh=The maximum charge available of the battery

Cr=The rated capacity

THINGSPEAK:

It is a network of "connected things," or the Internet of Things (IoT).

The essential element of ThingSpeak is a "ThingSpeak Channel."It offers the capability to gather data in real-time, display the data in charts, and create plugins and apps for interacting with web services, social networks, and other APIs.The information that we give to ThingSpeak is stored in channels, which are made up of the parts listed below:

Data from embedded devices or from sensors can be stored in 8 fields that can contain data of any sort.

Three fields for locations: These fields allow for the storage of latitude, longitude, and elevation. These are fantastic for tracking a moving item.

one status field: a brief message summarising the data stored in the channel.

2.1. CIRCUIT DIAGRAM & WORKING:

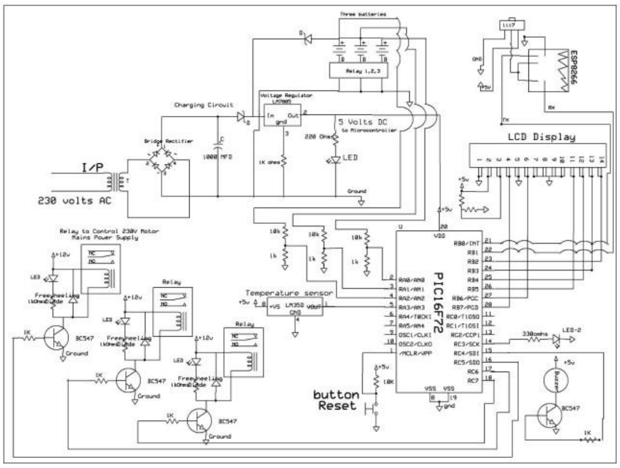

Fig.1.circuit diagram of BMS and SOC Development for electric vehicles

This is the BMS circuit diagram, and the transformer is where the circuits function begins. The converter receives 230 volts externally, which it steps down to 5 volts using a step down transformer. The rectifier will then use this 5V AC to transform AC to DC. The filter capacitor is then fed with it in order to balance the flow variance.

The Pic Microcontroller receives the filtered, pure form of power, and from here each battery's relay receives an input. The voltage sensor and Crystal oscillator are connected to the relay's other end of the microcontroller's A10, A11, and A12 pins which are linked to these three relays. The temperature of the battery is measured using a temperature monitor (Lm35). This sensor is used to measure the temperature of the battery during charging and discharging time i.e.,Whenever the temperature of batteries exceeds more than 50 degrees then a buzzer system alerts and sends a signal by buzz sound . This sensor is connected to the microcontroller pins. The lcd displays the output which is the voltage and temperature of batteries.

The microcontroller measure the soc from voltage sensors and based on that it will switch on the relays for battery charging.Here relay works as a switch to on/off the charging connection.And also it will send the voltage,temperature,soc values into the thingspeak cloud through ESP8266 wifi-module.The status of the project will display on LCD module.

Block Diagram Explanation:

The block architecture shown below illustrates the block diagram of BMS where a step down transformer is used of 230v/5v and this has an input source of 230v and it converts it to 5v.Then this converted 5v is send to Regulated Power Supply (RPS) where a purest form of 5v dc is obtained and this 5v dc is send to relays by microcontroller which are connected with three different batteries of 12v each, they are connected in parallel with voltage sensors the main functions of voltage sensor s is to sense the voltage and recharge i.e., whenever the voltage is less than 8v then automatically the batteries get charged. This output of batteries are connected to Microcontroller pins and the voltage sensors and temperature sensors are connected in parallel with circuit to identify the temperature of batteries at any time. The Microcontroller gets the power from this RPS system. ESP8266 wifi-module is connected to the PIC-microcontroller it will give access to your wifi network and ThingSpeak is a free and open data platform for the Internet of Things that enables you to access data from other channels and gather data in your own channel.

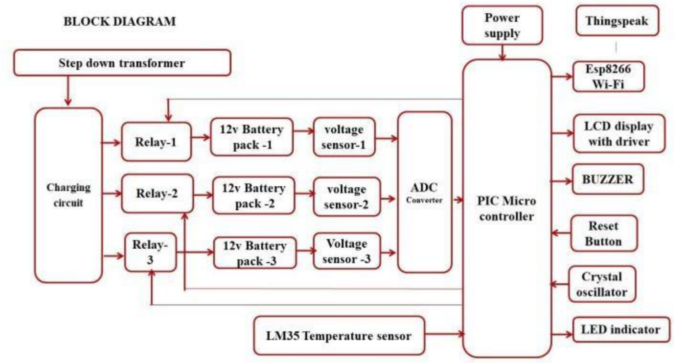

Fig.2. Block architecture of BMS AND SOC development for Electric Vehicle setup.

HARDWARE KIT

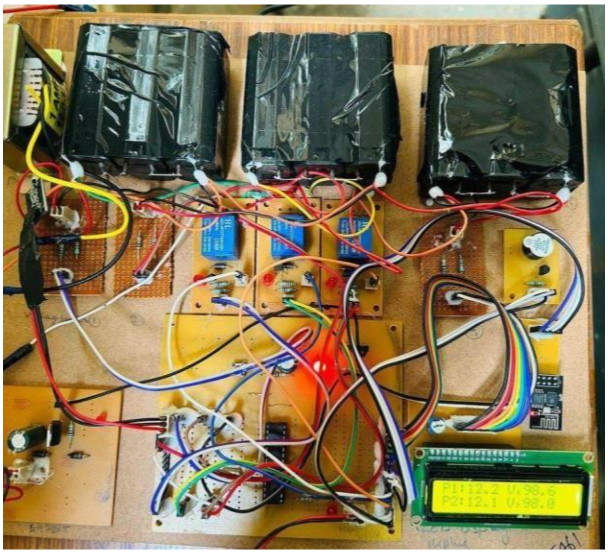

Fig.3. The Hardware kit of BMS and SOC development.

OUTPUT

Fig.4. It indicates the voltage of battery pack-1.

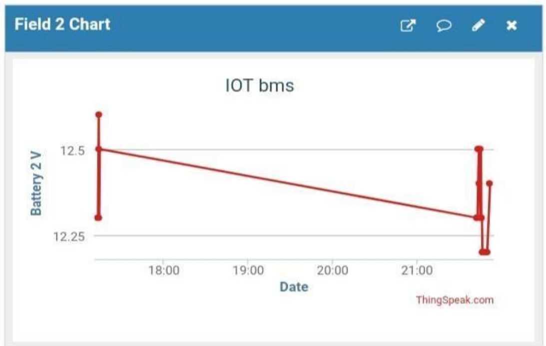

Fig.5. It indicates the voltage of battery pack-2.

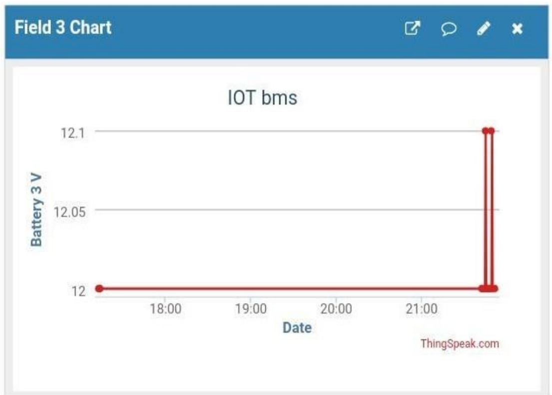

Fig.6. It indicates the voltage of battery pack-3.

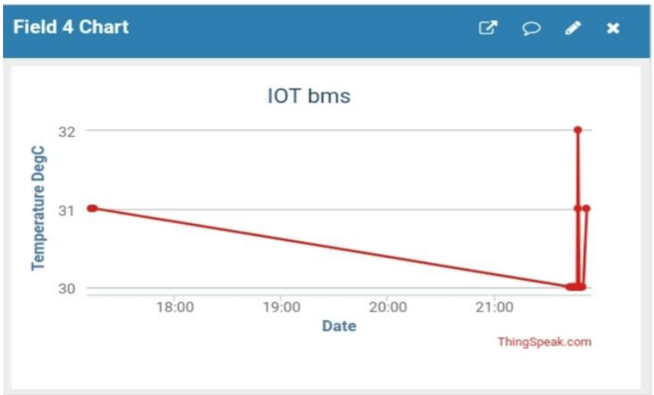

Fig.7. It indicates the temperature of the battery.

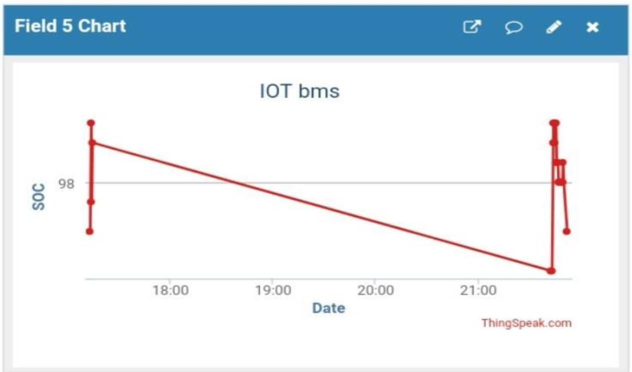

Fig.8. It indicates the state of charging(soc) of the battery.

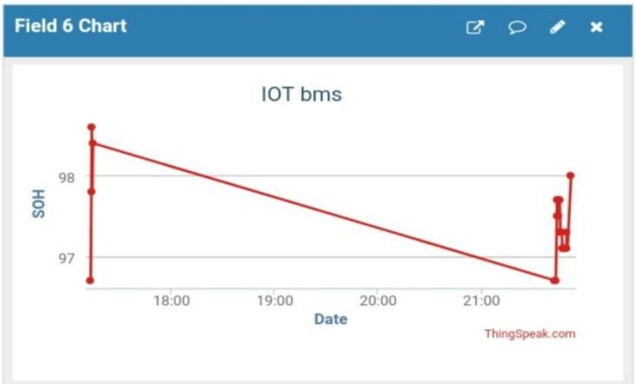

Fig.9. It indicates the state of health(soh) of the battery.

CONCLUSION:

- The battery-management system (BMS) is used in our project "Battery-Management System (BMS) and SOC Development for Electrical Vehicles" to control the status of batteries and to verify the voltage and temperature within their designated safe operating conditions.
- has been created with integrating features for all the hardware parts used. Every module's presence has been thoughtfully considered and arranged, which helps the unit function as best it can.
- Linking the data in THINGSPEAK data enables us to track the data of Battery Voltage, Temperature, SOC, and SOH, allowing us to detect errors early on whenever they occur.

REFERENCES

[1] C. Zou, X. Hu, Z. Wei, T. Wik and B. Egardt, "Electrochemical estimation and control for lithium-ion battery health-aware fast charging", IEEE Trans. Ind. Electron., vol. 65, pp. 6635-6645, Aug. 2018.

[2] M. S. H. Lipu, M. A. Hannan, A. Ayob, M. H. M. Saad and A. Hussain, "Review of lithium-ion battery state of charge estimation methodologies for electric vehicle application", Int. J. Eng. Technol., vol. 7, no. 3.17, pp. 219-224, Aug. 2018.

[3] K. W. E. Cheng, B. P. Divakar, H. Wu, D. Kai and H. F. Ho, "Battery-management system (BMS) and SoC development for electrical vehicles", IEEE Trans. Veh.Technol., vol. 60, no. 1, pp. 76-88, Jan. 2011.

[4] J. Lee, O. Nam and B. H. Cho, "Li-ion battery SOC estimation method based on the reduced order extended Kalman filtering", J. Power Sources, vol. 174, no. 1, pp. 9-15, Nov. 2007.

[5] H. He, et al., "State-of-charge estimation of lithium-ion battery using an adaptive extended kalman filter based on an improved thevenin model,"IEEE Trans. Veh. Technol., vol. 60, no. 4, pp. 1461-1469, May 2011.

[6] Jieyu Xu, Dongqing Wang, Meng Jiao, "SOC estimation of lithium battery with weighted multi-innovation adaptive Kalman filter algorithm", *2022 IEEE 5th International Electrical and Energy Conference (CIEEC)*, pp.624-629, 2022.

[7]P. Y. Kong and G. K. Karagiannidis, "Charging schemes for plug-in hybrid electric vehicles in smart grid: A survey", *IEEE Access*, vol. 4, pp. 6846-6875, 2016.

[8]C. Zou, X. Hu, Z. Wei, T. Wik and B. Egardt, "Electrochemical estimation and control for lithium-ion battery health-aware fast charging", *IEEE Trans. Ind. Electron.*, vol. 65, pp. 6635-6645, Aug. 2018.

[9]H. Fang, Y. Wang and J. Chen, "Health-aware and user-involved battery charging management for electric vehicles: Linear quadratic strategies", *IEEE Trans. Control Syst. Technol.*, vol. 25, no. 3, pp. 911-923, May 2017.

[10]J. Y. Yong, V. K. Ramachandaramurthy, K. M. Tan and N. Mithulananthan, "A review on the state-of-the-art technologies of electric vehicle its impacts and prospects", *Renew. Sustain. Energy Rev.*, vol. 49, pp. 365-385, Sep. 2015.

[11]A. J. Ilott, M. Mohammadi, C. M. Schauerman, M. J. Ganter and A. Jerschow, " Rechargeable lithium-ion cell state of charge and defect detection by in-situ inside-out magnetic resonance imaging ", *Nature Commun.*, vol. 9, no. 1, Dec. 2018.

[12]K. W. E. Cheng, B. P. Divakar, H. Wu, D. Kai and H. F. Ho, "Battery-management system (BMS) and SoC development for electrical vehicles", *IEEE Trans. Veh. Technol.*, vol. 60, no. 1, pp. 76-88, Jan. 2011.

[13]Y. Xing, E. W. M. Ma, K. L. Tsui and M. Pecht, "Battery management systems in electric and hybrid vehicles", *Energies*, vol. 4, no. 11, pp. 1840-1857, 2011.

[14]M. Corno, N. Bhatt, S. M. Savaresi and M. Verhaegen, "Electrochemical model-based state of charge estimation for Li-ion cells", *IEEE Trans. Control Syst. Technol.*, vol. 23, no. 1, pp. 117-127, Jan. 2015.

[15]H. He, R. Xiong and J. Fan, "Evaluation of lithium-ion battery equivalent circuit models for state of charge estimation by an experimental approach", *Energies*, vol. 4, no. 4, pp. 582-598, Mar. 2011.

[16] S. Yonghua, Y. Yuexi, H. Zechun, “Present Status and Development Trend of Batteries for Electric Vehicles,” PowerSystem Technology, Vol. 35, No. 4, pp. 1-7, 2011.

[17] L. Xiaokang, Z. Qionghua, H. Kui, S. Yuehong, “Battery management system for electric vehicles,” J.Huazhong Univ. Of Sci. & Tech. (Nature Science Edition). Vol. 35, No. 8, pp. 83-86, 2007.

[18] C. Piao, Q. Liu, Z. Huang, C. Cho, and X. Shu, “VRLA Battery Management System Based on LIN Bus for Electric Vehicle,” Advanced Technology in Teaching, AISC163, pp. 753-763, 2011.

[19]P. H. K. Utama, H. H. Husniyyah, I. N. Haq, J. Pradipta and E. Leksono, "State of Charge (SoC) Estimation of Battery Energy Storage System (BESS) Using Artificial Neural Network (ANN) Based on IoT- Enabled Embedded System," 2021 International Conference on Instrumentation, Control, and Automation (ICA), Bandung, Indonesia, 2021, pp. 77-82, doi: 10.1109/ICA52848.2021.9625697.

[20]M. S. Kale and B. N. Chaudhari, "“IoT Based Battery Monitoring System”," 2022 International Conference on Advances in Computing, Communication and Materials (ICACCM), Dehradun, India, 2022, pp. 1-5, doi: 10.1109/ICACCM56405.2022.10009576.