IoT Based Electrical Vehicle Battery Management System with Charge Monitor and Fire Protection

Santosh Kumar Tripathi
Department of Electrical Engineering
Rajkiya Engineering College
Kannauj, India
santosh@reck.ac.in

Swati Maurya
Department of Electrical Engineering
Rajkiya Engineering College
Kannauj, India
swatimaurya1990@gmail.com

Aditi Dubey
Department of Electrical Engineering
Rajkiya Engineering College
Kannauj, India
aditidubey911@gmail.com

Prakhar Pal
Department of Electrical Engineering
Rajkiya Engineering College
Kannauj, India
palprakhar365@gmail.com

Aparna Tiwari
Department of Electrical Engineering
Rajkiya Engineering College
Kannauj, India
aparnatiwari30.at@gmail.com

***Abstract*— It is an extensive review shows the study that how the world is struggling with pollution caused by harmful gases released by automobiles. Electric Vehicle (EV) Technology can be proved as a boon that can be a solution for this problem. But still Electric Vehicles are facing many challenges regarding to Battery Management System, Fire Safety, Charging stations, Charge Monitoring systems, etc. But with the advancement of Internet of Things (IoT), it can be controlled remotely, efficiently, and safely. An effective battery management system of an EV can be achieved with fire protection using IoT comprises of Lithium-ion batteries that are commonly used in EVs which can be harmful if not operated in Safety Operation Area (SOA) and Brushless Direct Current (BLDC) Motors give better efficiency than Permanent Magnet Synchronous Motor (PMSM) that can improve overall efficiency of the system.**

Keywords*— *Arduino UNO, BLDC Motor, ESP8266 Wi-Fi Module, Internet of Things(IoT), Li-ion Battery.

I. INTRODUCTION

In recent years, the extensive adoption of Electric Vehicles has remarkable contribution to the reduction of greenhouse reduction and adaptation towards sustainable transportation. The electrification of transportation has authenticated an exemplar shift with worldwide adaption of EVs.[1] The elemental components ensuring the safe and efficient operation of electric vehicles in the Battery Management System (BMS). The Battery Management System plays a pivotal role in any electric vehicle which comprise of monitoring, controlling safeguarding the battery pack and thereby certifying the optimal conduction, permanence and safety. The sophisticated functions of BMS varying from real-time monitoring of individual cell parameter to controlling thermal conditions during the charging and discharging cycles in the battery.[2] As electric vehicle technology continues to make headway, the integration of Artificial Intelligence (AI) and Machine Learning (ML) algorithms for estimation analysis, enabling dynamic maintenance and intensifying overall system efficiency. AI circumscribe algorithms and computational models that imitates human intelligence , while ML focuses on the enhancement of systems that are trained from the data.[3] An electric vehicle mainly comprises of Battery Management System, DC-DC converter, motor, inverter, onboard charger, etc. The Battery Management System mainly comprise of battery cells which are used to store electrical energy in the form of direct current. There are several different batteries, available for this purpose in the market. Some of them are named as solid-state batteries, lead-acid batteries, ultracapacitors, nickel-metal hydride batteries, lithium-ion batteries. In current scenario, we are utilizing Lithium-ion Batteries as they are much effective and preferred type. Temperature affects these batteries to a greater extent.[4]

Fig. 1. Charge Monitoring System of EV [30]

Lithium-ion batteries have emerged as the keystone of energy storage in Electric Vehicles (EVs), uprising the automotive industry by providing a high-density and light-weight solution. Lithium-ion battery manages the performance, longevity and safety of electric vehicle effectively.[5] There is a parameter called State of Charge(SoC) which demonstrate the remaining charge of battery in EVs as cars, bicycles, etc.[6][7] All the electric vehicles if not operated under SoC then they could be dangerous. SoC cannot be considered as constant parameters and should be varied or integrated which achieve the appropriate charger design. During charging and discharging process, parameters as voltage, current, temperature should be monitored to operate the vehicle under SOC.[8] Numerous methods are there for the estimation the SoC of Electrical Vehicles but now-a-days Extended Kalman Filtering method shows the best results till now.[9] Slow (220V-16A) and fast charging (400V-70A) affects the battery parameters as well as network grid.[10] For enhancing the remote monitoring of battery parameters, Internet of Things (IoT) is introduced. The integration of Internet of Things(IoT) technology with Battery Management System represents a radical change real- time monitoring and managing of Electric Vehicles. It enhances the overall efficiency and safety of the system.[11][12]

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Incorporating the Internet of things(IoT) technology with the basic battery management system will leads towards operating man-machine interaction with running status which is also required for battery fault diagnosis and safety protection.[13][14] As BLDC motor works remains on constant speed even when voltage varies and conclusively BLDC motor and DC- DC converter can increase the overall efficiency up to 20% and regenerative braking can increase up to 10-15% of the efficiency. Hence, BLDC could be a better option.[15] IoT based EV BMS also helps to indicate the nearby charging station to the driver and also helps to increase the charging stations.[31][32] Environmental conditions are very important for better performance of the Li-ion Battery for which there must be proper cooling system should be there which helps for the proper working.[33][34]

Section-I encompasses an introduction of the current scenario of EVs battery problem, Section-II shows a review of existing methods of monitoring in the literature, Section-III explains the framework of the system, Section-IV depicts the proposed methodology and Section-V concludes this work.

II. LITERATURE SURVEY

It focuses on large scale li-ion battery management system over cloud computing, which basically gives an overview about the cloud computing algorithm for BMS of large li-ion battery, cloud-based health monitoring is discussed. [16]

This paper basically describes the monitoring of voltage, current, temperature via battery management system over cloud computing in real time monitoring, it also gives a hardware device overview. This provides an IOT based solution towards venting of li-ion batteries due to overcharging.[17]

It suggests the acquiring of Current- Input-device in the cell structure more over it supports to have Built-in positive temperature coefficient and uses NDIR sensors for detection of Co2 sensors.[11]

It proposed information about the measurement of network impact from electric vehicles during fast and slow charging, the network impact provides information that there could be different impacts over fast charging and slow charging due to weak or strong grids or different areas for example Norway has Peak Load situation over some of the coldest winter days.[8]

It describes all about BMS, it uses IOT based approach using SOC estimation that suggests a system which installs WBMS i.e. wireless battery monitoring system and further concludes over middle ware application server and packet core network by incorporating MQTT sever.[18]

This works on the problem of SOC estimation for judgement of BMS, it proposes an adaptive method of SOC estimation which gives an hybrid model based on conventional coulomb counting and with EKF correction this provides quick and reliable error monitoring and control and shows within 2% of error and 70% decreased complexity compared to EKF method of estimation of SOC.[19]

III. PROPOSED FRAMEWORK

The proposed system comprises of sensors for data acquisition purpose which collects the information and then it will be proceed to the communication router. The communication component stores the collected data in the IoT device so that it can be sent to the cloud data storage with assured security in the cloud server via IoT gateway/router. The li-ion battery is used for storing DC charge as these type of batteries have higher energy density.

This overall systemmay help over battery management system and also gives better performance.

TABLE I. COMPARISON TABLE OF WIRELESS BMS [27]

Wireless Technologies	Cloud based Wireless BMS	Bluetooth based Wireless BMS	IoT based Wireless BMS
Major Difference	Platform is executed and validated through using the small-scale cloud BMS simulator that uses Google cloud and other three IoT devices. This technique validates that resistances, SOCs and capacities of individual battery cells can be accurately estimated by the hyperthreading of condition monitoring algos in the platform.	All the data collected through the application of the battery will be displayed on personal computer(PC) with LABVIEW program and android smartphone. It will show real-time monitoring of voltage, current temperature, etc.	The system used will show the current location, battery status, and time via internet by incorporating GPS system which will be displayed on Google Map application.

Opting Internet of Things(IoT) in Wireless Battery Management System(WBMS) of Electric Vehicles enhances the performance of EVs by contributing to improve reliability, safety and user satisfaction. It is best fit for the proposed system as it enabled BMS and allows for real-time monitoring of State of Charge(SoC) and State of Health (SOH) by equipping accurate information about basic parameters as current charge level and overall health of the battery. It also sends the alert while it is facing over voltage, temperature and current.[21][22][26][27]

TABLE II. COMPARISION OF EV MOTORS [4]

Parameters	Brushless DC Motor	Switched Reluctance Motor	Induction Motor
Power (kW)	110	77	93
Maximum Speed	9000	12000	12000
Base Speed	4000	2000	3000
Efficiency	80-95%	Increases with speed	80-90%

BLDC Motor has remarkable high efficiency and a better dissolution of heat, generally BLDC motors are used to work of lesser settling time and lesser overshoot time, this type of motors may have lesser losses hence have a better efficiency. It is a cheap and cater to enforce device. Thus, BLDC motor will be a better to work in an Electric vehicle Device. It has better power to weight ration which provides better efficiency for vehicles.

TABLE III. COMPARISON AMONG DIFFERENT EV BATTERIES [4]

Parameters	Li-ion	Lead-acid	Ni-Cad	Ni-MH
Nominal Voltage (V)	3.2 to 3.7	2	1.2	1.2
Life Cycle	600-3000	200-300	1000	300-600
Energy Density(W. H. Kg-1)	100-270	30-50	50-80	60-120
Power Density(W.K g-1)	250-680	10	150	250-1000
Self-Discharge Rate	3-10	5	20	30
Charging Efficiency	80-90	50-95	70-90	65
Discharging Temperature	-20 to 60	-20 to 50	70 to 90	65
Charging Temperature	0 to 45	-20 to 50	0 to 45	0 to 45
Charging Technique	Constant Current-Constant Voltage	Constant Current-Constant Voltage	Constant Current	Constant Current
Charging Staging	Energy cell charges at a rate of 0.5c to 1c. rise in temperature of around 5ºc (9º F) at full charge.	The V-threshold is lowered by 3mv/ ºc at high temperatures. charging at 0.3 or less below freezing.	At 60 ºc, the charging acceptance level drops from 70% to 45%, respectively .0.1 c charging rate between -17 ºc and 0ºc. 0.3 c charging between 0 ºc and 6 ºc.	At 60 ºc, the charging acceptance level drops from 70% to 45%, respectively.0.1 c charging rate between -17 ºc and 0ºc. 0.3 c charging between 0 ºc and 6 ºc.

A Li-ion battery have numerous advantages as comparedto other types of batteries available in the market. It is admirable due to high energy density, long life cycle, low self-discharge rate, fast charging, lightweight design, available in compatible designs and sizes and also requires low maintenance. Although, it has some issues regarding safety but conclusively after evaluating all the parameters, it can be concluded that Li-ion battery is felicitous for the system.[22]

It is also beneficial for cloud integration where the data will be sent to the cloud for remote monitoring and it also provides an easy platform for vehicle owners to access and understand battery related information.[23] Hence, from every aspect Lithium-ion battery best for EVs.

Conclusively, a collective combination of BLDC motor, Internet of Things(IoT) and Lithium-ion battery ensures a safely operated Electric Vehicle. It also enhances the efficiency of the vehicle.

IV. PROPOSED METHODOLOGY

Our proposed methodology consists of Arduino UNO, microcontroller, Li-ion battery, Voltage regulator, Step down Transformer, Voltage sensor, Current sensor, Temperature sensor, Wi-Fi Module, Electromagnetic Relays, Buzzer, etc. that connects to an Android app.

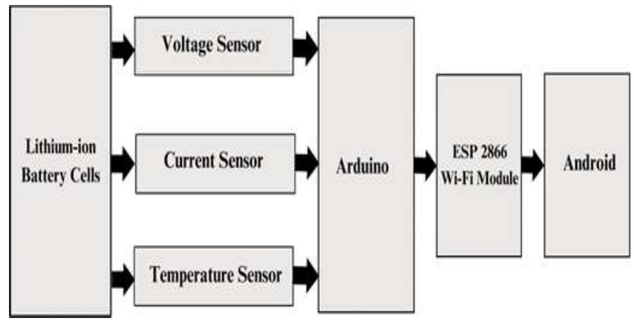

Fig. 2. Block Diagram of Proposed Methodology

A Power Supply of 220V is given to 5V Arduino UNO through a Step-down Transformer and Voltage Regulator which is used to regulate the voltage to get the desired output voltage. All the devices like sensors, buzzer etc. are connected to Arduino UNO for sharing information and follow instructions which will be further used for replica.There are 3 Li-ion cells yielding a voltage of 3.7 Volts and collectively 12V on full charging. 12V voltage is requiredto run Brushless Direct Current Motor (BLDC). Voltage Sensor, Current Sensor, DHT11 Temperature Sensor are connected near the Li-ion Battery to measure their respective parameters, they are also connected to the Analog pins of Arduino UNO to transfer the information to the Android App through ESP8266 Wi-Fi module.

If the temperature of the battery surrounding exceeds 50°C then temperature sensor will send this information to Arduino UNO which will cut-off the power supply given to the Li-ion battery for charging and turns on the fan . All the parameters are shown on the 16*2 LCD Display as well as on the Android App for monitoring. If any of the parameters exceeds thepre-defined range then buzzer starts beeping and the power supply cut-offs automatically. The following steps that taken are given in the flowchart-

1. 230V supply is provided to the step-down transformer which steps down the voltage up-to 12V.

2. Voltage regulator regulates the voltage up-to 5 Volt as the Arduino UNO works on 5V supply.

The Arduino UNO is connected with devices such as ESP8266 Wi-Fi Module, buzzer, 2x16 LCD Display, temperature sensor, fan, relays R1andR2 (which are connected for the supply of battery voltage) current sensor and the voltage sensor. When the supply is provided to the Arduino UNO, the relays then Switched ON and the battery gets charged, if any abnormal condition occurs the connected sensors will provide a signal to the Arduino UNO and automatic cut-off will be generated and charging will be switched off.

3. If the connected li-ion battery gets heated similar steps will be followed and signal will be sent via temperature sensor to the Arduino UNO and another signal is provided to the fan which is used to cool down the battery system.

4. The reading of the current and voltage is provided by the current sensor and voltage sensor which is first sent to the Arduino UNO and displayed on the LCD display for monitoring, one signal is also provided to the Wi-fi module which provides the reading over the Android or IOS based smart phone for 24x7 reading whenever it is needed it.

5. The brushless DC motor is used as a vehicle engine.

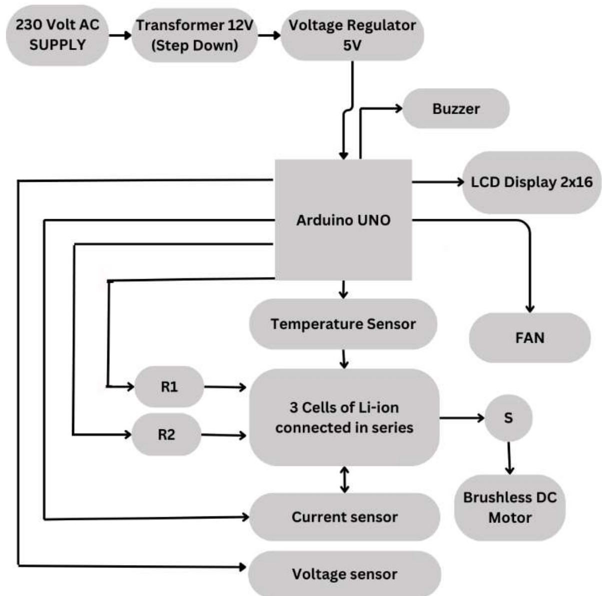

Fig. 3. Flowchart of Proposed Methodology

V. CONCLUSION

This review paper briefly explains the study of Battery Management System of an Electric Vehicle by considering several parameters which are important for monitoring and taken into consideration to avoid explosion of Li-Ion Battery Cells. Several papers are reviewed to understand the behavior of Li-Ion battery, technology used for gathering information through IoT, etc. Moreover, this paper has investigated about IoT technology that can be used for monitoring purpose of battery's voltage. The information or data we receive through different sensors is used for monitoring purpose and protecting our battery from being destroyed. It also helps to increase the life of the battery and makes it reliable to use for the Electric Vehicle.

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