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Original Article

Battery Parameter Monitoring and Control System for Electric Vehicles

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Abstract - *This paper presents a Battery Monitoring and Control system for an electric vehicle to monitor the voltage, current, and temperature of the battery and detect fire. This system consists of hardware (sensors, microcontroller, Bluetooth module, an android Smartphone) and software. It is designed with a low-cost microcontroller ATMEGA 328 (Arduino UNO). Voltage, current and temperature data are transferred to the microcontroller, and then the battery data is transferred using Bluetooth communication to the Android Application. In this work, monitoring the vehicle's parameters using an Android application is proposed so that the monitoring can be done directly. The proposed battery monitoring system is consists of two major parts i) monitoring device and ii) user interface. In this proposed system, an indication of the battery's voltage, current, and remaining charge capacity is monitored in a real-time scenario, and appropriate control measures are initiated. We have developed a data acquisition system to monitor these battery parameters by building a PIC-based system. Further, data are also displayed on an Android mobile device and are stored in a server database. A realistic model is developed here to create the final product for the proposed system.*

Keywords - *Electric vehicle, Battery Parameters, Monitoring, Control, Bluetooth module.*

I. INTRODUCTION

Electric vehicles (E.V.s) are gaining popularity as fuel prices become more expensive. Due to this scenario, many vehicle manufacturers are looking for alternatives to energy sources other than gas. The use of electrical energy sources may improve the environment since there is less pollution. In addition, E.V. produces great advantages in energy-saving and environmental protection. Most E.V.s use a rechargeable battery which is a lithium-ion battery. It is smaller to be compared with lead acid. It has constant power, and its energy's life cycle is 6 to 10 times greater than a lead-acid battery. Lithium-ion battery life cycle can be shortened for some reasons, such as overcharging and deep discharges.

On the other hand, E.V. usually has a limited travelling range due to battery size and body structure. One of the main reasons for limiting the use of E.V.s is the safety of existing battery technology. For example, overcharging a battery could significantly shorten the life of the battery but also cause a serious safety accident such as a fire [1]. Therefore, a battery monitoring system for E.V. that can notify the user about the battery's state is necessary to avoid the problems mentioned above. Previous battery monitoring systems were only monitoring and detecting the battery's condition and alarmed the user via battery indicator inside the vehicle. Due to the advancement of the design of the notification system, an android application is used to notify the users regarding the battery status. This can be considered one of the maintenance support procedures that the manufacturer can do. Motivated by the above-stated problems, the development of a battery monitoring and controlling system using a Bluetooth Module is proposed in this work.

A. Literature Review

To revise the problem objectives literature survey has been conducted. So many papers are collected, out of which three are presented and drawbacks are identified. Efforts have been made to overcome this drawback.

a) IOT-Based Battery parameters monitoring system for Electric Vehicle

This paper [1] describes the application of Internet-of-things (IoT) in monitoring the performance of an electric vehicle battery. Electric vehicle depends entirely on the energy source from the battery. However, the amount of energy supplied to the vehicle decreases gradually, which leads to performance degradation. This is a major concern for battery manufacturers. In this proposed system, monitoring the performance of the vehicle using IoT techniques is proposed so that the monitoring can be done directly. Based on experimental results, the system can detect degraded battery performance and send notification messages to the user for further action.

b) Wireless Battery Management System for Electric Vehicles

This paper [2] presents a qualitative analysis of different "wireless" communication protocols based on range, power consumption, performance, reliability, and simplicity parameters. Implementation of wireless architecture will enable a monitoring system that is cheap and accurate and result in a decrease in the overall weight and size of the battery pack. A number of wireless protocols like ZigBee (IEEE 802.15.4), Bluetooth Low Energy(BLE5.0), Near Field Communication, Wi-Fi (IEEE 802.11) and Wi-Fi HaLow (IEEE 802.11ah) are considered as part of the study in this paper.

The authors in [3] the IoT based Monitoring and Control of Faults in Power Distribution Transformers.

c) Efficient Battery Monitoring System for E-Vehicles

In this paper [4], the developed system monitors the battery parameters like voltage, current, temperature, power and state of charge. These parameters are then sent and stored in a database via the internet, which is then shown to the user by means of an android app. When a sufficient dataset is available in the database, intelligent machine learning algorithms can be used to predict the life cycle of the battery and give suggestions to the user regarding the time and duration of each charge cycle, the health of the battery and many more. If implemented in battery rental companies, the battery can only be charged when the user pays the rent on time.

d) A Critical Approach towards a Smarter Battery Management System for Electric Vehicle

The Battery Management System (BMS) is the most critical and essential component in electric vehicles. BMS assures reliability and guarantees the safety of the battery and its operation. The BMS must contain the functionality to calculate and monitor the cell balancing and charge controlling mechanisms to maintain reliability and assure safety. The battery is an electrochemical product and thus acts differently under different environmental and operational conditions. The varying nature of a battery's performance makes it challenging to implement these functions. Evaluating a battery state, which includes the state of life, state of charge, and health, is an important task for a BMS. In this paper [5], the latest research and technologies for the state evaluation and improved performance of the batteries are studied.

e) IoT Based Battery Management System for Hybrid Electric Vehicle

This paper [6] explains, in brief, the basic function of the BMS, Minimizing the risk of battery damage and monitoring the key parameters of the battery like the voltage, current, and temperature during both charging and discharging situations.

f) Overview of Electric Vehicles (E.V.s) and E.V. Sensors

E.V.s are making a significant impact on the power system and environment with fewer sensors, miniaturized components, and reduction of greenhouse gases. In this paper [7], an overview of different types of electric vehicles is also discussed in detail about the different kinds of sensors and their design for electric vehicles and automotive vehicles.

g) Battery Management System in Electric and Hybrid Vehicles

This paper [8] addresses concerns for current BMSs. State evaluation of a battery, including state of charge, health, and state of life, is a critical task for a BMS. By reviewing the latest methodologies for the state evaluation of batteries, the future challenges for BMSs are presented, and possible solutions are also proposed.

h) Battery Management System in Electric Vehicles

This paper [9] describes developing the system model for battery management in an electric vehicle by controlling the crucial parameters such as voltage, current, state of charge, state of health, state of life, and temperature. The BMS must be well maintained with battery reliability and safety. This paper also focused on studying BMS and optimizing the power performances of electric vehicles. Moreover, reducing greenhouse gases can greatly be achieved by using a battery management system.

The authors in [10] presented Dual-mode DC-DC Power Converter for Solar Battery Charger.

i) IoT Based Electric Vehicle Application Using Boosting Algorithm for Smart Cities.

The paper [11] presents the design and development of an IoT based battery monitoring system for the electric vehicle to ensure battery performance degradation, which can be monitored online. This system includes developing the hardware for the battery monitoring device and a web-based battery monitoring user interface. The system can show information such as location, battery condition and time via the internet by incorporating a GPS to detect the coordinate and display it on the Google maps application.

j. Review of Battery Management Systems (BMS) Development and Industrial Standards

The work in [12] investigates BMS safety aspects, battery technology, and regulation needs and offers recommendations. This studies current gaps in respect to BMS's safety requirements and performance requirements by focusing mainly on electric transportation and stationary application. The work further provides a framework for developing a new standard on BMS, especially on BMS safety and operational risk.

B. Problem statement

From the extensive literature available above, in all the existing methods, they have developed IOT based battery parameters monitoring systems. Even in all the methods, they are concerned only with monitoring the devices and the control action is not taken. For IOT based models, we need the internet, but the strength of the internet is not good in all areas. Here this method employs Bluetooth module HC05 to monitor the battery parameters and control and cut-off source side supply to avoid overcharging of the battery and to control and disconnect the load side circuit to avoid the damage caused to the circuit.

C. Objectives

The main objectives of this project are:
1. To monitor the voltage across the battery
2. To monitor the current drawn by the load
3. To monitor the temperature around the battery
4. To monitor the Percentage of remaining charge capacity in the battery
5. Fire sensing
6. Automatic cut-off of battery
7. Data reading in mobile phone.

II. PROPOSED METHODOLOGY

A. Block Diagram

Fig. 1 shows the block diagram of the methodology proposed, and Fig. 2 gives the flowchart, which states the process flow of parameter monitoring and controlling actions initiated.

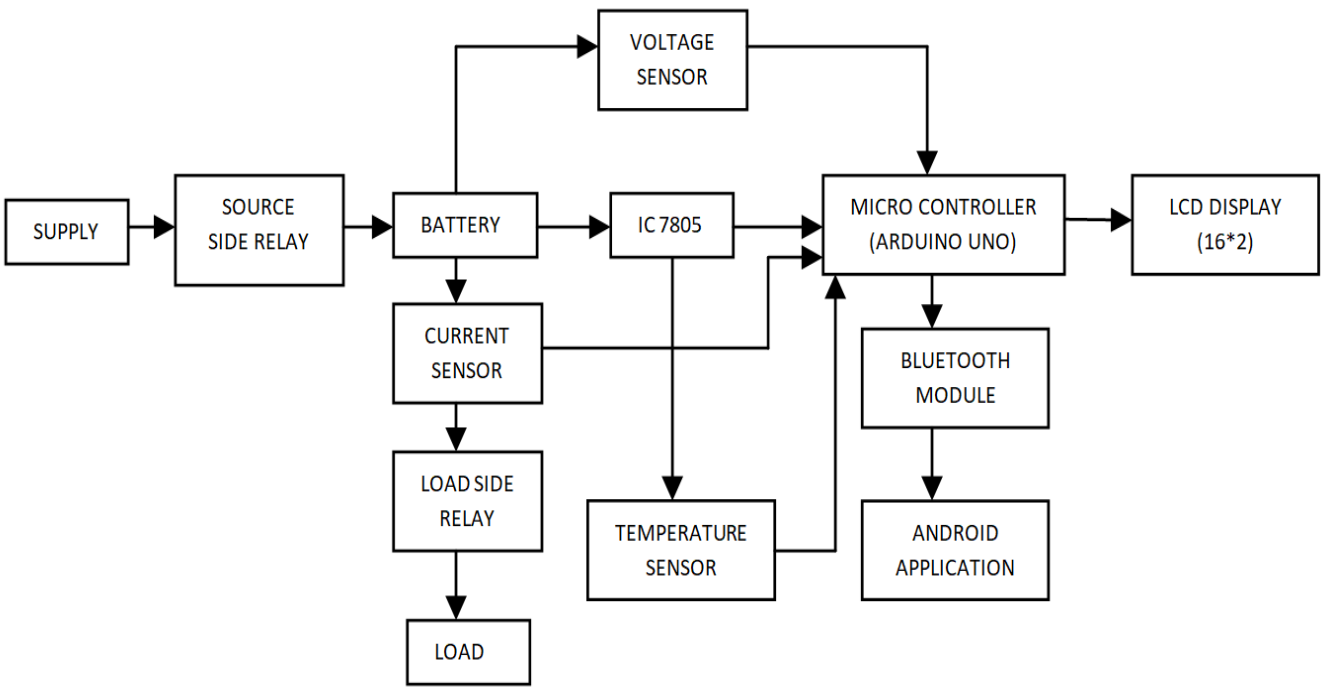

Fig. 1 Block diagram of the proposed methodology

B. Working Principle

The system shown in Fig. 1 consists of different sensors, like the current sensor, voltage sensor, and temperature sensor, for monitoring different parameters related to battery conditions in the vehicle. The current sensor monitors the amount of current flow to the load, and the voltage sensor is used to monitor battery voltage in real-time. The voltage sensor can monitor the voltage of up to 13V D.C., and the current sensor can monitor the current of up to 1A. The temperature sensor will monitor the temperature around the battery. The outputs of the current sensor, voltage sensor, and temperature sensor are analogue, and we need to convert that analogue output from the sensor into digital format. For that, we will use the inbuilt ADC of the controller, which is a 10-bit, 13-channel ADC. The information from sensors is processed in the controller and displayed on LCD. Also, this information is accessed in an android application through Bluetooth HC05. Relay is used for automatic cut off of the battery after the completion of charging to avoid the damages caused due to overcharging and deep charging. The temperature sensor can sense the fire based on the conditions used in the program and send a notification to the user.

C. Flow Chart of the Proposed System

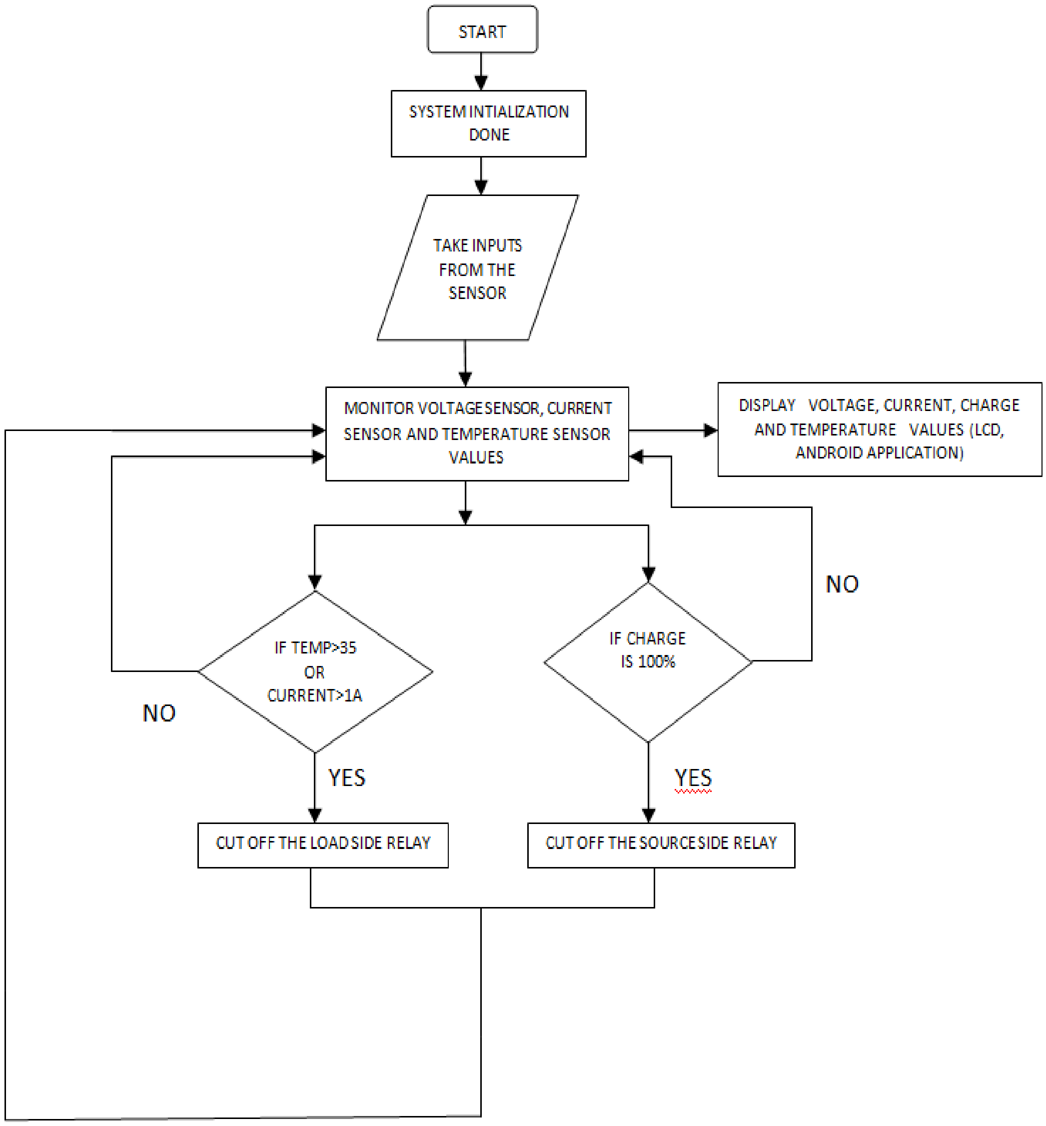

Fig. 2 Flow chart of the proposed system

III. RESULTS AND DISCUSSION

Fig.3 shows the practical setup of the proposed battery parameters monitoring and control system for electric vehicles. Initially, the battery is connected to the circuit. The voltage sensor connected to the battery terminals measures the voltage across the battery. Simultaneously, the LED bulb is turned ON, showing the working condition of the battery. The voltage level is continuously displayed on the LCD and in the Android Application; if the voltage level is reduced below 11.6V, an alert message is displayed in the application. The battery's charge level is displayed based on the battery voltage by considering Table 1.

When the battery level reaches 100%, the relay connected to the source side cuts down the supply to the battery to avoid problems due to overcharging. The current sensor is connected between the battery and load, considering the normal current supply to be till 1 ampere; if the current exceeds 1 ampere due to a short circuit or due to fault in the load side circuit, the relay separates the load from the supply. The temperature sensor senses the temperature around the battery, and the readings are continuously updated in the LCD and application (Table 2); if the temperature is found to be raised more than the normal temperature (i.e. 28 C), the load side relay separates the load from battery to avoid damages and also sends an alert message to the user via Android Application as shown in Fig. 4.

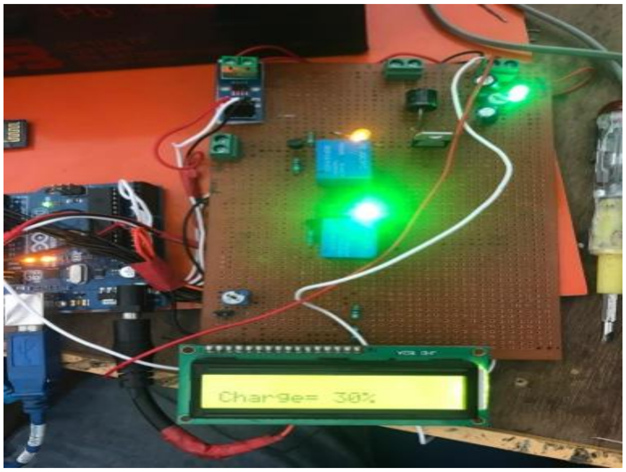

Fig. 4 Practical Setup of the Proposed Methodology

Table 1. AGM Battery State of Charge

CHARGE LEVEL	VOLTAGE
100%	13.00V
90%	12.75V
80%	12.50V
70%	12.30V
60%	12.15V
50%	12.05V
40%	11.95V
30%	11.61V
20%	11.56V
10%	11.41V

Table 2. Status display when the charge is 30%

Parameters	Display Status	Value
Charge	Battery Low	30%
Voltage	Low Voltage	11.60 Volts
Current	Normal	0.01 Amps
Temperature	Normal	28 ˚C

IV. CONCLUSION

Electric Vehicles have enormous potential for future transport communication by exchanging the present conventional vehicles. E.V.s will be becoming much more eco-friendly by saving the planet from global warming by reducing the greenhouse gases emitted from conventional vehicles. This miniaturized sensor will help reduce the cost and space and give better sensing capability for the upcoming vehicles. A lead-acid batteries real-time monitoring system was proposed here based on the onboard monitoring device with various sensors connected; an android smartphone with Bluetooth based application displays battery parameter values with and without load. It can collect and display the voltage, current, and temperature parameters of batteries over the phone. Further research on E.V.s batteries needs to be done at the laboratories in collaboration with the automobile industries, including associated sensors to give a better future with a pollution-free environment.

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