# BATTERY MONITORING SYSTEM FOR ELECTRIC VEHICLE USING IOT

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**ABSTRACT:**

This paper describes the utility of internet-of-things (IoT) in monitoring the overall performance of electric car battery. It is clean that an electric vehicle definitely relies upon at the source of energy from a battery. But, the amount of power supplied to the vehicle is reducing regularly that ends in the performance degradation. That is a chief issue for battery manufacture. On this paintings, the concept of monitoring the overall performance of the car the use of IoT techniques is proposed, in order that the monitoring may be completed at once. The proposed IoT-primarily based battery monitoring device is includes two most important elements i) monitoring device and ii) consumer interface. Primarily based on experimental effects, the gadget is successful to locate degraded battery overall performance and sends notification messages to the person for similarly motion.

## 1. INTRODUCTION:

These days, electric car (EV) is becoming famous for the reason that gas prices becoming greater expensive. Due to those scenario, many car producer looking for alternatives of energy resources aside from gasoline. The use of electrical power resources may also improve the surroundings due to the fact that there are less pollution. Similarly, EV produces top notch blessings in phrases of electricity saving and environmental safety. Most EVs used rechargeable battery which is lithium ion battery. It's far smaller to be in comparison with lead acid. In reality, it has a constant energy, and power's existence cycle is 6 to ten instances extra as compared with lead acid battery. Lithium ion battery lifestyles cycle may be shortened by way of some motives such as overcharging and deep discharges. Then again, EV typically has constrained variety of journeying because of battery size and frame shape. Now, an vital cause that limits the application of EV is the protection of present battery technology [1]. For instance, overcharging battery now not only could drastically shorten the existence of the battery, however additionally reason a serious protection injuries including fire [2-4]. Consequently, a battery tracking machine for EV that may notify the user about battery circumstance is necessary to save you the said problems.

Previous battery tracking gadget handiest reveal and discover the situation of the battery and alarmed the consumer via battery indicator inside the vehicle. Due to the development of the design of notification device, internet of things (IoT) generation may be used to notify the producer and customers regarding the battery popularity. This may be considered as one of the upkeep help. Manner that may be completed via the manufacturer. IoT utilizes internet connectivity past traditional application, in which diverse range of gadgets and regular things may be related via the internet, making the sector is on the person's finger hints. Motivating by way of the said problems, on this work, the layout and development of a battery monitoring system the usage of IoT era is proposed.

The remainder of the paper is prepared as follows. Phase 2 opinions the numerous wireless conversation technology and wireless battery monitoring structures for industries and EVs, phase 3 presents design and implementation of the gadget, section 4 describes distinct exams carried out, section 5 discusses the main issues confronted and section 6 eventually gives the conclusions of the paintings.

## 2. RELATED WORK

### Technology Based on Wireless Communication

Wireless communique is a type of data verbal exchange this is accomplished and delivered wirelessly. This is a vast term that includes all strategies and types of connecting and speaking between two or extra devices using a wi-fi signal through wireless verbal exchange technologies and devices. From the preceding paintings there are several varieties of era which have been used for wi-fi battery tracking system consisting of GSM, ZigBee, GPRS, Android, WIFI and Bluetooth communication. GSM (global device for cell communique) is a form of wireless communique which are very famous worldwide. Its frequency band is both 900MHz or 1800MHz. There are a few advantages and drawbacks for the GSM module. An advantage of GSM is that it has no problem with global roaming. How ever notice that, maximum of the generation are patented and have to have license from QUALCOMM Corp. There are numerous literatures on battery monitoring and control using wireless communication.

Worldwide Positioning gadget (GPS) makes use of GPS satellite tv for pc to transmit statistics that gives place and the modern time to a GPS receiver globally. It synchronizes the operation in order that these repeating alerts are transmitted at the same on the spot. The signals, transferring at the rate of mild, arrive at a GPS receiver at barely distinctive instances because a few satellites are similarly away than others. The distance to the GPS satellites may be determined with the aid of estimating the quantity of time it takes for hizzor her indicators to attain the receiver.

When the receiver estimates the distance to at least four GPS satellites, it is able to calculate its role in three dimensions. The accuracy of a function determined with GPS relies upon on the kind of receiver. Maximum client GPS devices have an accuracy of about +/-10m. Other styles of receivers use a method called Differential GPS (DGPS) to gain an awful lot higher accuracy [5]. A piece carried out in [5] utilized GSM/GPS in monitoring and handling an EV battery. Android is an operating device for cell telephones, capsules and a developing variety of devices encompassing the entirety from wearable computing to in-car amusement. Android is a Linux- primarily based software gadget, and just like Linux, is unfastened and open supply software. It is able to be advanced via every body as it's miles Linux-based open supply.

The running device is ready to tell you of a new notification, SMS, e mail or maybe the modern day articles from an RSS Reader. Unfortunately, it constantly need an active net connection or at the least GPRS net connection in that area in order that the tool is prepared to go online to match people's wishes. Moreover, the working machine has a number of technique inside the history causing the wasteful of batteries.

EV based totally on GPRS communique includes online monitoring terminal to measure battery parameters (voltage and temperature) with GPRS records transmitter unit and a person interface for battery monitoring [12]. Rahman et al. Proposed a battery control system for EVs the usage of ZigBee communication and factor-to-point wireless topology [13]. ZigBee was used due to its low power intake, low-fee, excessive reliability and coffee facts quotes. They concluded that wireless battery management system is important for EVs in particular to balance the fee to decorate battery lifespan, but it isn't efficient for controlling battery temperature. Extra these days, Menghua et al. Supplied a lithium-ion batteries monitoring gadget the usage of WIFI verbal exchange for EVs that collects and displays voltage, current, temperature and other parameters of batteries on a phone [14].Primarily based at the described preceding work, it suggests that there are no computerized tracking gadget available to inform the person with reference to the overall performance of the battery. Therefore, the used of IoT generation that consists of collectively within the tracking machine can help in improving the preventive maintenance in making sure the battery high-quality and boom the protection of the person.

**Technology based on wirelesss battery monitoring system**

Reliable battery management is vital for protection purposes. There are several motives that motive battery breakdown such as deterioration of battery and layout defects. Manual battery tracking device are like regular battery monitoring system because of this that it does not save the statistics into the database. However handiest show the records gathered in actual time. Consequently, it's miles essential to remotely monitor battery structures using wi-fi generation. There are various battery tracking gadget the usage of wireless verbal exchange which have been evolved for the enterprise along with uninterruptible strength deliver (UPS) which is critical to make sure continuity of strength deliver for home and commercial for the duration of energy interruption. Suresh et al. Proposed a p.C-based battery health monitoring device for an americausing GSM modules and SCADA through offering alert messages whilst batteries are in essential situation and room temperature [6]. Sardar et al.

EV based totally on GPRS conversation includes on-line tracking terminal to degree battery parameters (voltage and temperature) with GPRS statistics transmitter unit and a consumer interface for battery monitoring [12]. Rahman et al. Proposed a battery control machine for EVs using ZigBee verbal exchange and point-to-factor wi-fi topology [13]. ZigBee became used due to its low strength intake, low-fee, high reliability and low records quotes. They concluded that wi-fi battery control device is vital for EVs in particular to stability the charge to enhance battery lifespan, but it isn't always green for controlling battery temperature. More recently, Menghua et al. Supplied a lithium-ion batteries monitoring gadget using WIFI communique for EVs that collects and shows voltage, current, temperature and other parameters of batteries on a phone [14].Based on the described previous work, it suggests that there aren't any computerized monitoring gadget available to notify the consumer with regard to the overall performance of the battery. Consequently, the used of IoT technology that consists of collectively in the tracking machine can assist in enhancing the preventive maintenance in making sure the battery high-quality and boom the protection of the consumer.

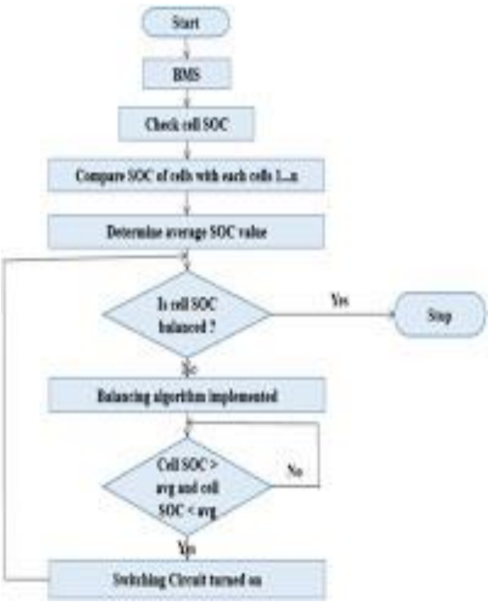


Fig.1 System Flowchart

### Hardware Design

Initially, in order to verify the suitability of the hardware parts, the design of the system was developed using Fritzing software. Figure 2 illustrates the circuit design of the system. The figure shows the system is consists of a voltage sensor, an Arduino Uno microcontroller, a SIM808 GSM/GPRS/GPS module and a 9V battery for power supply. Figure 3 shows the actual hardware design of the proposed IoT-based battery monitoring system. As shown in the figure, the design of the system is similar to the circuit prepared using the Fritzing software.

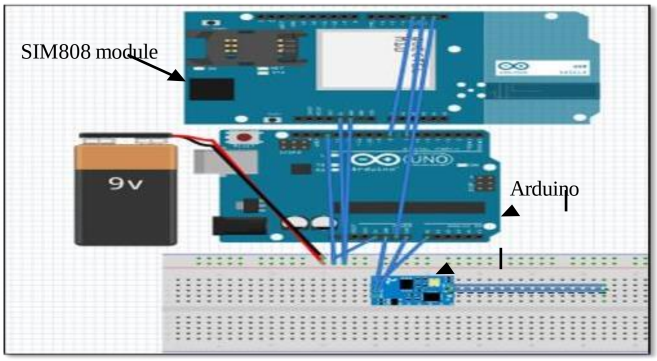


**Fig. 2:** The design of the circuit using Fritzing software.

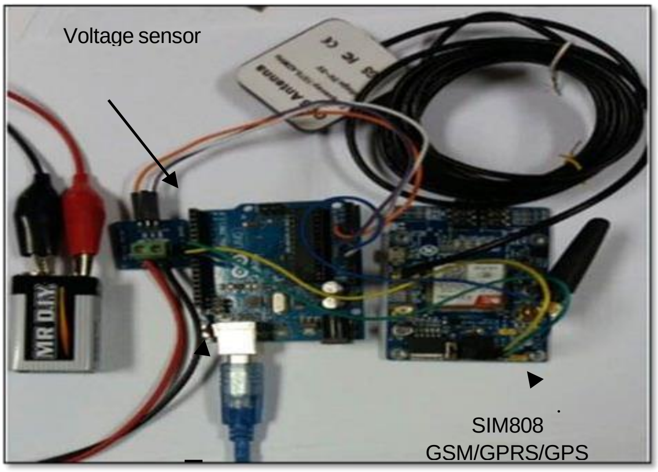


Fig. 3: The actual design of the hardware for the proposed battery monitoring system

## 2.EXPERIMENTS AND ANALYSIS

This section reports the experiments and analysis of the system. First, experiment steps and results on the characteristics of voltage sensor, GSM module will be described. This is to make sure the circuits are in good condition. Then, experiments and results to verify degradation of battery will be explained.

### Voltage Sensor Experiment

In this experiment, the values of five (5) batteries was measured using a multimeter as shown in Figure 4. Then, these values were compared with the values of the same batteries that were connected to the voltage sensor circuit as shown in Figure 5. The purpose is to show the differences and accuracy percentage between both values. The selected batteries were varied in voltage values. The batteries were a mixed of new and used ones. The results of measurement will show these differences.

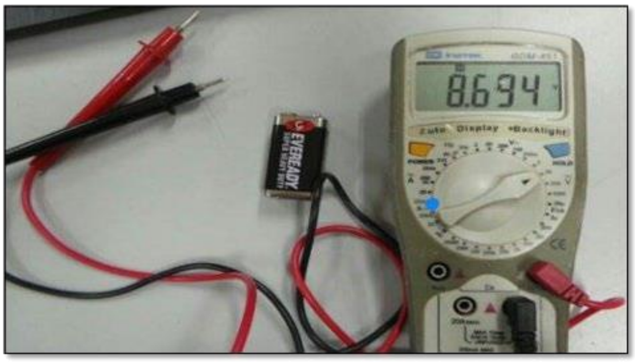


**Fig. 4:** Battery voltage measurement using multimeter

**Table 1:** Voltage measurements results

| Battery | Voltage measurement results | | Accuracy percentage (%) |
|---|---|---|---|
| | Voltage sensor | Multimeter | |
| 1 | 3.81 | 3.79 | 99.47 |
| 2 | 9.98 | 9.91 | 99.29 |
| 3 | 8.70 | 8.55 | 98.27 |
| 4 | 1.25 | 1.23 | 98.40 |
| 5 | 3.81 | 3.79 | 99.48 |

Table 1 shows the result of the experiments. As shown in thetable, since the batteries were a mixed of used and new batteries, the values are different from each other. From the results, it shows that the accuracy of the voltage measurements taken from voltage sensor are quite similar to the measurements taken using multimeter. The accuracy percentage for all of the measured batteries are above 99%. Therefore, it can be concluded that the voltage sensor provides valid measurement values of the batteries.

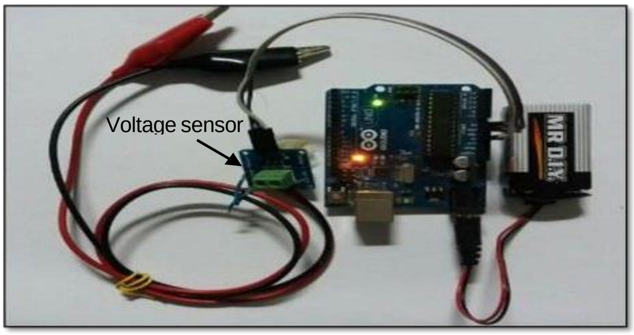


Fig. 5: Battery voltage measurement using voltage sensor circuit

### GPS Module Experiment

In this subsection, the characteristic of the SIM808 GSM/GPRS/GPS module was verified to determine the accuracy of the GPS coordinate. Furthermore, this experiment will also determine the functionality of the module. Figure 6 shows the experimental setup of the module. The experiments were done at five (5) different target locations, where the coordinates of each location were collected via GPS. These GPS coordinates were then compared with the coordinates derived from Google Maps website.

**Fig. 6:** SIM808 module experimental setup

Table 2 shows the results of the experiment. As shown in thetable, there are five (5) different target locations. The table shows the coordinates of all target locations taken from Google Maps and SIM808 module. From the results, it shows that the accuracy of the coordinates taken from SIM808 module are quite similar to the coordinates derived from Google Maps. The accuracy percentage for all of the measured coordinates are near 100% accurate.

| No. | Place | Coordinates from Google Maps | Coordinates from SIM808 module | Accuracy percentage (%) |
|---|---|---|---|---|
| 1 | Taman Universiti | 1.852154, 103.073998 | 1.852150, 103.073798 | 99.99 |
| 2 | HEP of UTHM | 1.856250, 103.084588 | 1.856240, 103.084580 | 99.99 |
| 3 | McDonald's, Taman Universiti | 1.848993, 103.075913 | 1.848980, 103.075920 | 99.99 |
| 4 | FKEE Block G, UTHM | 1.859067, 103.088704 | 1.859073, 103.088704 | 99.98 |
| 5 | KKTD I, UTHM | 1.862602, 103.089685 | 1.862638, 103.089680 | 99.96 |

**Table 2: Coordinate measurements results**

Therefore, it can be concluded that the SIM808 module provides valid coordinates that can be used in the proposed Battery Monitoring System. Figure 7 shows an example of the output from SIM808 module showing the location of a treat position.

**Fig. 7:** Output from SIM808 showing the location of a target position

**Battery Monitoring System**

The proposed battery monitoring system in this work is consists of a voltage sensor and SIM808 module. Experiments and analysis to show the characteristics and usefulness of the sensor and module have been presented in the previous subsections. Therefore, in thissubsection, the battery monitoring system usefulness is demonstrated.

Figure 8 shows the developed hardware circuit of the battery monitoring system. In the figure, the voltage sensor is connectedto the SIM808 module. The system has been verified to display voltage values and coordinates simultaneously. The voltage values and coordinates are updated in real time with a one (1) minute delay. The marker will bounce when the battery voltage value is lower than 2.8V with duration less than 2.4 hours.

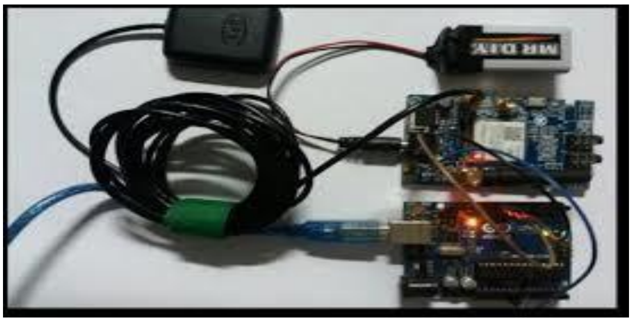

**Fig. 8:** Hardware for the developed battery monitoring system consists of voltage sensor and SIM808 GSM/GPRS\GPS module

Experiment to Determine Degraded Battery

Analyses has been carried out to determine degraded batteries by measuring the discharge rates of the battery against time. Basically, EVs utilize lithium ion batteries in bulk quantity. Therefore, in this project an experiment has been conducted to determine battery degradation by using two (2) 3.7V Li-MN batteries, where one (1) battery was in a new condition and another one was a degraded battery. Figure 9(a) shows an image of the 3.7V Li-MN battery. When a 3.7V Li-MN is discharged, there is a low cut-off voltage value that determine the battery is fully discharged.When it or 100% Depth-of-Discharge (DOD). In this experiment, in order to determine the degraded battery, the duration of the discharge battery per time was calculated. If the speed of the discharge state to reach the cut-off value is approximately 30% or less than from the speed of the healthy battery, it means that the battery is categorized as degraded battery. Usually, a 3.7V Li-MN battery takes 8 hours tocompletely reaching the minimum voltage of discharge state. Table 2 shows the grading of condition of the battery based on the duration taken to reach the cut off reaches the cut-off value, it means that the battery is at 0% discharged.

The time taken for a battery to discharge is depends on the capacity of the battery. The capacity of the battery is reduced as the maximum cycles are reached. Due to this reason, the timetaken to complete the discharge state are shorten. From Table 3, it shows that if the duration takes 2.4 hours to complete the discharge state, it means that the battery is near to degrading condition.An experiment has been carried out to test the degrading conditionof batteries using electronic cigarettes or vape. Figure 9(b) showsan image of the vape. Two (2) 3.7V Li-MN batteries (one (1) new condition and another one is in degraded condition)

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have been used in this experiment. Initially, both batteries were fully charged. Then, both batteries were inserted into vapes and the voltage readings were taken every one (1) hour for comparison. Table 4 shows the results of voltage readings for both batteries. Asshown in the table, the new battery takes 8 hours to complete the discharge state. Furthermore, the cut-off voltage value for the battery is 2.8V.


**Fig. 9:** Lithium Battery Types

**Table 3:** Battery grading based on duration to reach cut-off voltage value

| Duration taken to reach the cut off(hour) | Percentage of time taken toreach the cut off (%) | The condition ofthe battery |
|---|---|---|
| 8 | 100 | Good |
| 4 | 50 | Moderate |
| 2.4 | 30 | Bad |

**Table 4:** Battery for time taken to reach the cut off

| Duration taken to reach the cut off (hour) | Voltage readings for new battery (V) | Voltage readings for degraded battery (V) |
|---|---|---|
| 0 | 3.79 | 3.20 |
| 1 | 3.68 | 3.04 |
| 2 | 3.45 | 2.80 |
| 3 | 3.20 | 2.80 |
| 4 | 3.01 | 2.80 |
| 5 | 2.93 | 2.80 |
| 6 | 2.90 | 2.80 |
| 7 | 2.85 | 2.80 |
| 8 | 2.80 | 2.80 |

**Battery Monitoring System User Interface**

The developed battery monitoring system is also consists of a web-based user interface. The user interface is capable to monitor multiple battery monitoring devices' locations, and the conditions of batteries. Therefore, the idea of the user interface has taken into consideration the situation where there is a need to monitor multiple batteries conditions.


Fig. 10: User interface for the proposed battery monitoring system

Figure 10 shows the main page for the web-based user interface. Auser needs to login prior to use the interface. The login page is built for a secure data handling, where user is required to key-in username and password.

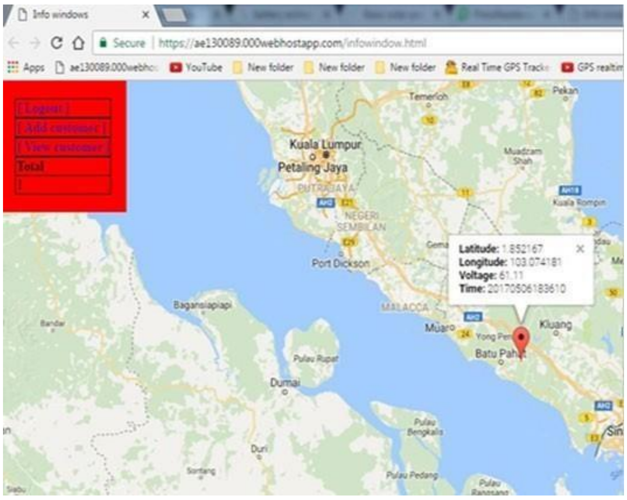


**Fig. 11:** Battery monitoring interface showing detail of a battery monitoring device. The location, battery voltage reading and time areshown.

Once the user has successfully login into the user interface, the battery monitoring interface is displayed. The interface shows a map based on Google Maps application of the location of registered battery monitoring devices marked by red markers. Ifthe battery voltage condition of a device is approaching cut-off discharge state, the red marker will bounce continuously at the location. Clicking the bouncing red marker will show the information of the device such as location (latitude and longitude),battery voltage reading and measured time as shown in Figure 11. This information can be used for the user/admin to inform the users/clients about their battery condition especially during critical battery condition or degraded battery.

Furthermore, based on Figure 11, the upper left of the interface (red box) shows a selection window where the user/admin can choose Logout, View customer and Add customer. The user can opt to log out safely by clicking Logout. View customer is to view the list of battery monitoring devices that are being monitored.Add customer is used to add new battery monitoring devices to be monitored.

When *View customer* is clicked, the interface shows the list of battery monitoring devices as shown in Figure 11. The list shows detail information about the registered battery monitoring devices, such as user name, phone number and users' address. Furthermore, the user can view battery information for each device. A registered data can be deleted by clicking Delete.

The developed battery monitoring device user interface is designed to assist user/admin monitoring degradation of batteries so that notification can be sent to the user of a battery monitoring device.

## Conclusion

The paper described the layout and development of an IoT-based battery monitoring gadget for electric powered automobile to make sure the battery overall performance degradation may be monitored on-line. The objective is to proof that the idea of the idea may be found out. The improvement of the machine consists of the development of the hardware for the battery monitoring device and an internet-based battery tracking consumer interface. The machine is successful to expose data including location, battery situation and time via net by way of incorporating GPS device to locate the coordinate and show it at the Google Maps software.Further change can be finished to improve the device via including extra features into the machine. The system may be utilized in smartphones by using developing smartphone software which could assist consumer to screen battery and as a battery degradation reminder. In an effort to enhance the internet connection, Ethernet can be used to get a better internet connection in comparison to GPRS.

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