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Internet of Things in Battery Management System

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Abstract: The battery is a vehicle's most important component. The optimum restoration of any battery is therefore very necessary for optimal performance. In automobile batteries, Lead Acid batteries are generally used and must be carefully inspected to operate more effectively in all conditions. Therefore, a more systematic battery control system is needed to enable constant monitoring of the battery's performance. The battery's SoH (State of Health), SoC (State of Charging), and SoD (State of Discharging) are the most crucial characteristics when it comes to batteries. There are several cogent methods for calculating such parameters. However, such methods cannot provide precise findings since the battery's materials, its environment, and the load it is under will all affect the parameters. Gases like hydrogen and oxygen are released when a battery is overcharged. This Battery Management System (BMS) uses sensors and an STM controller to show the voltage, current, and temperature of the battery in addition to attempting to identify the release of various gases from the battery in overcharge conditions. Additionally, it has a GPS module that enables vehicle tracking. Using IoT (Internet of Things) we can store on cloud and display when required

Keywords: Battery Management System, Internet of Things, State of Charging, State of Discharging, State of Health.

Introduction

The Battery's State of Charge and charge level indicate how much charge the battery can retain or, put another way, how much charge the battery has. The SoC parameter of the battery may be measured using a variety of methods. Each of those actions has drawbacks of its own [1]. There will no longer be a chance to overcharge the battery if the share is effectively assessed. But since each of them has its restrictions, there can be instances where the battery gets overcharged. The alternators will include the regulator for internal voltage that may provide steady voltage in the situation of car batteries as well. Failure might have several harmful repercussions.

Gases like hydrogen and oxygen, among others, may be released as a result of overcharging. They are created by evaporating the electrolyte's aqueous solution [2] that is sulfuric acid. Furthermore, there is a high chance of hydrogen sulfide fuel line emissions. These all gases are combustible, which makes them hazardous to work in commercial settings. The batteries might blow up in the event of a small spark near such gases. Therefore, it will be necessary for the identification of such gases, should they be released, and for the development of an alarm to prevent the battery from overcharging, so protecting you from any risks. An automobile battery can also be found in the same situation. In addition to the detection system for the gas and critical metrics such as temperature, voltage, and currents that are constantly monitored [3], we can also incorporate a GPS tracker within the car to enable us to follow it wherever it goes. We also provide permission for such values to be stored in the cloud.

MQ-8 HYDROGEN SENSOR

MQ-eight An electrochemical fuel sensor called a hydrogen fuel sensor is sensitive to the presence of hydrogen fuel in the environment. It can find various hydrogen amounts inside the environment and deliver accurate findings [4]. When exposed to clean air, it offers increased resistance. The resistance falls off as it

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becomes farther exposed to hydrogen, which increases the sensor's sensitivity. The sensors extrude in resistance when exposed to hydrogen may be utilized to track the output voltage.

With the use of a potentiometer, variable load resistance may be achieved. We will decide mine the awareness of the Hydrogen fueling released in ppm using the sensitivity curve of the Hydrogen fueling sensor MQ-eight, We can see a graph which is created between the ppm (at X-Axis), the proportion Rs/R0 (at Y-Axis). Before being exposed to both clean air and gasoline, the sensor has to be properly calibrated. By connecting the sensor output to the microcontroller's analog input, the voltage across the sensor can be calculated. The sensor's output voltage is the analog signal that has been digitally processed.

We will compute the sensor resistance using a simple voltage department rule of collecting resistance since the output voltage and the extrude in resistance of the sensor are identical. This sensor resistance is estimated using the sensor output while being exposed to both clean air and hydrogen fuel. Here, the gas sensor's resistance when exposed to hydrogen fuel is Rs, but the gas sensor's resistance when exposed to fresh air is R.According to the voltage department rule, when two resistances, let's say R1 and R2, are connected in series, the voltage across R2 is provided by:

$$VR2 = (Voltage\ Applied * R2) / (R1+R2) \quad (1)$$

The circuit diagram for a gas sensor is shown as follows:

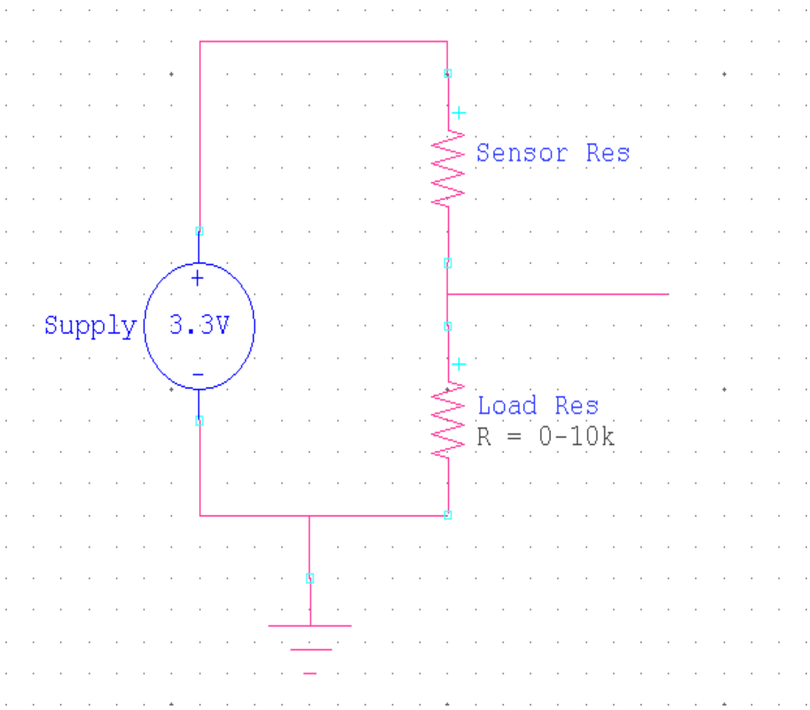

Figure 1. Circuit diagram of a gas sensor

In this example R1 and R2 are sensor resistance and load resistance. By adjusting the potentiometer, the load resistance may be tuned to a certain value. When the sensor is in contact with clean air, R1=R0 and the output voltage are measured. the output number "1023" refers to the highest voltage of the A2D (analog to digital) converter built into the microcontroller, which is 3.3 volts, and the output value "0" to the lowest voltage of 0 volts. By rearranging, the value of R0 is obtained (1), Where VR2=V0 is the digital output of the analog-to-digital converter built into the microcontroller when the sensor is exposed to fresh air, and RL is the load resistance of the fixed potentiometer, which must not be disturbed. The maximum applied voltage is 3.3V, mapping to the digital number 1023. The ADC output voltage is thus V0.

$$R0 = ((1023 / V0)-1) * R \qquad (2)$$

The sensing element's resistance reduces when it is in contact with atomic number 1 gas, dynamically increasing the value of R0 to Rs, which is then calculated to equal in (2). We may calculate the corresponding hydrogen concentration in components per million by determining the correlation points [5] from the hydrogen gas standardization curve. Thus, we frequently obtain the size relation Rs / R0 (ppm). The points of the calibration curve are awarded on an index scale. As a result, we should multiply the computed ppm value by the appropriate Rs/R0. Let,

X1 = log (Rs/R0) obtained X2 = log (Rs/R0) initial X3 = log (Rs/R0) final,

X4 = log (initial ppm) X5 = log (final ppm)

Next, the amount of hydrogen in ppm (parts per million) is calculated as follows:

$$log\ (ppm) = [(X1 - X2) / \{ (X3-X2) / (X5-X4) \}] + X4 \qquad (3)$$

The following table lists the hydrogen emission rates at various charging voltages: Table 1 displays the overcharge voltage and associated hydrogen emission.

Overcharging Voltage for a cell (Charging period = 1Ah)	**Hydrogen emission**
14 Volts	226.02 ppm
14.4 Volts	554.72 ppm
16 Volts	947.65 ppm
16.5 Volts	1171.47 ppm
18 Volts	1624.36 ppm
18.6 Volts	2257.14 ppm
19 Volts	3251.25 ppm
20.5 Volts	3622.59 ppm
22 Volts	5714.97 ppm
23.6 Volts	8201.03 ppm
24 Volts	9106.32 ppm
24.4 Volts	9737.19 ppm
25 Volts (ALERT ISSUED)	10001.23 ppm (1% in the air)

Measurement of the fundamental battery characteristics:

Monitoring the fundamental battery metrics is crucial for the battery management system. Voltage, current flow, and temperature are fundamental battery characteristics [6]. These variables must be measured often since they are crucial.

Voltage and Current Measurement*:*

The voltage of battery does not provide any information on the battery's charge level or charging voltage when the battery is being charged. It's not necessary for the voltage recorded at the battery terminals and the voltage used for charging to match. The voltage of a drained battery with no load connected may be about 12.5 volts (for lead-acid batteries). To measure the voltage at the battery terminals, we need a sophisticated circuit. Alternatively, we may use any voltage detecting module.

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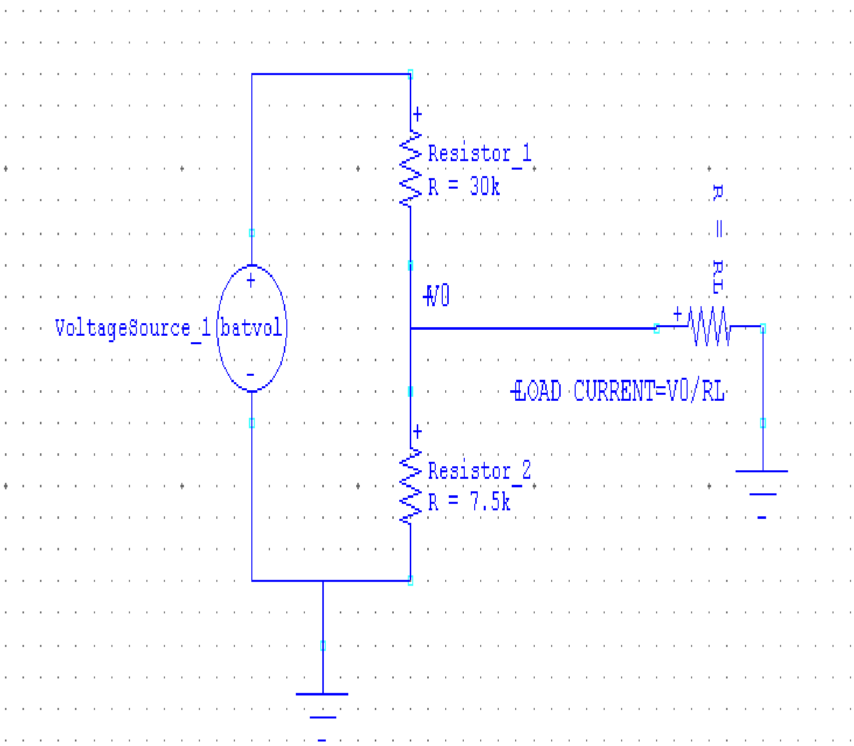

Figure 2. Voltage and current measurements using a circuit

Additionally, we may use the ACS712 Hall Effect current sensor module. The voltage that results from the intersection of the electric and magnetic fields may be used to calculate the current leaving the battery using the Hall effect concept. Once more, using the analog to digital converter, The microcontroller may be given input voltage, and the output can be obtained suitably. Using the sensitivity of the current sensor, we can determine the current delivered by the battery if V0 is the ADC's output. At that specific load and voltage. The ACS712's maximum current sensitivity is 185 mV/A, and the current is calculated as follows:

$$I = (V0 - (2^{Resolution\ Bits})/2) / 0.185\ Amp. \quad (4)$$

Temperature's Measurement:

The battery's temperature is a crucial factor since it tells you how the battery is doing right now. An unstable battery, or more particularly, a battery that behaves abnormally, is indicated by a high battery temperature. We search for the thermistor to measure the temperature. The resistance of a thermostat or device varies with temperature. When the voltage between the two resistors changes, which is similar to a change in temperature, the change in resistance reflects that change. This is coupled to a series resistor in a voltage divider network. This is sent as input to the analog to digital converter on the microcontroller, which determines the battery temperature by applying the Steinhart-Hart equation. The Steinhart-Hart formula is as follows:

$$T\ (in\ K) = 1 / (A + B * \ln (R) + C * [\ln (R)]^3) \quad (5)$$

In equation no. 5 resistance (R) of the thermistor is determined using the same formula as A, B, or C, depending on the kind of thermistor utilized (2). These temperature readings are gathered and sent to the cloud. The link between charging voltage and battery temperature is seen in the graph below:

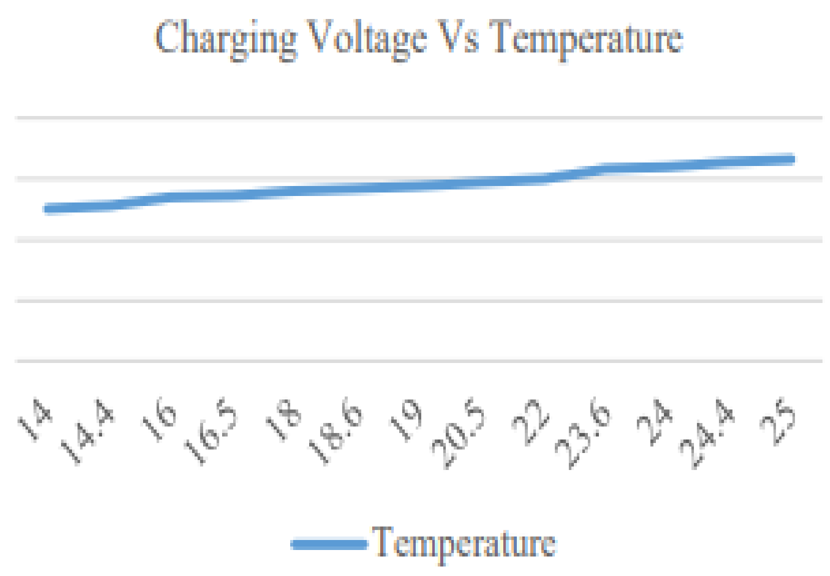

Figure 3. Charging, voltage, and temperature relationships

GPS-based vehicle tracking:

Vehicle tracking allows us to track the whereabouts of the vehicle by obtaining the latitude and longitude of the moving car when integrated into a car battery management system. Live monitoring enables us to identify the precise location of the vehicle in the event of a battery problem [7]. The UBlox Neo6M V2 module is the GPS module that is utilized. It's easy to utilize this module while driving. We can quickly locate the automobile even if our phone is not nearby. Invalid data will be displayed in NMEA (National Marine Electronics Association) instructions if the GPS cannot obtain a reliable fix. In the majority of its instructions, it is indicated by a string of commas and an 'A' value. A blue LED will begin blinking once it is beneath three-plus satellites.

The NMEA commands begin to contain the value "V," which stands for the value of a good solution, as soon as the GPS obtains a good solution. The needed instruction, where latitude and longitude are shown and extracted, is obtained from a sequence of five NMEA commands that are serially provided to the microcontroller. In fractional degrees and minutes, latitude and longitude are given. It is transformed into precise information with precise minutes, seconds, and degrees before being transferred to the cloud. That enables us to locate cars even without using our phones. This module has the benefit of having a built-in battery storage capacity and being simply attached to the microcontroller, making it convenient to use.

The interface between a GPS (Global Positioning System) and a microcontroller is depicted in the following graphic as a typical block diagram:

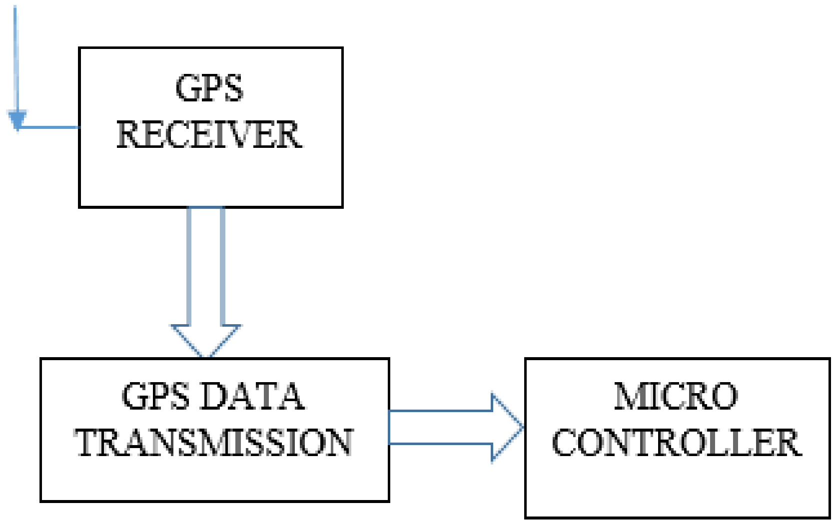

Figure 4. Block diagram of GPS and Microcontroller interface

Transmitting data to the cloud

Technology in the Internet of Things is developing extremely quickly. By linking the battery management system with the Internet of Things, we can access the data collected from the batteries from any location using a mobile device or save it in the cloud and access it whenever we need it for analysis. The usage of a GPRS module allows for the collection of data from the controller and the presentation of that data via one of the carrier services that are offered in the cloud. Sending AT instructions enables GPRS verification.

The microcontroller receives the GPRS request and answers messages and processes them before sending the data to the GPRS and adjusting for any necessary delays. The website server indicated in the GPRS bearer services has the stated values. After being linked to the carrier, the data may be posted to the website and then seen online. The URL of the website to which we must publish must be specified while setting the GPRS. GPRS The module receives power from the 12 V adapter. The graphic below displays the block diagram of the interaction between the GPRS module and the microcontroller:

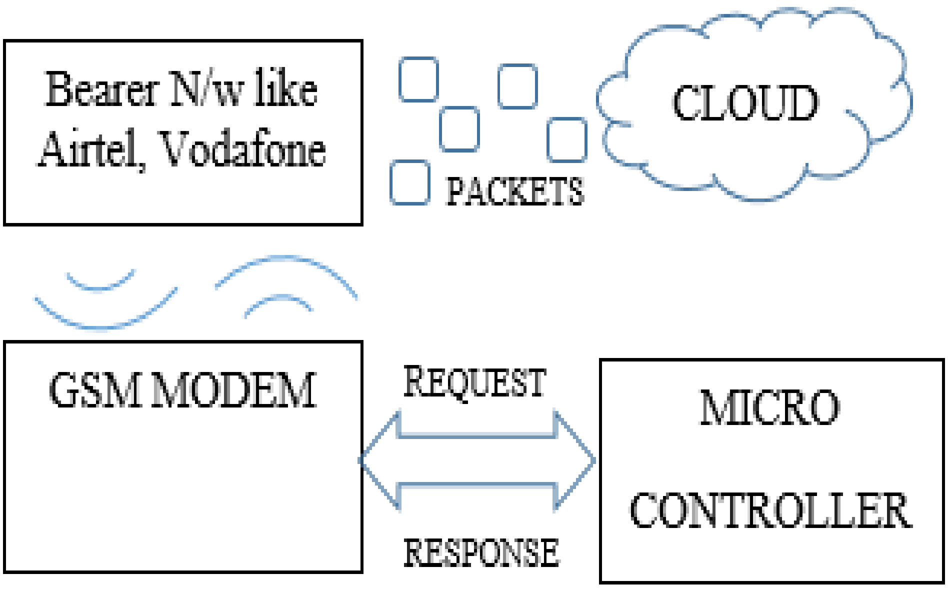

Figure 5. Block diagram of GPRS and Microcontroller interfacing

Before setting the bearer, settings and specifying GPRS as the connection type, we must first attach the GPRS. The next step is to supply the website server's IP address or URL. The next step is to declare whether we should use GPRS for getting or POST. The results acquired from the sensors and modules are published to the website server [8] if everything is perfect.

Future scope

Because the aforementioned architecture can be included in mobile devices, it is possible to create an Android application to show this data. This raw data may be gathered and sent to mobile phones as an SMS message even with a GSM modem. Mobile devices allow for the collection and viewing of data even in rural areas with poor internet connectivity. A multi-battery monitoring system may be built using this prototype as well.

Conclusion

The detection of hydrogen gas released by batteries has been covered in this study. Its goal is to make the vicinity of the battery extremely safe, which can help to produce an environment that is not harmful. Basic battery metrics also aid in keeping an eye on the health of the battery. The battery management system's interface with the cloud and IoT facilitates data analysis. Additionally, this BMS has a GPS tracker that enables vehicle monitoring and fast assistance. supplied. In light of all of this, a prototype model was created, implemented, and tested with success.

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