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Battery Monitoring System

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Abstract: In this paper, real-time monitoring the battery based on Internet of things. For safe and reliable operation of batteries on electric vehicles, the online monitoring and states estimation of the battery is necessary. To make it convenient for every vehicle owner to monitor the battery status of their vehicles anytime and anywhere. The Battery Monitoring System will monitor the battery's parameters continuously. Our proposed system monitors the State of Health, State of Charge and Depth of Discharge. We using an IOT technology for communicating the information. Buzzer alarm is used for indicating the abnormal condition of the battery. LCD display isused to display the information.
Key Word: Battery; IoT Technology; LCD Display; Sensor; Power Supply Unit; Micro Controller.

1. Introduction

A Battery Monitoring System (BMS) can monitor several critical parameters of a battery, including State of Health (SoH), State of Charge (SoC), and Depth of Discharge (DoD) refers to the overall health or condition of the battery. The BMS can monitor the internal resistance of the battery, the capacity of the battery, and other parameters to determine the battery's SoH. This information helps the user to determine when the battery needs to be replaced or serviced. State of Charge (SoC) refers to the amount of charge stored in the battery at any given time. The BMS can measure the voltage and current of the battery to determine its SoC. This information is important because it allows the user to know how much charge is left in the battery and when it needs to be recharged. Depth of Discharge (DoD) refers to the percentage of the total capacity of the battery that has been discharged. The BMS can monitor the voltage and current of the battery to determine the DoD. This information is essential because discharging the battery beyond its recommended DoD can damage the battery and reduce its lifespan. By monitoring these parameters, the BMS can help to maximize the battery's performance and lifespan, as well as prevent potentially dangerous situations such as overcharging or over-discharging. It typically consists of several components, including: Sensors: Sensors are used to monitor various parameters of the battery, such as voltage, current, temperature, and state of charge. These sensors provide critical information about the battery's performance and health. Battery Management Board: The battery management board contains the electronics necessary to monitor and control the battery. This includes voltage and current sensors, balancing circuits, and temperature sensors. The board manages the charging and discharging of the battery, and it ensures that the battery operates within its safe operating limits. Micro controller: The microcontroller is the brain of the BMS. It receives data from the sensors and makes decisions about how to manage the battery. The microcontroller uses complex algorithms to determine the state of the battery, and it can adjust the charging and discharging rates to maximize battery performance and life span. In this work, the design and development of a battery monitoring system using IoT technology is proposed. The battery is monitored by sensors such as thermistor sensor, voltage sensor, current sensor. By using this sensor, the State of Charge (SoC), State of Health (SoH), Depth of Discharge (DoD) can be monitored.

2. Materials and Methods

1. Existing System

There are various battery management systems (BMS) each designed to suit specific applications. Some of the data available from battery monitoring systems include

1. Wired or wireless: BMS can be wired or wireless. A wired BMS uses physical wires to connect the battery sensors to the control panel, while a wireless BMS uses radio frequency signals to transmit information from the sensors to the control

panel. A wireless BMS can reduce installation and maintenance costs because it eliminates the need for physical wiring.
2. Types of Batteries: Different types of batteries require different monitoring systems. For example, lithium-ion batteries require a more complex BMS than lead-acid batteries because they are more sensitive to overcharging and discharging. Scalability: The BMS must be scalable according to the size and capacity of the battery bank. A small-scale BMS may not be suitable for a large battery bank used in an electric vehicle or renewable energy system.
3. Monitoring parameters: BMS can monitor various battery parameters such as voltage, current, temperature and state of charge. Some advanced BMS systems can also monitor battery health (SoH), which provides information about the overall health and remaining life of the battery.
4. Redundancy: Some BMS systems have built-in redundancy, such as two power sources, two microcontrollers or two communication channels, to ensure the reliability of the battery system.
5. Alarms and Warnings: The BMS can alert the user with alarms and warnings when there are problems with the battery, such as overcharging or discharging. The user can set thresholds for these alerts and take necessary actions to prevent battery damage. In general, battery monitoring systems have become an integral part of many applications that use batteries, and technology is constantly evolving to improve battery performance, life and safety.

2. Proposed System

The block diagram of the proposed system is explained in figure 1. The proposed system consists of battery and different sensors like the current sensor, voltage sensor, a temperature sensor for monitoring different battery conditions in the vehicle. Current sensor is used to monitor the current through battery and voltage sensor is used to monitor battery voltage in real-time. The temperature sensor used to monitor the temperature of the battery. The power supply unit, microcontroller, PN junction diode, buzzer, LCD display, DC LED bulb, switch is used in this proposed methodology. IoT technology is used to send information of the health, charging and discharging about the battery.

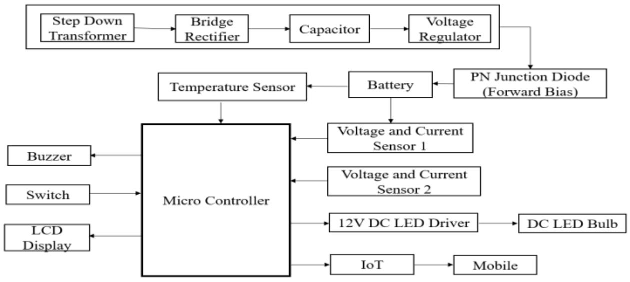

Figure 1 Block Diagram of proposed system

A power supply unit is consisting of step-down transformer, bridge rectifier, capacitor, voltage regulator, PN junction diode. Step down transformer is used to converts the high voltage (HV) and low current from the primary side of the transformer to the low voltage (LV) and high current value on the secondary side of the transformer. A Bridge rectifier is an Alternating Current (AC) to Direct Current (DC) converter that rectifies mains AC input to DC output. LM7812 voltage regulator is used to reduce the voltage and maintain constant level. The power supply unit is used to reduce the voltage level from 230v ac supply to 12v dc supply. The supply is given to the lithium-ion battery. A lithium-ion battery is a rechargeable battery that stores energy primarily using lithium ions. The temperature sensor is connected to battery and micro controller. Temperature sensor monitors the temperature of the battery while charging and discharge. Voltage and Current sensor 1 are used for state for charge. Voltage and Current sensor 2 used for depth of discharge. The discharge is measured by the dc led bulb. A 12v DC LED driver controls the voltage and current delivered to an LED light source that uses 12V DC power. Buzzer is used for alarming purposes. The frequency range is 300Hz.Operating Temperature ranges from – 20° C to +60°C.Operating voltage ranges from 3V to 24V DC. The sound pressure level is 85dBA or 10cm.The supply current is below 15mA. ESP32 controller is used in this proposed methodology. A 230v is supplied to the power supply unit and the output is 12v is connected to the battery for charging. The state of health (SoH), State of charge (SoC), depth of discharge (DoD) is monitored by using the temperature sensor, voltage sensor, current sensor. The temperature, charging and discharge are displayed in LCD display. The input is given to the controller and these data are displayed on LCD. In case of abnormality, it is alerted through the buzzer. The charging capacity is measured with the help of voltage and current sensor 1. Voltage and current sensor 2 are used to switch on 12v DC LED bulb. Fault detection switch is used to detect the abnormality. The information of the state of health, state of charge and depth of discharge is sent to the mobile of the user about the battery.

2.1 Power Supply Unit

Power supply unit is used to convert the 230v ac supply into 12v ac supply with the help of step down transformer. Bridge rectifier is used to convert ac current to a dc current. Output is connected to 12v battery which is forward biased so current flows only in one direction. The voltage and current flow are saved in battery.A capacitor is used to smooth the pulsating current from the rectifier. Some small periodic deviations from smooth direct current will remain, which is known as ripple. These pulsations occur at a frequency related to the AC power frequency. The power supply unit is explained in figure 2. The +12V regulated (fixed voltage) DC power supply circuit diagram. The ideal current requirement for this power supply circuit diagram is 1Amp. Based on IC LM7812, this circuit. A 3-terminal (+ve) voltage regulator IC is what it is. The IC LM7812 belongs to the LM78XX series.230V to 12V converted using a transformer (Tx=Primary 230 Volt, Secondary 12 Volt, 1Amp step down transformer). Here, the AC to DC conversion was done using a bridge rectifier built from four diodes. To lessen ripple and obtain a steady DC voltage, a filtering capacitor of 1000uF (Filtering is normally performed with one or more capacitors), 25V is utilized.

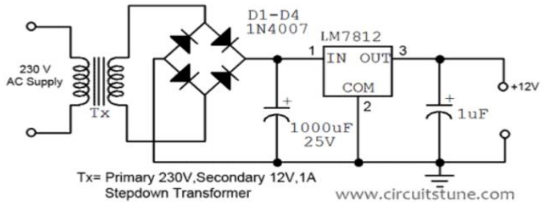

Figure 2 Power Supply Unit Circuit

2.1.1 Step down Transformer

A step-down transformer is a type of transformer that converts the high voltage (HV) and low current from the primary side of the transformer to the low voltage (LV) and high current value on the secondary side of the transformer. The primary side windings of a transformer convert electrical energy into magnetic energy, which is then transformed back into electrical energy. This sort of static electrical equipment also converts magnetic energy into electrical energy (on the secondary transformer side).

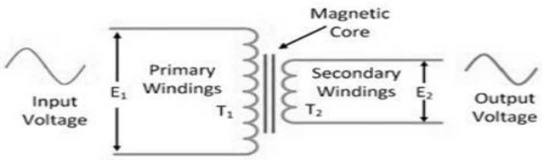

Figure 3 Step Down Transformer

Many different electrical systems and transmission lines employ step-down transformers. The voltage ratio is roughly inversely proportional to the transformer turns ratio (n).

$$n = \frac{V_P}{V_S} = \frac{N_P}{N_S}$$

Where N_p, N_s stands for the number of turns on the primary (LV) and secondary (HV) sides and V_p, V_s stands for the voltages. A step-down transformer's primary side (HV side) has more turns than the secondary side (LV side). It follows that energy moves from the HV side to the LV side. The primary voltage (input voltage) is stepped down to the secondary voltage (output voltage). It is possible to rearrange this equation to produce the output voltage formula (i.e., secondary voltage).

$$V_S = \frac{N_S * V_P}{N_P}$$

A transformer calculator is used quickly to determine the transformer turns ratio and whether the component is a step-up or step-down transformer.

2.1.2 Bridge Rectifier

A Bridge rectifier is an Alternating Current (AC) to Direct Current (DC) converter that rectifies mains AC input to DC output. Bridge rectifiers are frequently found in power supply that deliver the required DC voltage for electronic devices or components. These can be made with four or more diodes or any other controlled solid-state switches.

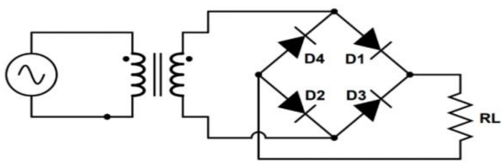

Figure 4 Bridge Rectifier

2.1.3 Voltage Regulator

Voltage regulator is to reduce the voltage and maintain the constant level. LM7812 is a voltage regulator IC that provides 12 v output when an input voltage of 14 v – 35 v is provided. The DC input is applied to pin number 1 and 2 and the output DC voltage is obtained from pin 2 and 3. Where pin 2 is usual for negative terminal.

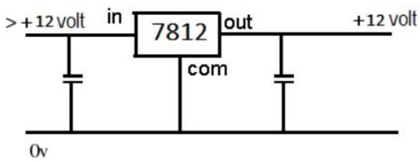

Figure 5 LM7812 Voltage Regulator

2.2 Thermistor Sensor

The temperature of a battery is typically measured by a thermistor sensor in Battery Monitoring Systems (BMS). The resistance of a thermistor, a particular kind of resistor, varies with temperature. Thermistors are used in BMS applications to measure the temperature of the battery cells to ensure reliable and effective operation. Typically, the thermistor sensor is mounted close to the battery cells and wired to the BMS circuit. The thermistor resistance is continuously monitored by the BMS, and it is used to determine the battery temperature. In order to make sure the battery functions within acceptable temperature ranges, the BMS uses the temperature information to modify charging and discharging parameters including charging rate and cutoff voltage. Using a thermistor sensor in a BMS is important because temperature can have a significant impact on battery performance and lifespan.

2.3 Voltage & Current Sensor

A voltage sensor is a component used in battery monitoring system (BMS). The voltage sensor is responsible for measuring the voltage of the battery and this information of battery is monitored. A voltage sensor is placed in close proximity to the battery and connected to the BMS circuit. The BMS then uses this voltage information to determine the battery's state of charge (SOC) and state of health (SOH), which is important for optimizing battery performance and preventing over- or under-charging. A current sensor in battery monitoring system is used to monitor the current in the battery. A current sensor battery monitoring system provides accurate and reliable information about the battery's performance, which can help prevent overcharging, undercharging. By using current sensor the state of charge is monitored and information is displayed in LCD display.

2.4ESP32 Controller

The ESP32 is developed by Espress if Systems. It is widely used in a variety of applications, including Internet of Things (IoT), home automation, robotics, and industrial control systems. Based on a dual-core Tensilica LX6 processor, the ESP32 has built-in Bluetooth, Wi-Fi, and Bluetooth Low Energy (BLE) connectivity. Together with a variety of analogue and digital sensors, it also supports a wide range of peripherals, including GPIOs, SPI, I2C, UART, ADC, and DAC. The ESP32's ability to connect to Bluetooth and Wi-Fi networks makes it perfect for IoT applications and one of its main features. In addition to connecting to other BLE devices, it can serve as a Wi-Fi client or access point. C/C++, Python, Arduino, and other programming languages are all supported for use with the ESP32.In order to store and run sophisticated programs and applications, the ESP32 also features onboard flash memory and supports external memory.

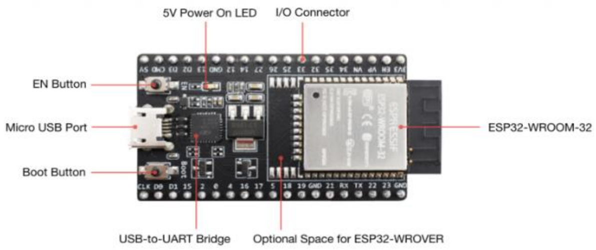

Figure 6 ESP32 Controller

2.5 LCD Display

A liquid crystal display (LCD) has liquid crystal material sandwiched between two sheets of glass.The 16X2 LCD display is used to monitor the sensor values. It is interfaced with the microcontroller by connecting its data pins D4 to D7 with pins 11 down to 8 of the controller respectively. The RS and E pins of the LCD are connected to pins 13 and 12 of the controller respectively. The RW pin of the LCD module is connected to the ground.

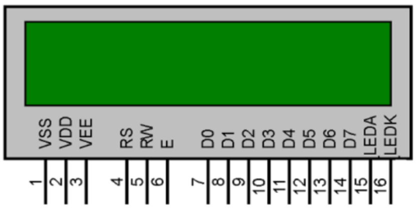

*Figure 7 LCD Display 16*2*

2.6Lithium-ion Battery

A lithium-ion battery is a rechargeable battery that stores energy primarily using lithium ions. Smart phones, computers, and electric cars all frequently use lithium-ion batteries. Two electrodes, a positive electrode (cathode) and a negative electrode (anode), separated by an electrolyte, make up the basic building blocks of a lithium-ion battery. The anode is typically made of graphite, while the cathode is typically made of a metal oxide material, such as lithium cobalt oxide (LCO) or lithium iron phosphate (LFP).Lithium ions are stored in the graphite substance in the anode of the battery when it charges because they migrate there from the cathode. During discharging, the lithium ions return to the cathode and create an electric current. Lithium-ion batteries provide a number of benefits over other types of batteries, including a high energy density, a low rate of self-discharge, and the absence of a memory effect (meaning they can be charged at any time, regardless of their current charge level.

2.7 DC LED Driver & DC LED Bulb

A 12v dc LED driver is used. A 12v DC LED driver controls the voltage and current delivered to an LED light source that uses 12V DC power. It is made to transform AC electricity from a wall socket or a DC power source, like a battery, into the right voltage and current needed to run LED lights. To ensure that an LED light source functions safely and effectively, an LED driver's primary function is to deliver a constant, stable output voltage that matches the needs of the LED light source. Without an LED driver, the LED lights could fade, flicker, or burn out too soon. A DC LED bulb is a type of light bulb that operates on direct current (DC) electricity instead of alternating current (AC) electricity. It typically contains one or more light-emitting diodes (LEDs) that convert the electrical energy into visible light.

2.8 IoT Technology

IoT (Internet of Things) technology has become increasingly popular in battery monitoring systems (BMS) to provide real-time monitoring and control of battery performance. IoT-enabled BMS typically use sensors to gather data on battery parameters such as voltage, current, temperature, and state of charge (SOC), and then transmit this data to a cloud-based platform for analysis and visualization. One of the key benefits of IoT-enabled BMS is the ability to remotely monitor battery performance and receive alerts in real-time in case of any issues or anomalies. This can help prevent potential safety hazards and optimize the battery's lifespan and performance. For example, IoT-enabled BMS can automatically adjust charging and discharging parameters to ensure that the battery is charged to the optimal level, minimizing the risk of overcharging or over-discharging. In order to maximize a system's total energy efficiency, IoT-enabled BMS can also offer useful insights about battery usage trends and energy consumption.

3. Result

The proposed battery monitoring system is mentioned in Figure 8 by using proteus simulation. The simulation is done by using temperature sensor, current sensor and voltage sensor. Instead of buzzer LED is used. If the temperature is high the LED will glow and also displayed in the LCD display. Current sensor and voltage sensor are used to if the current and voltage are high (Overcharging) it will notice and displayed in the LCD. If the temperature is higher than 120 it will show “temperature is high”. The signal from temperature sensor is analog so t*0.4848 is denoted in coding for controller. The values of the current and voltage that are also displayed. If the current sensor is greater than 60 and voltage sensor above 120 it will show “Power is high”. Voltage and current sensor are represented in code for controller is c*0.4848 and v*0.4848. These are the system is used in this proposed method.

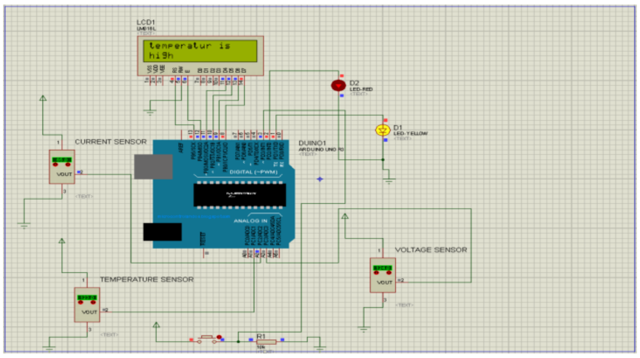

Figure 8 Simulation

4. Discussion

In this project the Soh, Soc and DoD is monitored by using this proposed system. The state of health, state of charge and depth of discharge is explained.**a) State of Health (SoH):**The state of health in a battery monitoring system refers to the current condition of the battery and its ability to perform its intended function. This includes factors such as the battery's capacity, resistance, and overall performance.**b) State of Charge (SoC):**The state of charge (SoC) in a battery monitoring system refers to the amount of charge remaining in the battery at a given time, expressed as a percentage of the battery's total capacity. **c) Depth of Discharge (DoD):**The depth of discharge (DoD) in a battery monitoring system refers to the percentage of the battery's total capacity that has been discharged at a given time.

5. Conclusion

The design and development of a battery monitoring system using IoT technology is proposed in this article. The battery is monitored by sensors such as temperature sensor, voltage sensor, current sensor. By using this sensor, the State of Charge (SoC), State of Health (SoH), Depth of Discharge (DoD) is monitored. The temperature sensor used to monitor the temperature of the battery, charging of the battery is monitored by using the current and voltage sensors. Depth of discharge is monitored by using load. The information of these parameters is sent to the user by using IoT technology.

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