Smart Energy Management System for Electric Vehicles Using IoT Technology

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Abstract

As electric vehicles become more popular, it's crucial to monitor the health and performance of their batteries to ensure optimal efficiency and longevity. In this paper, we propose an IoT-based battery monitoring system that leverages wireless communication and cloud computing to collect and analyze battery data in real-time. Our system consists of three main components: battery sensors, a gateway device, and a cloud platform. The battery sensors are placed in each battery cell to measure key parameters such as voltage, current, temperature, and state of charge. These sensors transmit data wirelessly to the gateway device, which aggregates and processes the data before sending it to the cloud plat form. Our system offers several benefits, including improved battery performance, reduced maintenance costs, and enhanced safety. By leveraging IoT and cloud technologies, we can provide real-time monitoring and analysis of battery data, enabling more informed decision-making and proactive maintenance. At the present time, the resources that we use for electricity are costly and inefficient. That is why we must rely on those that are of in the least harmful to the environment and inexpensive. photovoltaic cells are used in applications that allow the use of taking solar energy and expanding it into electricity most of the solar systems are situated in sparsely populated regions, large-scale agricultural communities, as well as in medium-sized farm sites and smaller, agricultural local agricultural production facilities that have power grids. For a machine to function, it must be operated by a human. This is a hardware- timed sensor system that tracks various variables, like temperature, voltage, and fire and battery percentage and reports them on the cloud so you can see exactly when everything has reached the right value.

Introduction

Electric vehicles (EV) are playing a key role because of its zero-emission of harmful gases and use of efficient energy. Electric vehicles are equipped by a large number of battery cells which require an effective battery management system (BMS) while they are providing necessary power. The battery installed in electric vehicle should not only provide long lasting energy but also provide high power. Lead-acid, Lithium-ion, -metal hydride are the most commonly used traction batteries, of all these traction batteries lithium-ion is most commonly used because of its advantages and its performance. Battery management system (BMS)

makes decisions based on the battery charging and cell voltage, temperature, etc. To ensure safe operation of the battery pack, the Battery Management System (BMS) has to make sure the cells remain in this safety window. Electric vehicles are becoming more commonplace as the technology matures and gas prices remain higher than in previous decades. While the internal combustion engine still dominates much of the world's roads, electric vehicles and hybrids (vehicles with both an internal combustion engine and some form of electric motor) are more prevalent in urban areas than previous decades. Electric vehicles do not have any on board power generation and rely solely on stored energy in batteries to power the electric motors during operation. This paper outlines a scalable method of determining the voltage across each battery in an electric vehicle charging and an eventual path for the development of a real-time battery monitoring for use in the Department Electric Vehicle.

Block Diagramme
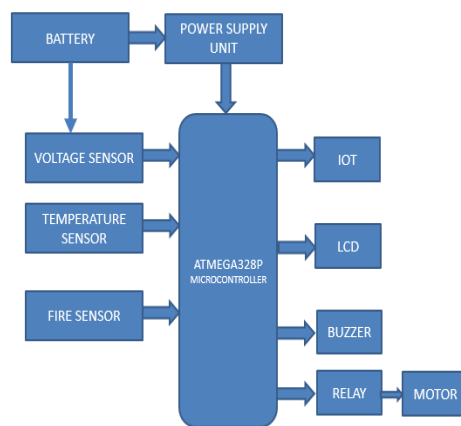
Circuit Diagram
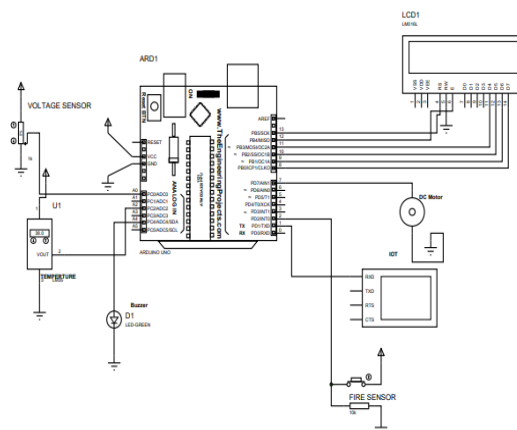
Software requirements

Arduino Ide

The Arduino integrated development environment (IDE) is a cross-platform application (for Windows, macOS, Linux) that is written in the programming language Java. It is used to write and upload programs to Arduino board. The source code for the IDE is released under

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the GNU General Public License, version 2. The Arduino IDE supports the languages C and C++ using special rules of code structuring.[4] The Arduino IDE supplies a software library from the Wiring project, which provides many common input and output procedures. User-written code only requires two basic functions, for starting the sketch and the main program loop, that are compiled and linked with a program stub main() into an executable cyclic executive program with the GNU tool chain, also included with the IDE distribution. The Arduino IDE employs the program argued to convert the executable code into a text file in hexadecimal encoding that is loaded into the Arduino board by a loader program in the board's firmware. Arduino is an open-source electronics platform based on easy-to-use hardware and software. Arduino boards are able to read inputs - light on a sensor, a finger on a button, or a Twitter message - and turn it into an output - activating a motor, turning on an LED, publishing something online. You can tell your board what to do by sending a set of instructions to the microcontroller on the board
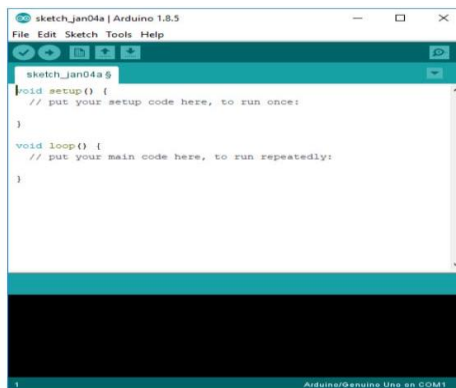
The Arduino IDE
The Arduino IDE is incredibly minimalistic, yet it provides a near-complete environment for most Arduino-based projects. The top menu bar has the standard options, including "File" (new, load save, etc.), "Edit" (font, copy, paste, etc.), "Sketch" (for compiling and programming), "Tools" (useful options for testing projects), and "Help". The middle section of the IDE is a simple text editor that where you can enter the program code. The bottom section of the IDE is dedicated to an output window that is used to see the status of the compilation, how much memory has been used, any errors that were found in the program, and various other useful messages. Projects made using the Arduino are called sketches, and such sketches are usually written in a cut-down version of C++ (a number of C++ features are If uploaded successfully, the LED on your board should blink on/off once every second. Most Arduino boards have an LED prewired to pin 13. It is very important that you do not use pins 0 or 1 while loading code. It is recommended that you do not use those pins ever. Arduino code is loaded over a serial port to the controller. Older models use an FTDI chip which deals with all the USB specifics. Newer models have either a small AVR that mimics the FTDI chip or a built-in USB-to-serial port on the AVR.

Hardware requirements

Power supply circuit:

Power supply is a reference to a source of electrical power. A device or system that supplies electrical or other types of energy to an output load or group of loads is called a power supply unit or PSU. The term is most commonly applied to electrical energy supplies, less often to mechanical ones, and rarely to others. Power supplies for electronic devices can be broadly divided into linear and switching power supplies. The linear supply is a relatively simple design that becomes increasingly bulky and heavy for high current devices; voltage regulation in a linear supply can result in low efficiency. A switched-mode supply of the same rating as a linear supply will be smaller, is usually more efficient, but will be more complex.

Linear Power supply:

An AC powered linear power supply usually uses a transformer to convert the voltage from the wall outlet (mains) to a different, usually a lower voltage. If it is used to produce DC, a rectifier is used. 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 (for example, a multiple of 50 or 60 Hz).

Transformer:

Transformer

Transformers convert AC electricity from one voltage to another with little loss of power. Transformers work only with AC and this is one of the reasons why mains electricity is AC. Step-up transformers increase voltage, step-down transformers reduce voltage. Most power supplies use a step-down transformer to reduce the dangerously high mains voltage (230V in UK) to a safer low voltage. The input coil is called the primary and the output coil is called the secondary. There is no electrical connection between the two coils; instead they are linked by an alternating magnetic field created in the soft-iron core of the transformer. The two lines in the middle of the circuit symbol represent the core. Transformers waste very little power so the power out is (almost) equal to the power in. Note that as voltage is stepped down current is stepped up. The ratio of the number of turns on each coil, called the turn's ratio, determines the ratio of the voltages. A step-down transformer has a large number of turns on its primary (input) coil which is connected to the high voltage mains supply, and a small number of turns on its secondary (output) coil to give a low output voltage.

Bridge rectifier:

A bridge rectifier can be made using four individual diodes, but it is also available in special packages containing the four diodes required. It is called a full-wave rectifier because it uses the entire AC wave (both positive and negative sections). 1.4V is used up in the bridge rectifier because each diode uses 0.7V when conducting and there are always two diodes conducting, as shown in the diagram below. Bridge rectifiers are rated by the maximum current they can pass and the maximum reverse voltage they can withstand (this must be at least three times the supply RMS voltage so the rectifier can withstand the peak voltages). Please see the DIODES page for more details, including pictures of bridge rectifiers.
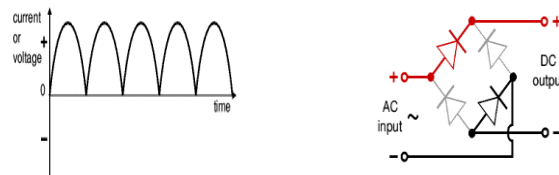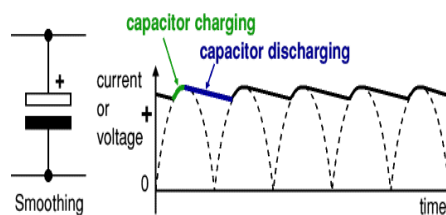

Bridge rectifier

Alternate pairs of diodes conduct, changing over the connections so the alternating directions of AC are converted to the one direction of DC.
Output: full-wave varying DC: (using the entire AC wave):

Smoothing:

Smoothing is performed by a large value electrolytic capacitor connected across the DC supply to act as a reservoir, supplying current to the output when the varying DC voltage from the rectifier is falling. The diagram shows the unsmoothed varying DC (dotted line) and the smoothed DC (solid line). The capacitor charges quickly near the peak of the varying DC, and then discharges as it supplies current to the output.

Smoothing

Note that smoothing significantly increases the average DC voltage to almost the peak value ($1.4 \times$ RMS value). For example, 6V RMS AC is rectified to full wave DC of about 4.6V RMS (1.4V is lost in the bridge rectifier), with smoothing this increases to almost the peak value giving $1.4 \times 4.6 = 6.4$V smooth DC.

Battery Charger

The rechargeable backup battery provides power to Finger Tec terminals when the primary source of power is unavailable. With the right backup battery, your system won't have to be interrupted during a power failure. 12V1.5Ah Backup Battery Access Control System: The external Rechargeable Backup Batteries are almost always used in an access control system. The backup battery prevents intruders from disabling the access control by turning off power to the building, and continues locking the doors secured by the system. Time & Attendance System: For Time and Attendance System that records clocking-in and out data for employees, power failure might cause discrepancies in the payroll system. Thus, external rechargeable backup batteries are often used in Time & Attendance terminals as a backup power. A battery charger is a device used to put energy into a cell or (rechargeable) battery by forcing an electric current through it. Lead-acid battery chargers typically have two tasks to accomplish. The first is to restore capacity, often as quickly as practical. The second is to maintain capacity by compensating for self discharge. In both instances optimum operation requires accurate sensing of battery voltage. When a typical lead-acid cell is charged, lead sulphate is converted to lead on the battery's negative plate and lead dioxide on the positive plate. Over-charge reactions begin when the majority of lead sulphate has been converted, typically resulting in the generation of hydrogen and oxygen gas. At moderate charge rates, most of the hydrogen and oxygen will recombine in sealed batteries. In unsealed batteries however, dehydration will occur. Size This is pretty straight forward, how big are the batteries? Lead acid batteries don't get much smaller than C-cell batteries. Coin cells don't get much larger than a quarter. There are also standard sizes, such as AA and 9V which may be desirable. Weight and power density This is a performance issue: higher quality (and more

Maintenance

Store in a clean and dry place; occasionally clean the case and cords with a dry cloth.

Voltage Sensor

A simple but very useful module which uses a potential divider to reduce any input voltage by a factor of 5. This allows you to use the analogue input of a microcontroller to monitor voltages much higher than it capable of sensing. For example, with a 0-5V analogue input range you are able to measure a voltage up to 25V. The module also includes convenient screw terminals for easy and secure connection of a wire.

**Specification:**

Divider ratio: 5:1

Resistor Tolerance: 1%

Max input voltage: 25V

Resistor Value: 30K/7.5K Ohm

Fire Sensor

A fire detector is a device that senses fire, typically as an indicator of fire. Commercial security devices issue a signal to a fire alarm control panel as part of a fire alarm system, while household fire detectors, also known as fire alarms, generally issue a local audible or visual alarm from the detector itself or several detectors if there are multiple fire detectors interlinked. Fire detectors are housed in plastic enclosures, typically shaped like a disk or square about 150 millimeters (6 in) in diameter and 25 millimeters (1 in) thick, but shape and size vary. Fire can be detected either optically (photoelectric) or by physical process (ionization); detectors may use either, or both, methods. Sensitive alarms can be used to detect, and thus deter, smoking in areas where it is banned. Fire detectors in large commercial, industrial, and residential buildings are usually powered by a central fire alarm system, which is powered by the building power with a battery backup. Domestic fire detectors range from individual battery-powered units, to several interlinked mains-powered units with battery backup; with these interlinked units, if any unit detects smoke, all trigger even if household power has gone out.
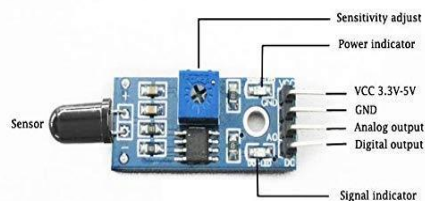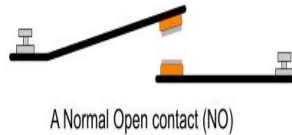

Relay

A relay is an electrical switch that opens and closes under the control of another electrical circuit. In the original form, the switch is operated by an electromagnet to open or close one or many sets of contacts. It was invented by Joseph Henry in 1835. Because a relay is able to control an output circuit of higher power than the input circuit, it can be considered to be, in a broad sense, a form of an electrical amplifier.

Relay contact conditions:

▪ **Normally Open Contact (NO)** – NO contact is also called a make contact. It closes the circuit when the relay is activated. It disconnects the circuit when the relay is inactive.

A Normal Open contact (NO)

▪ **Normally Closed Contact (NC)** – NC contact is also known as break contact. This is opposite to the NO contact. When the relay is activated, the circuit disconnects. When the relay is deactivated, the circuit connects.
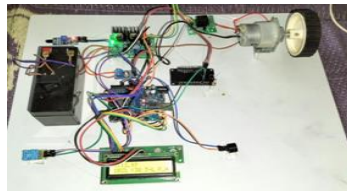

A Normal Closed contact (NC)
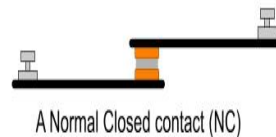
▪ **Change-over (CO) / Double-throw (DT) Contacts** – This type of contacts are used to control two types of circuits. They are used to control a NO contact and also a NC contact with a common terminal. According to their type they are called by the names **break before make** and **make before break** contacts.
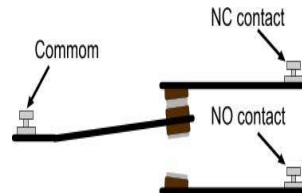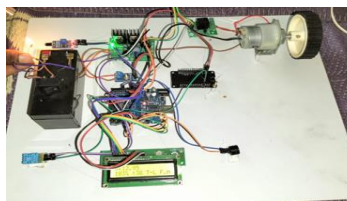

Test Report

Off Condition

On Condition

Conclusion

In this paper, we have proposed an IoT-based battery monitoring system for electric vehicles that leverages wireless communication and cloud computing to collect and analyze battery data in real-time. Our system offers granular and accurate insights into battery health and performance, real-time monitoring and analysis capabilities, cloud-based analysis, and enhanced safety. Through our experiments and evaluations, we have demonstrated the effectiveness and reliability of our system in detecting potential issues and providing actionable insights to users. We have also shown that our system can be easily integrated into existing electric vehicle infrastructure and can scale to accommodate large fleets of vehicles. The paper described the design and development of an IoT-based battery monitoring system for electric vehicle to ensure the battery performance degradation. We are developing the system for battery management in electric vehicle by controlling the crucial parameters such as voltage and temperature. It is very important that the BMS should be well maintained with battery reliability and safety. This present paper focuses on the study of Battery Management System and optimizes the power performances of electric vehicles. Moreover, the target of reducing the greenhouse gases can greatly be achieved by using battery management system.

Future Enhancement

An IoT-based battery monitoring system in electric vehicles is an essential aspect of ensuring efficient operation and prolonging the battery life of electric vehicles. IoT-based battery monitoring systems can collect a significant amount of data related to battery usage and performance. By applying advanced data analytics, such as machine learning and artificial intelligence, to this data, the system can gain a deeper understanding of battery performance and predict potential issues before they occur. Integrating IoT-based battery monitoring systems with smart grids can enable better control and optimization of the energy flow between the vehicle and the grid. This can help to ensure that the battery is charged efficiently and at the optimal time. Wireless charging technology is becoming more prevalent and can be integrated with IoT-based battery monitoring systems to provide a seamless and effortless charging experience for electric vehicle users. Multi-modal battery management is a system that can manage the performance of multiple batteries in an electric vehicle. By monitoring and balancing the performance of these batteries, the system can help to optimize battery life and improve overall vehicle performance. Blockchain technology can be used to create a secure and transparent record of battery usage and performance. This can help to ensure that batteries are properly maintained and replaced when necessary, reducing the risk of battery failure and improving overall vehicle safety. Overall, the future of IoT-based battery monitoring systems in electric vehicles is exciting, with many potential enhancements that can improve battery performance, vehicle efficiency, and overall user experience. As technology continues to advance, we can expect to see more innovative solutions for battery monitoring and management in electric vehicles.

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