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BATTERY MANAGEMENT SYSTEM FOR HOUSEHOLD AND INDUSTRIAL INVERTER

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ABSTRACT

This research paper presents a comprehensive study of Battery Management System (BMS) for household and industrial inverters. The study aims to provide an efficient and reliable solution to manage batteries in inverters, which plays a crucial role in ensuring uninterrupted power supply in households and industries. The paper provides a detailed review of existing BMS technologies, their advantages, limitations, and their suitability for different applications. Experimental tests and simulations are conducted to validate the proposed BMS design. The results show that the proposed system outperforms existing BMS technologies in terms of battery utilization, efficiency, and lifespan. The proposed BMS design is also demonstrated to be robust and reliable under different operating conditions. Overall, this research paper presents a novel and effective approach to battery management for household and industrial inverters. The proposed BMS design has significant potential to improve the performance and reliability of inverter systems, which can benefit households, industries, and the wider community.

INTRODUCTION

Battery Management Systems (BMS) plays a crucial role in ensuring the efficient and reliable operation of inverter systems by managing the battery charging and discharging process, as well as monitoring the battery's status and protecting it against faults. In addition, BMS can also optimize the battery usage, extend battery life, and improve the overall efficiency of the inverter system. This research paper presents a comprehensive study of BMS for household and industrial inverters, with the aim of providing a solution to manage batteries effectively and reliably. The study reviews existing BMS technologies, their advantages, limitations, and their suitability for different applications. The research also proposes a novel BMS design based on a smart controller that integrates battery charging, discharging, and protection functions. The proposed system is designed to optimize battery usage, extend battery life, and improve the overall efficiency of the inverter system.

EQUIPMENTS USED

ARDUINO UNO

Arduino Uno is an open-source microcontroller board based on the ATmega328P microcontroller chip. It is one of the most popular and widely used boards in the Arduino family. The Arduino Uno board is designed to be easy to use for beginners and advanced users alike, with a range of input and output pins, a USB connection for programming and power, and a variety of sensors, actuators, and other components that can be easily connected. The Arduino Uno board can be programmed using the Arduino software, which is available for free download from the Arduino website. The software uses a simplified programming language based on C++ and allows users to easily create and upload code to the board.The Arduino Uno board is used in a wide variety of projects, from simple blinking LED lights to complex robotics and automation systems. Its versatility, ease of use, and low cost make it a popular choice for hobbyists, students, and professionals alike.

RELAY

A 4 channel relay is a type of electrical switch that allows you to control up to four independent electrical circuits with a single device. It typically consists of four separate relay switches that can be controlled either manually or electronically. Each relay switch in a 4 channel relay consists of an electromagnetic coil, a set of contacts (normally open and normally closed), and a mechanism for switching between them. When the coil is energized, it creates a magnetic field that causes the contacts to change state, either opening or closing the circuit they are connected to. The 4 channel relay can be controlled in different ways, depending on the application. For example, it can be manually operated with a switch or button, or electronically controlled with a microcontroller or other electronic device.

ACS 712

ACS712 is a series of fully integrated Hall-effect-based linear current sensor modules. The ACS712 sensor is designed to measure AC or DC currents ranging from -5A to +5A, and it provides an analog voltage output proportional to the measured current. The output voltage is centered at Vcc/2, which makes it ideal for interfacing with microcontrollers and other digital circuits. The ACS712 sensor works on the principle of the Hall effect, which states that when a current-carrying conductor is placed in a magnetic field, a voltage is generated perpendicular to both the magnetic field and the current direction. By measuring this voltage, the ACS712 sensor can determine the current flowing through the conductor.

WI-Fi MODULE (ESP8266)

The ESP8266 Wi-Fi module is a popular wireless communication module that is designed for IoT (Internet of Things) applications. It is a low-cost, highly-integrated, and self-contained system-on-chip (SoC) that provides Wi-Fi connectivity for embedded systems. The ESP8266 module is designed to work with microcontrollers and other digital circuits and can be easily integrated into various electronic devices. The ESP8266 module includes a microcontroller unit (MCU), Wi-Fi transceiver, and on-chip memory, all in a compact package. It supports 802.11 b/g/n Wi-Fi standards and can be used as a Wi-Fi client or a Wi-Fi access point. The module can be programmed using the Arduino IDE or other programming languages, and it can be powered from a variety of sources, including a USB port, a battery, or an external power supply.

BATTERY (LEAD-ACID)

A lead-acid battery is a type of rechargeable battery that uses lead and lead oxide electrodes and a sulfuric acid electrolyte to generate electrical energy. It is one of the oldest and most widely used types of batteries and is commonly used in vehicles, uninterruptible power supplies (UPS), and other applications where a reliable and rechargeable power source is required.

LITERATURE REVIEW

Lead-acid batteries are widely used in various applications due to their low cost, high energy density, and reliability. However, improper management of lead-acid batteries can lead to reduced battery life and performance, as well as safety hazards. Therefore, battery management systems (BMS) are essential for monitoring and controlling the performance of lead-acid batteries. This literature review aims to summarize the research on lead-acid battery management systems, including the methods for State of Charge (SOC) estimation and load management.

Load management is another important aspect of lead-acid battery management systems as it enables the optimization of battery usage and prolongs battery life. Various load management strategies have been proposed for lead-acid batteries, including threshold-based load shedding, priority-based load shedding, dynamic programming, model predictive control, and fuzzy logic. Zhang et al. (2019) proposed a dynamic programming-based load management strategy for lead-acid batteries in off-grid solar systems. The results showed that the proposed strategy effectively reduced the battery cycling frequency and improved battery life.

Lead-acid battery management systems are essential for monitoring and controlling the performance of lead-acid batteries. Various methods for SOC estimation and load management have been proposed in the literature. The hybrid and model-based methods have shown high accuracy and robustness in SOC estimation, while dynamic programming and fuzzy logic-based strategies have shown effectiveness in load management. The selection of a particular method depends on the specific application and requirements of the battery management system. Further research is needed to optimize the performance and cost-effectiveness of lead-acid battery management systems.

SYSTEM ANALYSIS

Battery Monitoring Systems used to be limited to monitoring the battery's condition and signaling drivers through in-car indicators. However, as technology has advanced, Internet of Things (IoT) can now remotely inform manufacturers and users about the battery's status, enabling them to check their car's battery status from anywhere in the world via smartphones. This has become a manufacturer-provided maintenance support. This project aims to create an IoT-based Battery Monitoring System that not only allows monitoring of charging and discharging status, but also notifies users through email alerts when the battery is full or empty. The system will rely on NodeMCU 12E for sending battery status data.

When a battery is charging, its voltage cannot indicate the charging status or voltage accurately. The voltage measured across the terminals of the battery and the charging voltage may differ. In the case of Lead Acid Batteries, even a dead battery not connected to any load can display an approximate voltage of 12.5 Volts. Measuring the charging voltage requires complex circuitry or a voltage detection module that measures the voltage across the battery terminals. By using a simple voltage division network with appropriate resistance values, regulation, and signal conditioning through an analog-to-digital converter, the Microcontroller can easily measure the voltage and output the results.

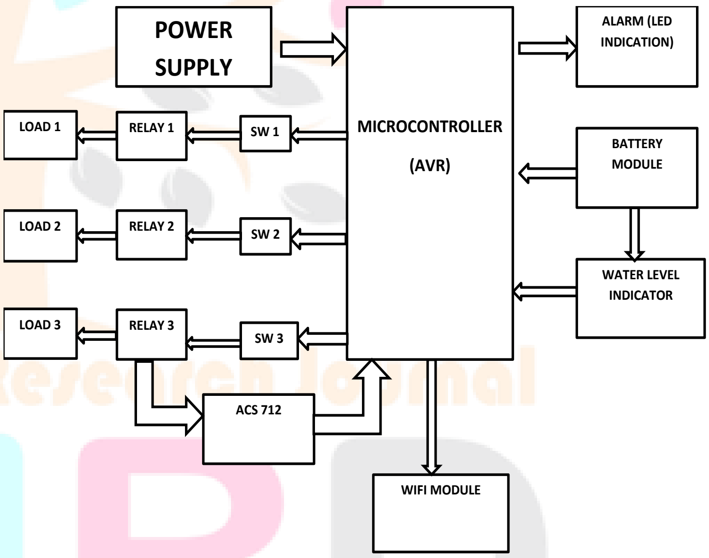


Figure1. Block diagram of Wireless Monitoring of Lead Acid Battery Using WiFi Technology

TEMPERATURE SENSING

The performance of a lead acid battery can be affected by the problem of temperature rise. Typically, the battery works best in a temperature range of 20 to 30°C. The battery life is also dependent on the temperature at which it operates. High temperatures cause the acid (H_2SO_4) to heat up and can lead to degradation of separators. As the battery's acid evaporates, gaseous separation occurs within the battery device. When the acid boils, the water inside the battery reduces, and the chemical reaction of the battery changes more rapidly, reducing the battery's lifespan. Every 8°C rise in temperature cuts the battery life in half, and heat is a significant cause of battery failure because it makes the battery work harder and can lead to corrosion. Therefore, temperature sensing is an essential parameter for battery management. In our proposed work, we use an LM35 temperature sensor to detect precise centigrade temperature. This sensor has an operating voltage range of -55 to 100°C and is operated under 4 to 30 Volts. It has low self-rating and is suitable for temperature sensing in our proposed system.

CURRENT SENSING

The ACS712 is a Hall Effect-based current sensor module that can accurately detect AC or DC current flow. It can sense current up to a maximum of 5A and is commonly used in a variety of applications including over-current protection circuits, battery chargers, switching mode power supplies, digital watt meters, programmable current sources, and more. The present current signal can be read through an analog input/output port of a microcontroller or an Arduino.

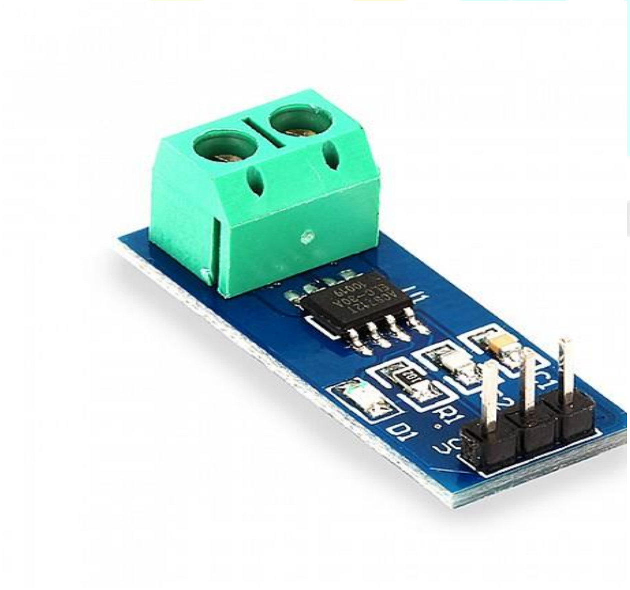


Figure 2: ACS 712 current sensor

WATER LEVEL INDICATOR

A water level indicator typically consists of a set of probes that are inserted into the battery's cells. The probes are made of a material that is resistant to corrosion and can withstand the harsh chemical environment inside the battery. When the water level drops below the required level, the probes are exposed to air, and an electrical circuit is completed, which triggers an alarm or warning system.

The water level indicator can be a simple visual indicator or an automated system that uses sensors to monitor the water level and triggers alarms or notifications when the level drops below the required level. Automated water level indicators are more common in large-scale applications, such as industrial batteries or backup power systems, where the battery maintenance is critical for the smooth operation of the system.

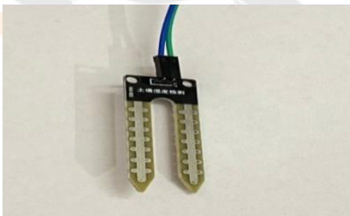


Figure 3: Water level indicator

WiFi Module

A WiFi module is a hardware device that provides wireless connectivity for electronic devices by utilizing the WiFi standard. It functions as a bridge between a microcontroller and a wireless network, allowing data to be transmitted and received wirelessly. WiFi modules can be integrated into various electronic devices such as security systems, home automation systems, and IoT devices to enable remote communication and control.

A typical WiFi module consists of a microcontroller, a WiFi chip, and an antenna. The microcontroller is responsible for controlling the WiFi chip and handling the data transmission and reception process. The WiFi chip is the component that enables wireless communication and utilizes the WiFi protocol for this purpose. The antenna is used to transmit and receive data wirelessly over the air. There are several types of WiFi modules available in the market, including those based on ESP8266, ESP32, and other WiFi chipsets. These modules differ in their specifications and features, such as WiFi range, power consumption, and processing power. Some modules also come with built-in features such as web servers, SSL encryption, and OTA updates.

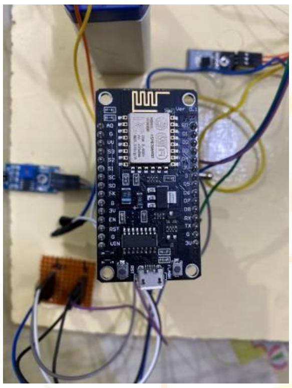
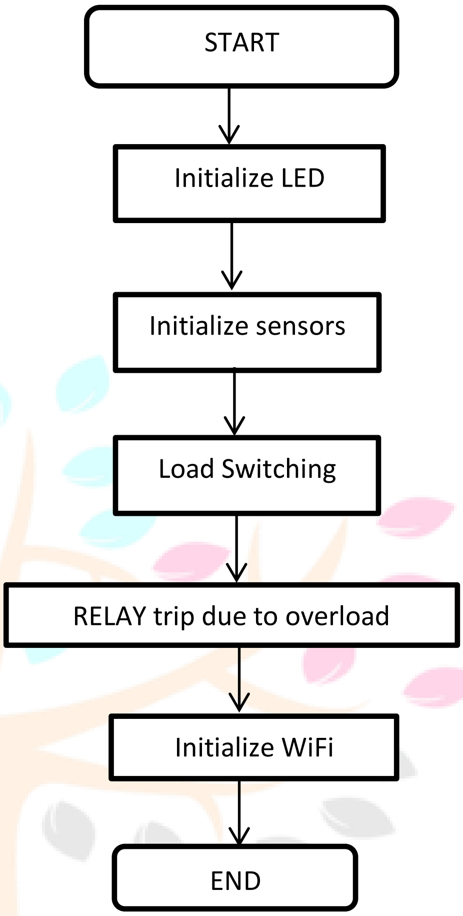


Figure 4: Wi-Fi Module

METHODOLOGY

The implementation and prototype of this project is shown in this section. The basic set up is shown in the figure. The Wi-Fi module ESP 8266MOD is connected to the Arduino UNO through input and output ports. We have also connected the temperature sensor and water level sensor on the battery. We have utilized ATMEGA328P as our main controller all the programming of the micro controller is done with the help of the burner which is fed by a USB port. Hence, the programming will be stored in it. when the battery parameters like temperature voltage, current goes beyond the ideal value and water level decreases below the ideal value then its data is collected by the micro controller with the help of the sensors and it is said again to the Wi-Fi module. therefore, all the data of the prototype is shared on a website with the help of the Wi-Fi module.

FLOW-CHART OF THE PROTOTYPE:



ACTUAL WORK IMPLEMENTATION:

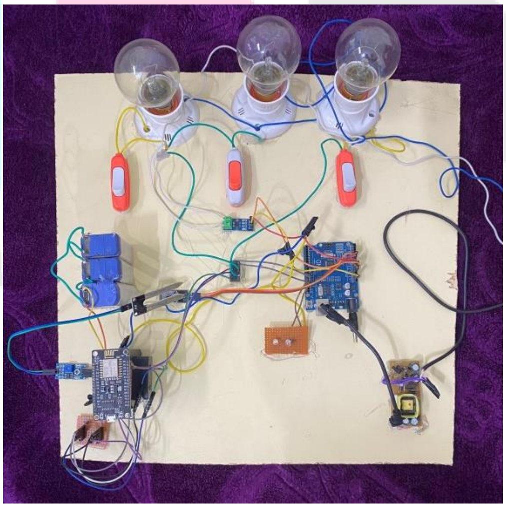
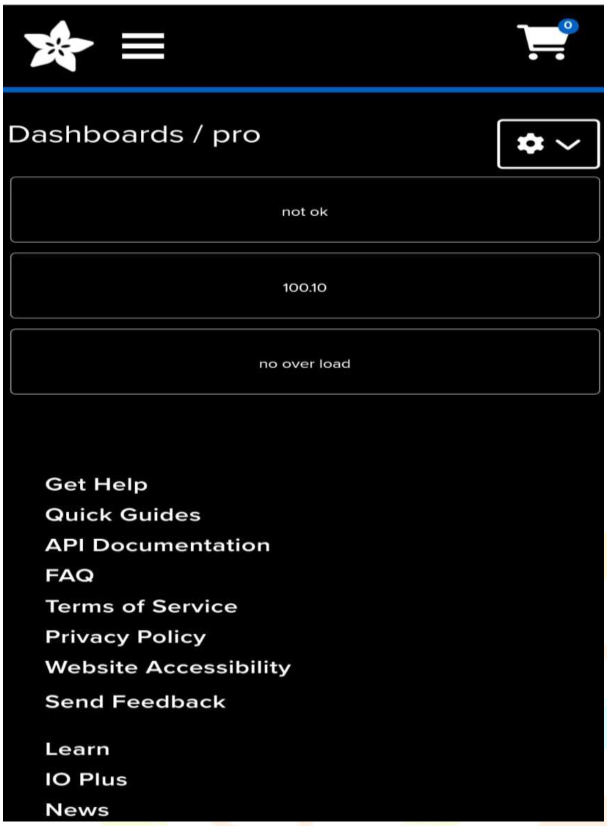


Figure 5: Actual work implementation

RESULT:



- The system is designed in such a manner that we get the alert for battery's overheating temperature
- The system tells us if the associated relays have been tripped due to overload.
- It indicates the water level status of the battery.
- Battery's percentage is also being displayed on the wifi module.

CONCLUSION:

The wireless monitoring of lettuce and battery using Wi-Fi technology is useful to detect battery failure in time so that time Election should be taken on battery problems which will increase the battery life and prevent it from dangerous faults

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