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Battery temperature monitoring system using Arduino

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ABSTRACT

Energy storage technologies are playing a key role in the modern world. The energy storage technologies are battery and ultracapacitors. This paper presents designing and implementing an Arduino-based battery temperature monitoring system for real-time battery temperature monitoring in a variety of applications, including industrial equipment, renewable energy systems, and electric cars. An Arduino microcontroller, temperature sensors, and optional display and communication modules make up the system. The Arduino receives temperature data from the sensors and processes it to provide information, send out alerts, and log data for further analysis. The technology provides an affordable and adaptable way to guarantee both the safety and best possible performance from batteries.

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1. INTRODUCTION

This essay emphasizes how crucial battery management systems (BMS) are to maintaining the performance, longevity, and safety of batteries. It covers temperature monitoring, heat control, and performance optimization to prevent thermal runaway and highlights thermal management as an important component. The study presents a lumped thermal model with four states and evaluates the characterization of a lithium-ion battery. It uses machine learning methods like particle swarm optimization and genetic algorithms for parameter determination and the third-order equivalent circuit model to compute heat generation. Furthermore, it suggests a new 3rd-order smooth variable structure filter that outperforms previous filters such as the extended Kalman filter and the 2nd-order smooth variable structure filter (SVSF), providing improved accuracy in thermal estimate [1]–[5].

In order to ensure the longevity and safety of lithium-ion batteries, particularly in electric vehicles, this research presents a novel approach to determining the interior temperature of these batteries. An enhanced magnetic nanoparticle thermometer (MNPT) is suggested in order to measure temperatures more precisely. The study creates a new model for the enhanced MNPT and looks into how a direct current (DC) magnetic field affects temperature precision. The interior temperature of the battery can be accurately determined by applying this technique [6]–[10]. The increased MNPT's accuracy is demonstrated by simulation and experimental findings, providing a potential method for battery temperature monitoring in new energy vehicles.

In order to track line joint temperatures in high-voltage transmission lines, especially in remote areas where conventional methods are inadequate, this research introduces a revolutionary real-time monitoring system. ZigBee and low power wide area network (LPWAN) (low-rank adaptation (LoRa) and narrowband internet of things (NB-IoT)) technologies are used by the system to provide long-distance communication. Every power tower functions as a communication node, with a main node and several smaller nodes. In order to obtain greater coverage and longer transmission distances, temperature data collected by ZigBee is processed locally and transferred over LoRa multi-hop communication. An NB-IoT gateway at the network's end transmits all node data to the "USR Cloud" using LoRa-NB-IoT technology. Long-distance communication and low power usage are confirmed by system tests. At an average power usage of 21.19 milliampere-hour and a packet loss rate of roughly 3.3%.

In this study, a novel temperature sensor intended for application in the perishable goods cold supply chain (CSC) is introduced. This sensor works passively (without batteries), unlike other technologies, and it can last several temperature cycles before needing to be reset [11], [12]. It does this by utilizing cutting-edge cold-responsive liquid crystal elastomers (LCEs), which undergo shape change in cold weather and revert to their original form when heated. In a first-of-its-kind method, the sensor alternates between two radio frequency identification (RFID) integrated circuits (ICs) to transmit temperature threshold crossings. The efficacy of the design is demonstrated by validation utilizing RFID data and simulation analysis with Ansys high-frequency structure simulator (HFSS) and circuit designer for Ansys.

The difficulties in creating battery-powered tools are discussed in this article, with particular attention to problems with motor drive controllability and limited operating time. Manufacturers are switching to permanent magnet synchronous motor drives, which offer the desired features but call for more sophisticated electronics, in order to overcome these obstacles. It is vital to maintain safety standards, especially when it comes to keeping an eye on the temperature of inverter switches [13], [14]. The article suggests a software approach for temperature estimation and monitoring in place of the conventional negative temperature coefficient (NTC) resistors, which lowers prices and printed circuit board (PCB) area. The efficacy of this method is confirmed by safety certification and experimental findings.

The development of a battery monitoring system for automobile starter batteries, which is essential for starting the engine and running the car, is the main goal of this research. It deals with the problem of batteries deteriorating and failing as a result of voltage drops during engine cranking. The suggested system evaluates the battery's condition in real-time by measuring voltage, current, and temperature using a microcontroller on an Arduino-Uno R3 board [15]–[17]. The device notifies the driver of the battery's state by comparing voltage loss to a preset threshold, which may help to avert unanticipated failures. The system's effectiveness is confirmed by experimental findings using two batteries, which provide drivers with early warnings of approaching battery problems so they may take prompt action.

This study describes a wireless battery monitoring system (WBMS) with a voltage, current, and temperature monitoring focus that is specifically designed for electric vehicles. The system consists of matching software and hardware, including sensors, an Android smartphone, a microcontroller, and a Bluetooth module. Constructed around an affordable ATmega328 microcontroller (Arduino-Uno), the system gathers battery statistics and sends them to display devices using Bluetooth. Using the LabVIEW software, the monitoring system can show real-time battery data on a personal computer (PC) and an Android smartphone at the same time [18]–[20]. This configuration improves the safety and performance of the vehicle by enabling thorough monitoring of the battery characteristics.

In order to improve battery performance, efficiency, and conservation, this study presents a battery management system designed specifically for lead-acid battery banks in electric cars, or e-vehicles. It highlights how crucial it is to do a thorough examination and diagnostic of traction batteries in order to properly maintain their health. In order to calculate metrics such as state-of-charge (SOC), state-of-health (SOH), discharge rate, and remaining useful life, the system measures battery characteristics such as load voltage, no-load voltage, load current, and temperature [21]. Regression analysis and correlation analysis are used to estimate using real-time data that is recorded to a secure digital (SD) card module. In response to the increased demand for more compact, lightweight, and portable electric vehicles, this research advances battery identification, monitoring, and diagnostics in the e-vehicle industry.

This essay addresses the growing popularity of electric cars in Indonesia and highlights how they can help cut down on air pollution. It emphasizes how crucial a strong BMS is to preserving battery health by averting problems like misuse and overcharging. The Arduino-Uno is used as the controller in the BMS design, together with the ACS712-30A current sensor module for measuring current and the DS18B20 waterproof sensor module for measuring temperature [22]. Voltage measurement is done using a voltage divider circuit. Examining each module's accuracy and contrasting multimeter and Arduino data are part of the testing process. The system's accuracy rate is great, especially when it comes to calculating temperature and current (97%). The computed power is used to determine battery capacity. When the BMS is connected to a computer, information can also be seen on a serial monitor.

The battery management system for lead-acid battery banks in electric vehicles (e-vehicles) is presented in this work. In order to improve battery performance and efficiency, it includes diagnostic, measurement, and monitoring capabilities. There is a growing need for traction battery research due to the growing need for lighter, more compact electric vehicles. Using correlation and regression analysis, the system determines the SOC, SOH, discharge rate, and remaining useful life based on real-time metrics stored in an SD card module [23]–[25]. This work facilitates thorough and continual advancement in the e-vehicle industry by adding to the ongoing advancement of battery identification, monitoring, and diagnostics.

2. BATTERY TEMPERATURE MONITORING BLOCK DIAGRAM

A temperature sensor, DS18B20 or LM35, gauges the battery's temperature. Temperature readings are sent to the Arduino. Figure 1 shows the block diagram of the BMS system. Microcontroller Arduino the Arduino, which serves as the central processing unit, gets temperature readings from the sensor. It analyzes this data and, under specified conditions, carries out actions that are planned. Temperature readings for the user interface are graphically represented by a display module, such as a liquid-crystal display (LCD) screen or a light-emitting diode (LED) display. Optional communication module: this module, which is another optional component, permits communication with systems or devices outside of the system. It can be a global system for mobile communications (GSM) module, Bluetooth, or Wi-Fi module that enables data transmission or remote monitoring. Power source: an appropriate power source, such as a battery or regulated power supply, powers the Arduino and the sensors. Among the Arduino family's most well-known and often-used microcontroller boards is the Arduino-Uno. It is an open-source electronics platform built on user-friendly hardware and software that aims to increase accessibility to the use of electronics in interdisciplinary projects. The ATmega328P, an 8-bit AVR-RISC microprocessor, is the foundational chip of the Arduino-Uno. It has two KB of SRAM, one KB of EEPROM, and 32 KB of flash memory for storing code (of which the bootloader uses 0.5 KB). Although the board runs at 5 V, it can be powered by an external power supply that has a voltage range of 7 to 20 V or by a USB connection. Digital input/output (I/O) pins range in number from 0 to 13.

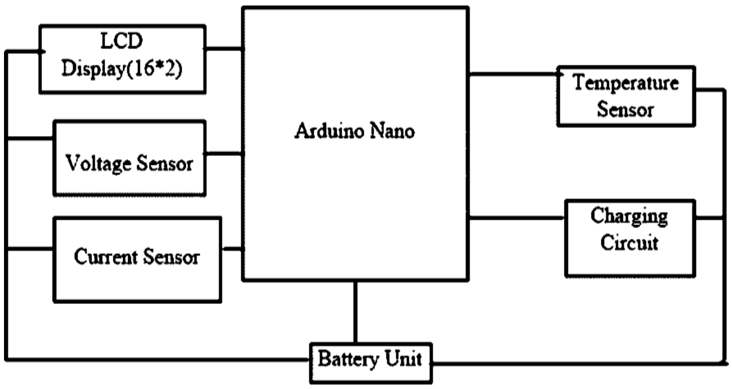

Figure 1. Block diagram of BMS

3. SIMULATION RESULTS

Figure 2 shows the MATLAB simulation diagram of BMS. The main output blocks simulation diagram are overcurrent, under temperature, and over temperature. The main objectives of the proposed simulation work, monitoring battery temperature and current. The over and under temperature of the battery is 2700 to 3200. Figure 3 shows the over-temperature and under-temperature of the battery. The waveform has three colors red color indicates the lower temperature, and yellow color indicates the battery operating condition temperature. Figure 4 indicates the battery current waveform. The waveforms have a charging limit and a discharging limit.

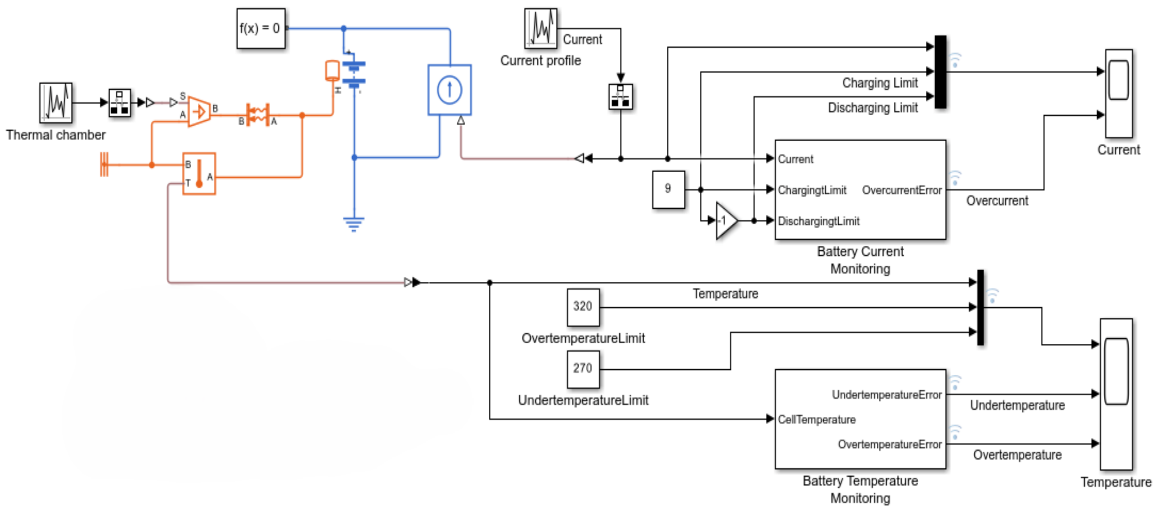

Figure 2. Battery temperature and current monitoring MATLAB

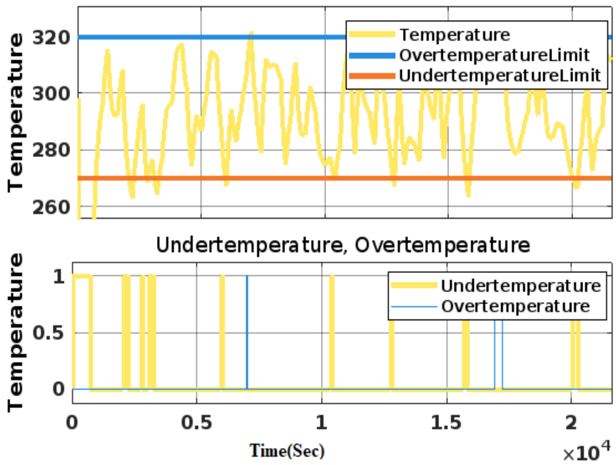

Figure 3. Output waveform of battery temperature

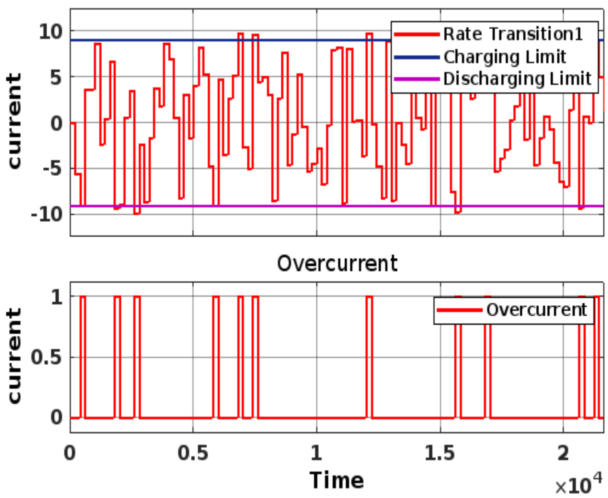

Figure 4. Battery current waveforms

Figure 5 shows the battery monitoring system diagram. The diagram was implemented and tested in Tinkercad software. The major components of the diagram are Arduino, battery, display, transistor, and DC fan. The Arduino controller is mainly for generating pulse, the DC fan is load, display is used for monitoring temperature. Resistors and capacitors are protecting devices. Figure 6 shows the hardware diagram of the battery temperature monitoring system. We can observe the battery temperature in the display. The relay is used for protecting devices in the system. The batteries are connected in series in a circuit.

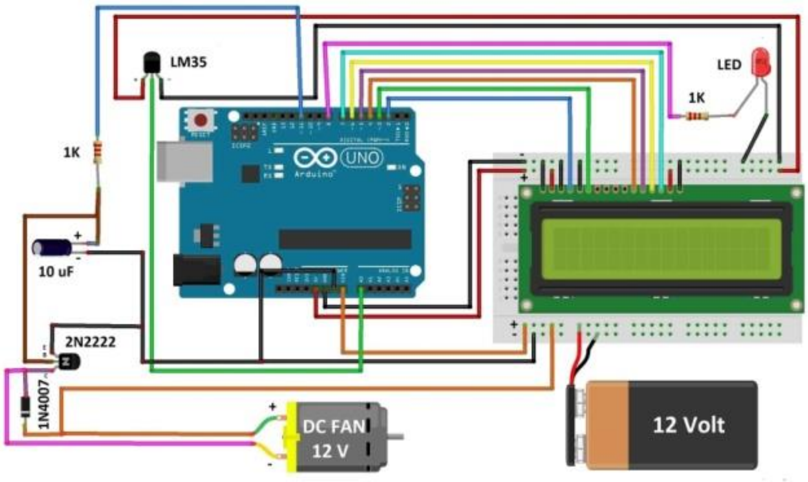

Figure 5. Battery temperature, voltage, and current monitoring hardware kit

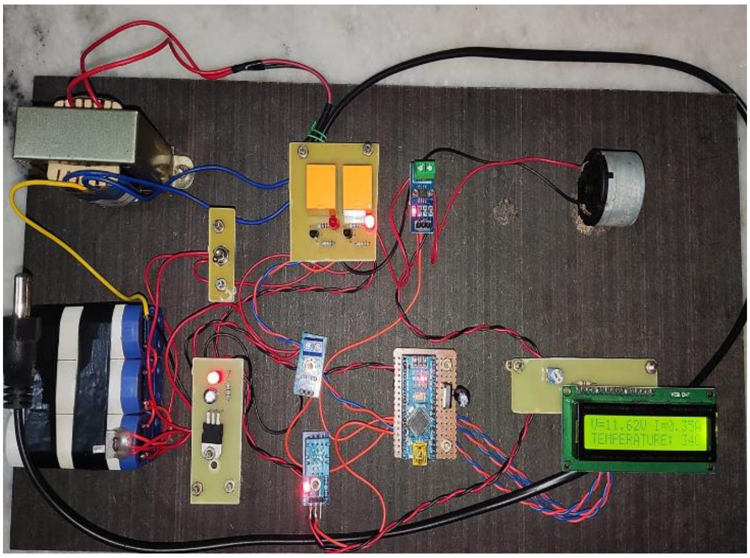

Figure 6. Output of battery temperature monitoring

4. CONCLUSION

In this research, we have developed and tested a battery temperature monitoring system utilizing Arduino technology. The primary objective was to design a cost-effective, reliable, and efficient system capable of monitoring and managing the temperature of batteries, ensuring their safety and longevity. The results of our study indicate that the system performs admirably in real-time temperature monitoring and data logging, offering significant benefits for various applications, particularly in renewable energy systems and electric vehicles. In conclusion, our research demonstrates that an Arduino-based battery temperature monitoring system is not only feasible but also highly beneficial. It offers a practical solution to enhance the safety and efficiency of battery-operated systems, contributing to the advancement of renewable energy technologies and electric mobility.

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