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Full Length Article

EV BMS With Charge Monitor and Fire Detection

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Abstract

With the rapid rise in electric vehicles (EVs), intelligent Systems are being developed that will facilitate battery reliability, improve performance and optimize safety while operational. This paper includes an advanced Battery Management System (BMS) that monitors battery charge in real-time and takes proactive measures in preventing fire. The BMS will be used for real-time monitoring of critical parameters of the battery, such as voltage, current drain, temperature, and state of charge (SOC). These will enable accurate control and extension of the life of battery packs. Each BMS will be connected to a monitoring unit that will process sensors for abnormal thermal and electrical states, which may cause hazardous situations. To minimize safety risks associated with EV battery packs, the BMS will include a module for early detection and prevention of fire by monitoring thermal runaway and taking pre-emptive actions, i.e., isolating circuits and alerting. Intelligent algorithms will be included for effective energy management andefficient performance for various battery states of charge. These will be integrated into an enhanced safety system for overall safety and optimal charge/discharge cycles. This model is intended to provide a robust, scalable and cost-effective solution to the next generation of electric mobility while promoting greater.

Keywords

Electric Vehicles (EVS); Battery Management System (BMS); State of Charge (SOC); Thermal Runaway; Internal Combustion Engine (ICE)

Introduction

Electric vehicles (EVs) are a modern class of automobiles that utilize one or more electric motors for propulsion, replacing the conventional internal combustion engine (ICE) that relies on fuel combustion. In the case of EVs, the electrical energy is stored in the battery pack and is then supplied to the motor for the rotation of the wheels. In comparison to conventional vehicles, EVs have various advantages. These advantages include reduced emissions, reduced noise levels, energy efficiency, and reduced dependence on fossil fuels. In addition to the above advantages, the cost of operation is also reduced since the cost of electrical energy is less compared to the cost of gasoline. As the world is moving toward sustainable and environmentally friendly technologies, the usage of EVs is increasing at a rapid pace due to government incentives and the advancements being made in automobile technology. However, despite these advantages, there are some challenges associated with EVs, especially in the context of that constantly monitors parameters such as voltage, current, and temperature, and it is also responsible for estimating the SoC and health of the battery.

The BMS regulates the charging and discharging of the battery to prevent overcharge, over-discharge, and overheat. The general components found in a BMS include sensors, control circuits, and intelligent algorithms working together for the optimization of battery performance. Among the important functions performed by BMS is the ability to regulate the battery temperature within a predetermined safe temperature range through the regulation of charging rates or the disconnection of the battery when necessary. Additionally, BMS regulates the charging of individual cells, which is important for lithium-ion battery types used for EVs.In this project, an advanced monitoring and protection system is designed to increase the safety of the battery. In the system, the battery's voltage, current, humidity and temperature are monitored. In addition, the system is equipped with a fire detection system. When the temperature is higher than the predetermined limit, the system disconnects the battery using a relay.

Literature Review

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Existing System

In conventional Battery Management Systems (BMS), the primary focus is on monitoring electrical parameters such as voltage, current, and temperature to ensure safe battery operation. While these systems are effective in preventing overcharging, deep discharging, and basic thermal issues, most existing designs do not incorporate direct fire detection mechanisms. Additionally, many systems rely only on passive thermal monitoring without implementing active cooling solutions such as cooling fans. As a result, in situations involving rapid temperature rise or internal faults, the response may be limited to system shutdown without addressing the root cause of overheating.

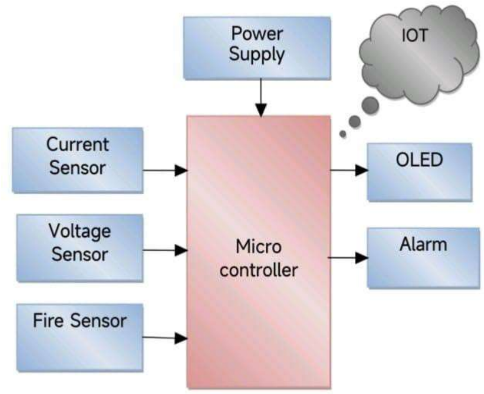
Proposed System

In contrast, the proposed system enhances the safety and reliability of conventional BMS by integrating a flame sensor for real-time fire detection and cooling fans for active thermal management. The inclusion of a flame sensor enables early identification of fire hazards, allowing immediate preventive action. Similarly, the use of cooling fans helps in regulating battery temperature proactively, reducing the chances of thermal runaway. These additional features make the proposed system more robust, responsive, and suitable for high-safety applications, thereby providing a significant improvement over existing solution.

Advantages:

- **Enhanced Safety through Fire Detection:** Unlike existing systems that rely only on temperature monitoring, the proposed system incorporates a flame sensor, enabling direct and early detection of fire hazards. This significantly reduces the risk of accidents.
- **Active Thermal Management:** The inclusion of cooling fans provides an active method to regulate battery temperature. This is more effective than passive thermal monitoring used in traditional systems, helping to prevent overheating and thermal runaway.
- **Real-Time Multi-Parameter Monitoring:** The system continuously monitors voltage, current, temperature, humidity and fire conditions simultaneously, ensuring a more comprehensive assessment of battery health compared to conventional BMS.
- **Automatic Protection Mechanism:** The use of a relay-based cut-off system allows immediate disconnection of the battery under unsafe conditions, improving response time and preventing damage. International Journal of Science and Research Archive, 2026, 18(03), 1270-1276 1274
- **Improved Battery Lifespan:** By maintaining optimal operating conditions through proper monitoring and cooling, the system helps in reducing battery stress and extending its service life.
- **Higher Reliability and Fault Detection:** The integration of multiple sensors improves the accuracy of fault detection and reduces the chances of system failure. \

Block Diagram



Working Principle :

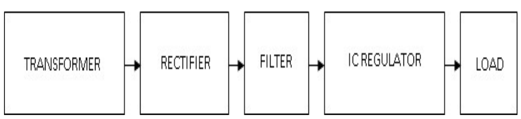
The system operates as an integrated IoT monitoring and safety network centered around a core microcontroller. First, the dedicated power supply provides stable electrical energy to run the controller and its connected peripherals. Next, the current sensor continuously tracks the electrical flow while the voltage sensor measures live circuit levels. Simultaneously, the fire sensor scans the surrounding environment for any immediate signs of heat, smoke, or flames. The microcontroller acts as the central brain, reading these incoming analog or digital signals at regular intervals. It evaluates the collected data by comparing the values against pre-programmed safe operational thresholds. For local interaction, the microcontroller outputs real-time voltage and current measurements directly onto the OLED display. If a threshold is breached or a fire is detected, it instantly triggers the alarm to warn nearby personnel. Finally, the system utilizes an IoT module to transmit all gathered telemetry data to the cloud for remote monitoring.

Hardware Implementation :

- **Microcontroller:** ESP32 NodeMCU-32S [Dual-core 240MHz, 4MB Flash, Built-in Wi-Fi & Bluetooth, 3.3V]
- **Current Sensor:** ACS712 Module [Hall-effect, ±20A AC/DC range, 100mV/A sensitivity, 5V supply]
- **Voltage Sensor:** ZMPT101B Module [AC Voltage Transformer, 0V-250V AC input, adjustable

analog output]
Fire Sensor: YG1006 Infrared Module [760nm-1100nm wave range, 60° detection angle, Digital/Analog output]
OLED Display: SSD1306 Screen [0.96-inch, 128x64 pixels, I2C interface, Blue/White monochrome pixels]
Alarm: TMB12A05 Piezo Buzzer [Active internal oscillator, 5V DC drive, 85dB output sound level]
Power Supply: Hi-Link HLK-PM01 [Isolated switching step-down, 100-240V AC input, 5V DC 3W output]

Power Supply:
The power supply section is the section which provide +5V for the components to work.
IC LM7805 is used for providing a constant power of +5V.
The ac voltage, typically 220V, is connected to a transformer, which steps down that ac voltage down to the level of the desired dc output. A diode rectifier then provides a full-wave rectified voltage that is initially filtered by a simple capacitor filter to produce a dc voltage.
Bridge Rectifier:
When four diodes are connected as shown in figure, the circuit is called as bridge rectifier. The input to the circuit is applied to the diagonally opposite corners of the network, so in this happen
and the output is taken from the remaining two corners. Let us assume that the transformer is working properly and there is a positive potential, at point A and a negative potential at point
B. the positive potential at point A will forward bias D3 and reverse bias D4.



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 India) to a safer low voltage.
Microcontroller:
Node MCU is an open-source Lua based firmware and development board specially targeted for IoT based Applications. It includes firmware that runs on the ESP8266 Wi-Fi SoC from Express if Systems, and hardware which is based on the ESP-12 module.
Node MCU ESP8266:
The Node MCU development board, based on the ESP32 chip, serves as the high-performance central processor for this IoT monitoring network. It powers the system using its dual-core 32-bit architecture operating at a fast clock speed of 240MHz [NodeMCU-32S]. This processing unit handles sensor sampling while running its built-in
2.4GHz Wi-Fi stack for seamless, standalonewireless cloud connectivity. Multiple dedicated analog-to-digital converter pins interface directly with the current, voltage, and fire sensors for continuous data collection. Finally, its onboard hardware buses drive local output actions by managing I2C display updates to the OLED screen and sending immediate digital triggers to the emergency alarm buzzer.

OLED Display:
An OLED display have the following advantages over an LCD display:
1. >Improved image quality - better contrast, higher brightness, fuller viewing angle, a wider colour range and much faster refresh rates.
2. >Lower power consumption.
3. >Simpler design that enables ultra-thin, flexible foldable and transparent displays.
4. Better durability - OLEDs are very durable and can operate in a broader temperature range.

Current sensor
A current sensor is a device that detects and converts current to an easily measured output voltage, which is proportional to the current through the measured path. It can be
Then utilized to display the measured current in an ammeter or can be stored for further analysis in a data acquisition system or can be utilized for control purpose.

Voltage sensor
The Voltage Sensor is a device that converts voltage measured between two points of an electrical circuit into a physical signal proportional to the voltage.
Voltage sensor circuit is a combination of various electronic component by using which the accurate voltage value can be achieved. The major component utilize in voltage sensor are potentiometer & ADC.

Fire sensor
The Fire sensor, as the name suggests, is used as a simple and compact device for protection against fire. The module makes use of IR sensor and comparator to detect fire up to a range of 1-2 meters.
The device, weighing about 5 grams, can be easily mounted on the device body. It gives a high output on detecting fire. This output can then be used to take the requisite action. An on-board LED is also provided for visual indication.Buzzer:
A buzzer or beeper is a signaling device, usually electronic, typically used in automobiles, house hold appliances such as a microwave oven, or game shows.
It most commonly consists of a number of switches or sensors connected to a control unit that determines if and which button was pushed or a preset time has lapsed, and usually illuminates a

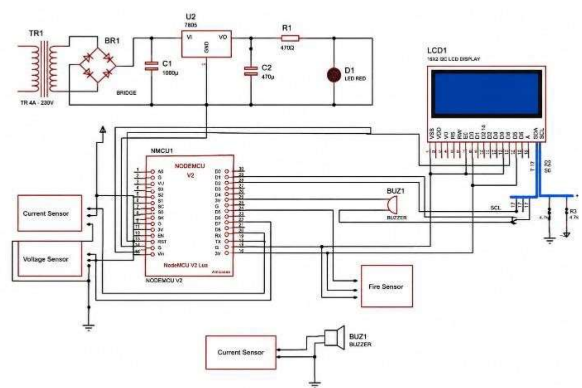
light on the appropriate button or control panel, and sounds a warning in the form of a continuous or intermittent buzzing or beeping sound. Initially this device was based on an electromechanical system which was identical to an electric bell without the metal gong (which makes the ringing noise).

DHT11–Temperature dity Sensor:

The DHT11 is a commonly used Temperature and humidity sensor. The sensor comes with a dedicated NTC to measure temperature and an 8-bit microcontroller to output the values of temperature and humidity as serial data. The sensor is also factory calibrated and hence easy to interface with other microcontrollers.

Sensor physical interfacing is realized through a 0.1” pitch 3-pin connector: +5V, GND and DATA. First two pins are power supply and ground and they are used to power the sensor, the third one is the sensor digital output signal.

SCHEMATIC DIAGRAM :



RESULTS :

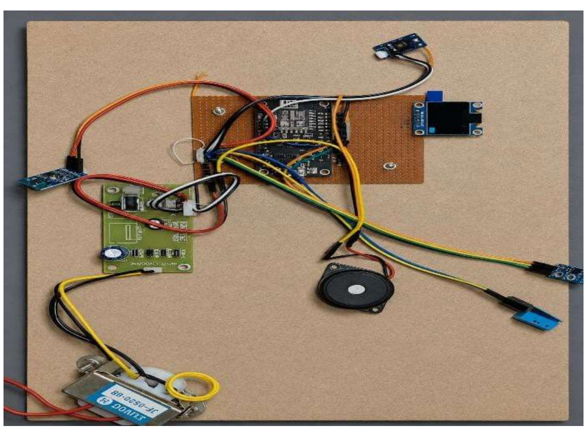


Fig.1: Hardware Kit in OFF Condition

The figure shows the complete hardware setup in the OFF or idle state. In this condition, the power supply is connected but the system is not actively processing or displaying sensor data. The microcontroller remains in an initial standby mode, and no signals are sent to the output devices such as the OLED display, relay, or buzzer.

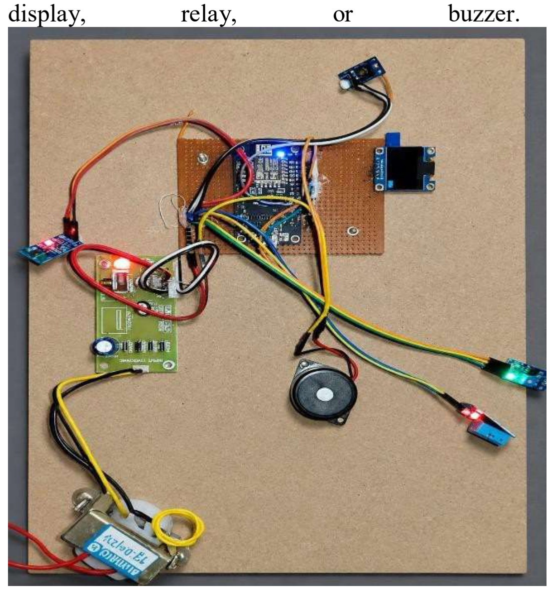


Fig 2: Hardware Kit in ON Condition

All sensors and components are active. The system begins collecting and processing environmental data.to NodeMCU ESP8266 initializes all connected sensors and begins real-time data acquisition. The sensors start detecting environmental parameters. Output devices such as the OLED display and IoT module become active.

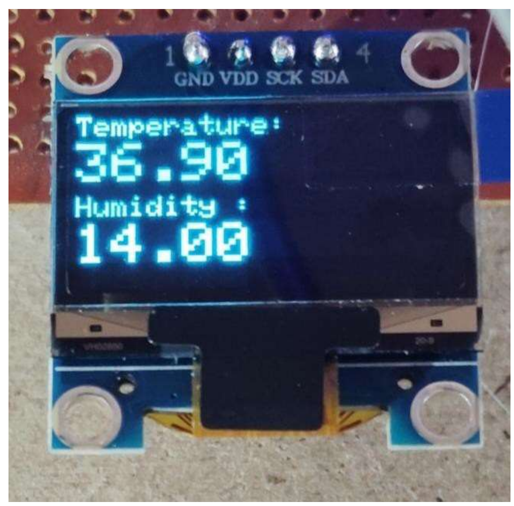


Fig.3 : Display shows Temperature and Humidity values

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The OLED display in this figure shows real-time temperature and humidity readings obtained from the DHT11 sensor. The values are updated periodically and displayed in a clear, readable format. This helps users understand the surrounding environmental conditions instantly.

Fig.4: Display shows MQ135 sensor Value

The output of the system is displayed on the OLED screen, which shows real-time battery monitoring values such as temperature and humidity under normal conditions. When abnormal conditions like fire or overheating occur, the display shows a warning message such as “Fire Occurred.” Simultaneously, the buzzer activates to alert the user and ensure quick action is taken. This output system helps in improving battery safety, preventing damage, and enabling effective monitoring of EV battery conditions.

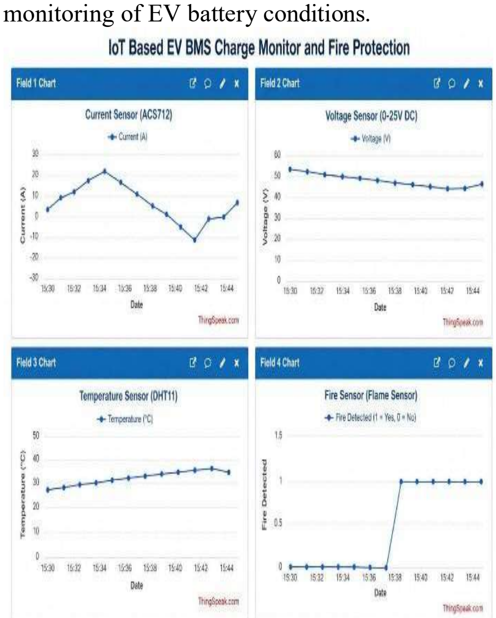

Fig.5: Displaying sensors data through Thing speak

This figure illustrates the Thing Speak output graph displays the real-time monitoring data of the IoT Based EV BMS Charge Monitor and Fire Protection system. The first graph shows the current sensor values, which are used to monitor the charging and discharging current of the EV battery. The second graph represents the voltage sensor values, helping to track battery voltage continuously and prevent overcharging or low voltage conditions.

CONCLUSION:

The IoT-based air quality monitoring and air purifier system provides an efficient and cost-effective solution for real-time environmental monitoring. By integrating sensors, microcontroller, and cloud technology, the system ensures continuous tracking of air quality and automatic purification when required. It overcomes the limitations of traditional monitoring systems by offering portability, affordability, and real-time accessibility.

The system is suitable for indoor environments such as homes, offices, and small industries. Experimental results show reliable performance in detecting pollutants and maintaining air quality. Overall, this project contributes to improving public health and environmental safety through smart technology.

ABBREVIATIONS :

- ❖ IoT: Internet of Things
- ❖ EV / EVs: Electric Vehicle / Electric Vehicles
- ❖ BMS: Battery Management System
- ❖ SOA: Safety Operation Area
- ❖ BLDC: Brushless Direct Current
- ❖ PMSM: Permanent Magnet Synchronous Motor
- ❖ MCU: Microcontroller Unit (indicated in index as NODE MCU)

FUTURE SCOPE :

AI-based battery health monitoring.
Mobile app for real-time tracking.
Advanced fire detection and safety.
Improved fast charging system.
Smart EV and IoT integration

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