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EV BMS with fire protection and charge monitoring system

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Abstract:

Electric vehicles (EVs) are undoubtedly the way of the future. However, as of 2023, EV technology has not reached its full potential in terms of efficiency and safety. The cause of majority of the electric vehicle fire events is a battery explosion or fire. This paper presents an integrated approach to manage EV battery systems, which combines a Battery Management System (BMS) with charge monitoring and fire detection. The system is built to continuously monitor the battery's voltage, current, and temperature and to immediately turn off the battery's input or output if any unexpected behaviour is noticed.

1. Introduction:

The adoption of electric vehicles (EVs) has been steadily increasing in recent past, driven by a combination of factors viz. environmental concerns, fuel efficiency, and government incentives. However, managing the battery systems that power EVs is a serious challenge that must be addressed to ensure the safety and efficiency of these vehicles. The battery system in an EV consists of several battery cells, which need to be monitored and regulated to prevent overcharging or discharging, which can lead to reduced battery The BMS consists of battery cells, a battery life, reduced performance, and even safety hazards such as fires. (*Zeng, Y., Zhou)*

Battery Management Unit (BMU), and sensors, which work together to monitor and regulate the Voltage sensors are used to monitor voltage and control the amount of current that can go to the battery while it is charging. Charging circuitry is utilised to do this. Battery voltage is displayed on the LCD. The current sensor monitors current drawn from the battery when it is connected to a load and shows the parameter on LCD. The temperature sensor is used to keep track of the battery's temperature both while charging and discharging. The system automatically sounds a buzzer alarm and displays a message on the LCD if the battery temperature is seen to differ from the expected values. As a result, the technology enables an intelligent and effective battery charging and detecting system. Battery's state of health, state of charge, and temperature. The charge monitoring system provides real-time feedback on the charging process, including the amount of power being delivered, the battery's charge level, and the charging speed. Additionally, the fire protection system uses a combination of thermal management and fire suppression techniques to detect and prevent potential fires from occurring. *(Pesaran, A., Keyser,)*

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2. Block diagram of BMS

This system is designed for an Electric Vehicle (EV) Battery Management System (BMS) with integrated fire protection and charge monitoring. It ensures safety by monitoring temperature, voltage, and current while controlling relays for charge management and fire safety mechanisms.

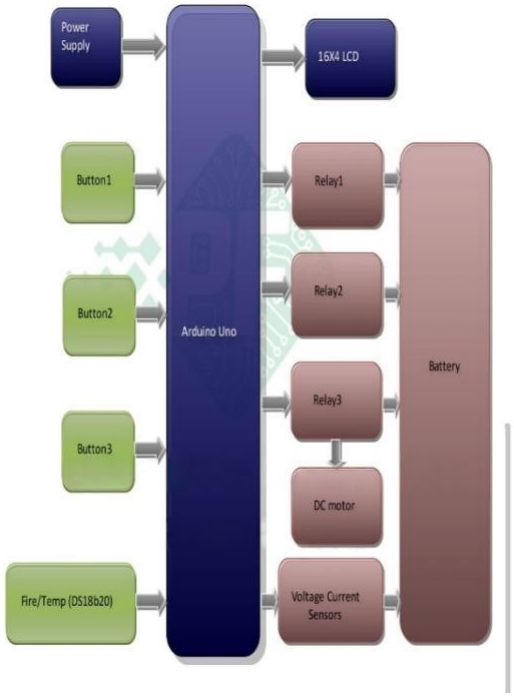

Fig 1 : Block Diagram

The system is powered by a regulated power supply, providing the necessary voltage and current for the Arduino Uno and other components.

The Arduino Uno microcontroller is the central processing unit of the system. It collects data from sensors, processes it, and controls relays and the LCD display.

A 16x4 Liquid Crystal Display (LCD) is used to display real-time system parameters such as battery voltage, current, temperature, and system status.

The buttons provide user interaction for different functions such as for Fast Charging , for slow charging and to turn on the motor.

A DS18B20 temperature sensor continuously monitors the battery temperature. If the temperature exceeds a predefined safety limit, the system activates fire protection measures (e.g., relay-based cooling or shutdown).

The three relays are used for controlling various operations such as a relay Controls battery charging process , a relay Controls battery discharging , a relay controls the motor on/off.

Battery Voltage & Current Sensors measure the real-time voltage and current of the battery. The data is used for monitoring charge levels, detecting overcharging, and ensuring battery health.

Sensors continuously measure battery voltage, current, and temperature. If the DS18B20 detects high temperatures, the system triggers Relay3 to activate a cooling mechanism or shut down power. The Arduino controls Relay1 and Relay2 to regulate battery charging and discharging. The LCD display shows real-time data, and buttons allow manual control or system reset. This system ensures safe charging, overcurrent protection, fire hazard prevention, and efficient battery health monitoring, making it an essential part of an EV Battery Management System.

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3. Circuit Diagram

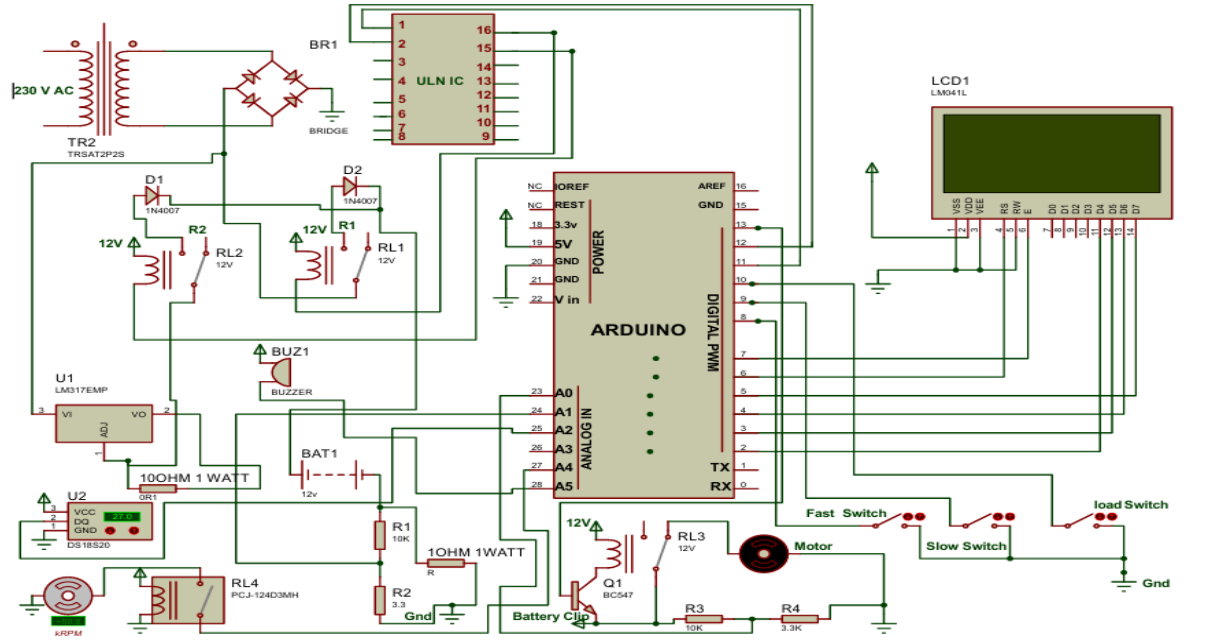

Fig 2: Circuit Diagram

4. Components:

1. Power Supply

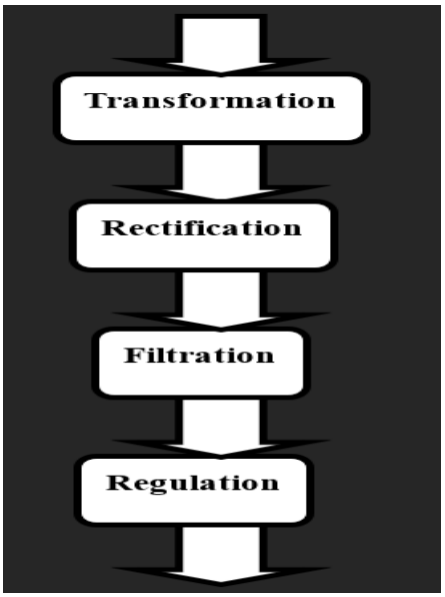

Fig 3: Flow chart of Power Supply

TR2 (Transformer): Steps down the 230V AC mains to a lower AC voltage.

Bridge Rectifier (BR1): Converts the stepped-down AC voltage into DC.

D1 & D2 (Diodes): Provide reverse polarity protection and rectify AC voltage.

BAT1 (Battery): Provides backup power, ensuring continuous operation during power outages.

2. Arduino Microcontroller

Fig 4: Arduino Microcontroller

It is the central control unit of the circuit. It receives inputs from sensors and switches and controls the relays, buzzer, motor, and display.

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Key Pins:

Analog Pins (A0–A5): Read sensor inputs (e.g., temperature).

Digital Pins (D0–D13): Control relays, switches, and LCD.

Power Pins (VIN, GND): Receive power from the supply.

3. Sensors

U2 (DS18B20): A digital temperature sensor interfaced with the Arduino for accurate temperature readings.

4. Relays

Fig 5: Relay

RL1, RL2, RL3, RL4: Electromechanical switches controlled by the Arduino.

RL1 & RL2: Control the charging (slow charging and fast charging).

RL3: Controls the motor.

RL4: Controls the turn on/off of buzzer and fan.

5. Motor and Control

A motor is connected through RL3, allowing the Arduino to start/stop it based on inputs from the switches (Fast Switch and Slow Switch).

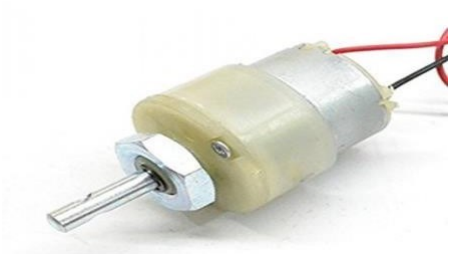

Fig 6: Dc Motor

ULN IC : Amplifies the control signal to drive multiple relays.

Fig 7: ULN IC

6. Buzzer (BUZ1)

Sounds an alarm or notification based on the Arduino's logic, e.g., in case of high temperature (above 55 deg).

Fig 8: Buzzer

8. DC Fan

Fig 9: Dc Fan

It is used as heat sink for the batteries when the temperature of the battery exceeds a specified temperature (ex 55 deg).

7. LCD Display

LCD1 (LM041L): A 16x4 character LCD used to display real-time data such as temperature, motor status, and battery level. Controlled via Arduino's digital pins.

Fig 10: LCD Display

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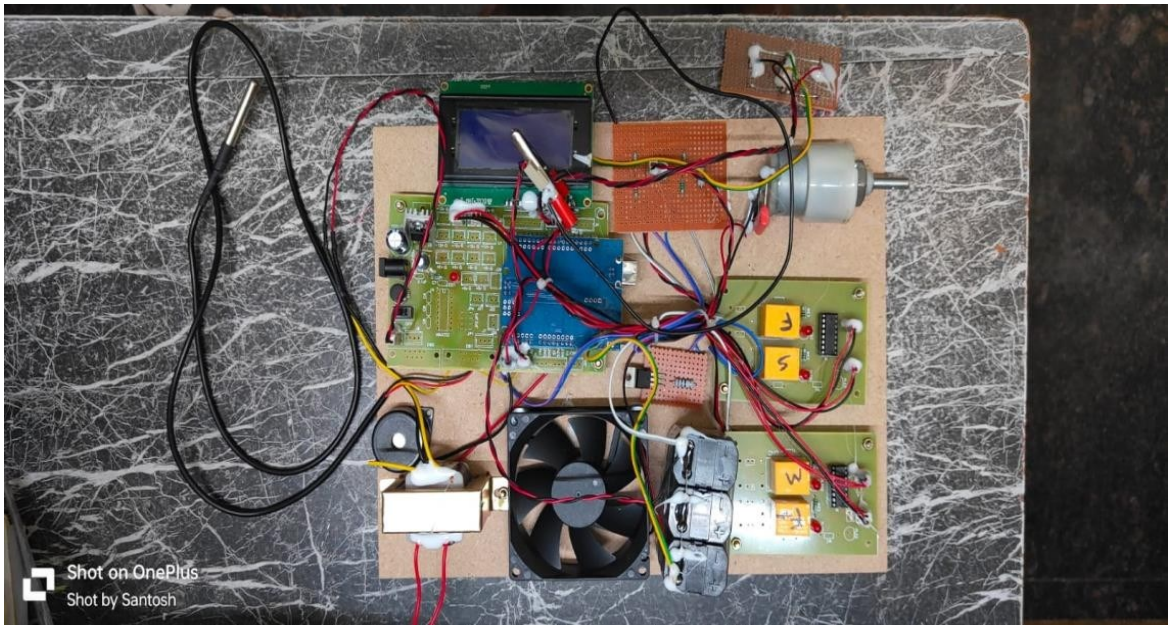
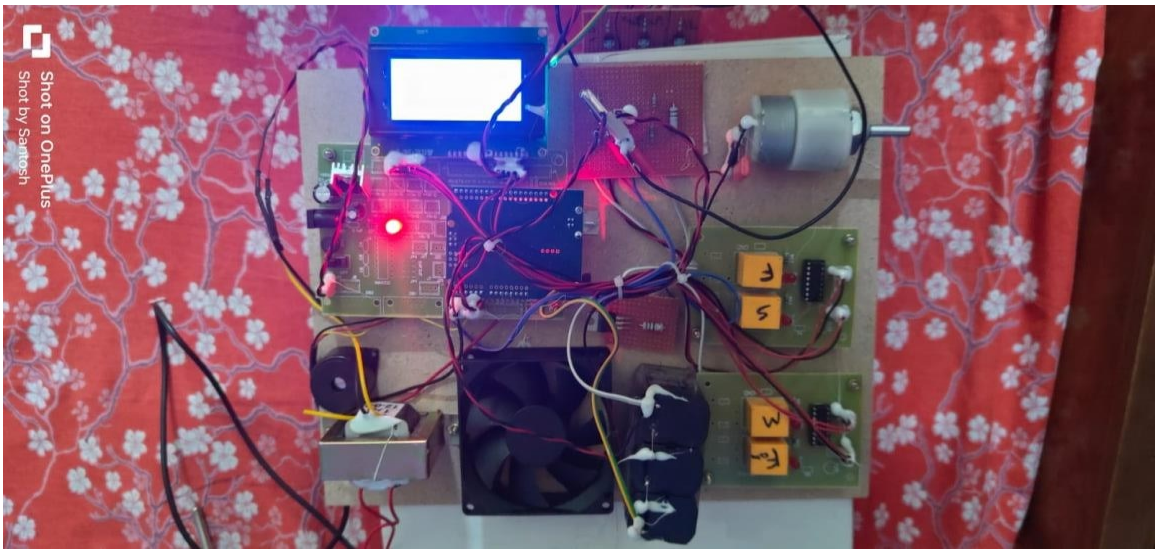
5. Experimental Results:



All the components are brought together and connections are made as per the circuit diagram.The software code is dumped in the Arduino for the implementation.



From the above execution of project , the battery voltage obtained is 12V and it is in fast charge mode, current obtained is 1A , and the buzzer gets on when Temperature of battery exceeds 55°C.

6. Conclusion:

The system is intended to monitor battery voltage, current, and temperature continuously and to immediately stop taking input or output from the battery when any odd behaviour is noticed.

The advantages that this system offers are as follows:

i. Battery Status Display and Monitoring

ii. Battery charging according to the necessary input parameters

iii. Temperature monitoring with an automatic cutoff

iv. When temperature increases above a certain level, an alarm is set to notify the user

v. Automatic cooling for the battery when the temperature exceeds the specified temperature.

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