

# Design And Implementation Of Battery Monitoring System In Electric Vehicle

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**Abstract** - lectric vehicles (EVs) represent a significant advancement in sustainable transportation, with their widespread adoption contributing to reduced greenhouse gas emissions. However, ensuring the safety and reliability of EV battery systems remains a critical concern. The proposed system continuously monitors the temperature and detects smoke within the battery compartment in an electric vehicle. Temperature sensors are strategically placed to measure the temperature of a battery cell, while smoke sensors are deployed to detect any signs of overheating or potential fire hazards. The sensors are integrated into a centralized monitoring unit, which processes the sensor data in real-time. In the event of abnormal temperature readings or the detection of smoke, the monitoring system triggers immediate alerts to the vehicle operator or relevant authorities, enabling timely intervention to prevent potential safety hazards. Implementing this monitoring system increases the safety and reliability of an electric vehicles, addressing concerns related to battery overheating, fire risks, and ensuring the overall well-being of vehicle occupants and surrounding environments. Moreover, it contributes to the broader goal of advancing sustainable transportation by instilling confidence in the safety of an electric vehicle technology

**Keywords**— Electric Vehicle, Battery Temperature Monitoring System, Temperature Sensor, Smoke Sensor, Safety, Real-time Monitoring.

## I. INTRODUCTION

As fuel prices rise, an electric vehicles (EVs) are becoming increasingly popular. This trend is prompting manufacturers to explore energy alternatives to gasoline. The shift towards electric power will lead to environmental benefits due to reduced pollution. EVs offer significant energy savings and contribute to environmental conservation [1]. The majority of EVs utilize lithium-ion batteries, which are more compact than lead-acid batteries. These batteries deliver consistent power and have a life cycle that is 6 to 10 times longer than that of lead-acid batteries [2]. However, the lifespan of lithium-ion batteries can be reduced by factors such as overcharging and deep discharges. Additionally, EVs often have a limited travel range, constrained by the size of the battery and the vehicle's design [3]. A major concern hindering EV adoption is the safety of current battery technology. For instance, overcharging a battery can drastically reduce its lifespan and even pose serious safety risks, including fires. Consequently, an effective battery monitoring system for EVs is essential. Such a system should inform users about the battery's status to prevent these issues[4]. Unlike earlier systems that only monitored and signaled battery conditions through an in-vehicle indicator, modern systems need to be more comprehensive.

In response to this demand, this project proposes the development of an Electric Vehicle Battery Monitoring System (EVBMS) utilizing temperature sensors interfaced with the ATmega328P microcontroller. The

ATmega328P, known for its versatility and efficiency, serves as the central processing unit to collect, analyze, and respond to temperature data from the sensors.

The central aim of this project involves creating a reliable monitoring system that can precisely measure the real-time temperature of an electric vehicle (EV) battery. By continuously monitoring temperature fluctuations, the Electric Vehicle Battery Management System (EVBMS) offers valuable information about the battery's thermal behaviour. This data enables proactive actions to enhance performance and prevent safety risks, such as overheating.

This introduction sets the stage for the project, highlighting the importance of battery temperature monitoring in an electric vehicles and outlining the proposed approach utilizing the ATmega328P microcontroller and temperature sensors. The subsequent sections will delve into the system architecture, sensor selection, hardware implementation, software development, and testing procedures to realize a functional of Electric Vehicle Battery Monitoring System.

### *A. Roll of Electric Vehicle*

Electric vehicles (EVs) have emerged as a vital solution in combating climate change and promoting environmental sustainability. Let's delve into the details:

#### 1. Reduced Emissions:

- Unlike conventional gasoline or diesel-powered vehicles, EVs produce lower or zero tailpipe emissions. This transition from the internal combustion of engines to electric motors significantly reduces carbon dioxide emissions and other pollutants.
- By driving EVs, we contribute to improved air quality and take steps toward a greener planet.

#### 2. Global Climate Goals:

- EVs are prominently featured in mitigation pathways aimed at limiting global warming below 2°C or 1.5°C, aligning with the targets set by the Paris Agreement.
- While EVs themselves do not emit greenhouse gases directly, they rely on electricity, which is often still produced from fossil fuels in many regions. However, as countries transition to cleaner sources, the advantages of EVs will become more pronounced.

#### 3. Lifecycle Emissions:

- Across Europe, EVs are responsible for considerably lower lifetime emissions compared to conventional internal combustion engine vehicles.
- In the UK, the Nissan Leaf EV exhibited significantly lower lifetime emissions per kilometer driven compared to the average conventional car. This reduction was evident even before considering the declining carbon intensity of electricity generation over the vehicle's lifespan.
- The contrast between electric and traditional vehicles can fluctuate depending on several factors, including vehicle dimensions, fuel-efficiency evaluations, emissions calculations for electricity usage, driving habits, and local climate conditions.

#### 4. Emissions from Battery Production

- Battery production is a critical aspect of EVs. Approximately half of battery production emissions arise from the electricity used during manufacturing and assembly.
- As battery prices decline and automakers integrate larger batteries with extended driving ranges, the significance of emissions from battery production grows.

- Opting for battery production in regions with low-carbon electricity sources or utilizing renewable energy can greatly mitigate these emissions.

#### *B. Literature Review*

In their 2022 study, MS Ramkumar, C Reddy, A Ramakrishnan, et al. [6], presented a comprehensive review of lithium-ion batteries and their integration with battery management systems (BMS) in electric vehicles (EVs). The paper elucidates the various functions performed by BMS in regulating and overseeing battery operations within EVs. With the rising popularity of EVs, there is a growing emphasis on their advantages, such as compact size, environmental friendliness by eliminating the need for fossil fuels, and cost-effectiveness. Among the key components of EVs, batteries play a pivotal role as they significantly influence performance and efficiency. Consequently, prioritizing battery management becomes imperative. BMS plays a crucial role in monitoring and controlling the battery's functions, thereby safeguarding it, prolonging its lifespan, and enhancing its efficiency throughout the charging and discharging processes.

In their 2021 publication, S. Mishra, SC Swain, et al. [8], presented a comprehensive review of battery management systems (BMS) and their integration in electric vehicles (EVs). The paper provides insights into various strategies employed in BMS, including battery modeling, state estimation, and prediction techniques. Specifically, the review discusses state estimation parameters such as State of Charge (SOC), State of Power (SOP), State of Health (SOH), and the prediction of Remaining Useful Life (RUL). Given the pivotal role of battery performance in EVs, particularly with the prevalent use of Lithium-ion (Li-ion) batteries due to their lightweight, high energy density, and rapid charging capabilities, BMS becomes indispensable. BMS designs are tailored to address dynamic performance, economic efficiency, safety considerations, and environmental sustainability. They aim to tackle challenges such as battery energy management, reducing heating time at low temperatures, and accurately predicting RUL. BMS primarily focuses on ensuring the reliability and safety of battery operations. Accurate state estimation of the battery is crucial for effective vehicle control and optimal energy management.

In their 2021 paper, PR Tete, MM Gupta, SS Joshi, et al. [9], highlighted the significance of power batteries as the core component of electric vehicles (EVs). The primary challenge facing EV technology is the identification of an appropriate energy storage solution capable of supporting long distances, rapid charging, and efficient driving. Lithium-ion batteries (LIBs) emerge as the most viable power source for EVs due to their inherent advantages. Notably, LIBs are composed of environmentally friendly materials, devoid of harmful gassing issues, and boast high levels of safety. However, the performance, lifespan, and safety of LIBs are heavily influenced by storage or operating temperatures and environmental factors. Despite their merits, the performance of LIBs is constrained by internal heat generation. Hence, the implementation of a Battery Thermal Management System (BTMS) becomes imperative to shield the batteries from detrimental effects stemming from temperature increases and internal heat generation.

#### *C. Problem Statement*

In the available literature, various methods have been developed for IoT-based monitoring systems for battery parameters. However, these methods primarily focus on monitoring the devices, with limited emphasis on implementing control actions. There is insufficient emphasis on monitoring battery heating and temperature in existing literature.

#### *D. Objectives*

The objective of this project is

- To develop a prototype to measure temperature and to simulate a model of a battery.
- Utilize the LM35 temperature sensor to continuously monitor temperature of an electric vehicle battery.

- Implement temperature regulation mechanisms to maintain the battery operates within safe temperature limits.
- Trigger cooling actions, such as activating the DC fan, when the battery temperature exceeds predefined thresholds, preventing overheating and potential damage.

## II. PROPOSED METHODOLOGY

### A. Lithium-ion Battery overview

Most electric vehicles (EVs) prefer lithium-ion batteries because they are more compact than lead-acid batteries. These batteries provide consistent power output and have a lifespan that is 6 to 10 times longer than lead-acid batteries. However, their longevity can be reduced by factors such as overcharging and deep discharges. Additionally, the travel range of EVs is generally limited by the battery's capacity and the design constraints of the vehicle. Lithium-ion batteries, much like their counterparts, function by storing and converting energy into electrical form during operation [11]. This electrical energy generation is facilitated by the movement of electrons, fundamental particles carrying a negative charge present in all atoms. Within the battery, chemical reactions orchestrate the transfer of these electrons between two essential components: the anode (negative electrode) and the cathode (positive electrode). Initially housed in the anode, electrons traverse through an electrolyte medium, which may exist in liquid or solid form, to reach the cathode. During discharge, electrons flow from anode to cathode, whereas during charging, the reverse occurs. A critical element of the battery design is the separator, a thin, porous membrane responsible for spatially segregating the anode and cathode electrodes. While facilitating the movement of lithium ions between electrodes, the separator also serves to prevent short-circuiting, a phenomenon where an electric current deviates from its intended path. Through the modification of a unique manganese oxide spinel structure to match the specific capacity of cobalt oxide spinel, a battery has been engineered with a specific energy of 115 Wh/kg and a rate capability of 60 Ah.

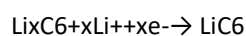
Year	Cathode	Anode	Electrolyte	Battery system
1980 - 1990	LiWO <sub>2</sub>	LiCoO <sub>2</sub> , LiNiO <sub>2</sub>	Polymer	Li/MoO <sub>2</sub> , LiVO <sub>x</sub>
1990 - 2000	LiC <sub>6</sub>	LiMn <sub>2</sub> O <sub>4</sub>		C/LiMn <sub>2</sub> O <sub>4</sub>

Table 1 Development of Li-based battery system

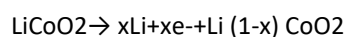
Li-ion cells must be operated within a safe voltage range to prevent damage and potential fire hazards. Charging beyond the safe voltage limit or discharging below the minimum voltage can lead to cell damage. Additionally, maintaining operation within the specified temperature range was crucial to prolonging the cells' lifespan.

The electrochemistry of the Li-ion battery on charging is shown below

-At negative electrode



- At positive electrode

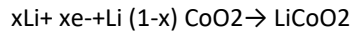


The electrochemistry of discharge is as follows

- At negative electrode



- At positive electrode



### B. Thermal Management

Effective thermal management on battery-powered electric vehicles is crucial as it directly impacts their performance, reliability, and durability. These vehicles require optimal operating temperatures to function efficiently, neither too warm nor too cold. Maintaining battery pack, a power electronic systems, and a motor within this optimal temperature range is crucial for their proper operation. When operating at optimum temperatures, the battery's charge, health, and capacity is conserved, while power systems and motors demonstrate their peak performance.

The thermal management system make sure that the battery pack remains within this range to maximize performance, extend battery life, and prevent overheating or overcooling. This may involve active cooling (such as liquid cooling or air cooling) or heating systems to regulate temperature.

The performance, longevity, and cost-effectiveness of a battery packs and an electric vehicles are closely intertwined. The feasibility of discharge of power for acceleration, charge acceptance during regenerative braking, and overall battery health are optimized at optimum temperatures. Conversely, as temperatures rise, battery life, vehicle drivability, and fuel efficiency decline. Therefore, comprehensive battery thermal management are critical to mitigate these thermal effects and ensure the overall efficiency and longevity of EV.

### C. Block Diagram

Figure 1 depicts the block diagram illustrating the proposed methodology, while Figure 2 presents the flowchart detailing the process flow of parameter monitoring and the subsequent controlling actions initiated.

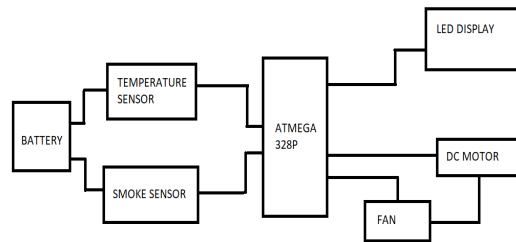


Fig.1 Block diagram of proposed system

### D. Working Explanation

In the complex framework of an electric vehicle's (EV) battery monitoring system, relays connected to the fan and motor play a crucial role in maintaining thermal balance. These relays function as electrically operated switches, allowing the battery management system (BMS) to control high-power cooling components such as fans and motors using low-power signals. This capability is vital for ensuring the battery operates within its optimal temperature range, which is essential for both safety and performance.

When the BMS detects that the battery temperature exceeds a safe threshold, it sends a low-power signal to the relay. This signal energizes the relay's coil, generating a magnetic field that closes the relay contacts. This action completes the circuit, allowing current to flow from the power source to the fan and motor, thereby activating these cooling components. The cooling system then works to dissipate heat from the battery pack, preventing overheating and potential damage.

Once the temperature drops back to an acceptable level, the BMS sends another signal to de-energize the relay's coil. Without the magnetic field, the relay contacts return to their default open position, breaking the circuit and cutting off power to the fan and motor. This stops the cooling process, conserving energy and reducing wear on the cooling components. This cycle of activation and deactivation ensures that the battery remains within its optimal temperature range, protecting it from the adverse effects of overheating and enhancing its overall efficiency.

The use of relays in this context offers numerous benefits. By precisely controlling the cooling components, relays help maintain the battery's thermal balance, which is crucial for its longevity and performance. They enable intermittent operation of the cooling system, enhancing energy efficiency by preventing unnecessary power consumption. The isolation provided by relays ensures safe switching of high-power loads with low-power control signals, protecting the system from electrical faults. Furthermore, relays facilitate automation within the BMS, allowing for responsive and autonomous thermal management without the need for manual intervention. This enhances the reliability and safety of the EV's battery system.

Relays connected to the fan and motor are essential components of an EV's battery monitoring system. They enable effective thermal management by allowing the BMS to control cooling components precisely. This ensures the battery operates within safe temperature ranges, preventing overheating and improving efficiency. The use of relays enhances the overall reliability, safety, and performance of the EV, making them indispensable for modern electric vehicles.

E. Flow chart

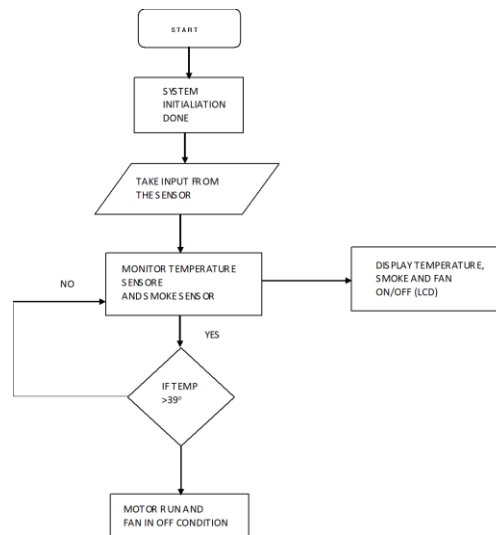


Fig.2 Flow chat of proposed system

III. PARAMETERS

The project utilizes several parameters to guarantee its functionality and effectiveness. These parameters include:

- Temperature sensor
- Smoke sensor
- Atmega328p microcontroller
- Fan (cooling system)
- Motor

- LCD

#### A. *Temperature sensor*

The LM35 temperature sensor is renowned for its capacity to generate an analogue signal directly correlated to the current temperature. This output voltage simplifies the activity of obtaining temperature readings in Celsius. Unlike thermistors, the LM35 doesn't necessitate external calibration, enhancing its user-friendliness. Additionally, its protective coating prevents self-heating, ensuring more accurate readings. Because of its affordability and superior accuracy, the LM35 has gained widespread popularity among hobbyists, DIY enthusiasts, and students. Its cost-effectiveness and precision have led to its integration into numerous low-end products, further extending its utility across various applications.

#### LM35 Temperature Sensor Features

- Calibrated Directly in Celsius (Centigrade)
- Linear + 10-mV/°C Scale Factor
- Ensured 0.5°C Accuracy (at 25°C)
- Rated for the Entire -55°C to 150°C Range
- Ideal for Remote Applications
- Operates Within 4 V to 30 V
- Less than 60-μA Current Drain
- Low Self-Heating, 0.08°C in Still Air
- Non-Linearity Only  $\pm\frac{1}{4}$ °C Typical.

Smoke sensors typically utilize one of several detection methods to identify smoke particles:

1. Photoelectric Detection: This method relies on a light source and a photosensitive receiver. When smoke enters the sensing chamber, it scatters light, causing a reduction in the light intensity reaching the receiver. These changes in the light intensity trigger the sensor to activate the alarm.

2. Ionization Detection: The smoke detector contains an ionization chamber supported with two plates of voltage between them. Electrons present between the plates are displaced by smoke entering the chamber. When smoke particles enter a chamber, they involve the flow of ions. Specifically, the alpha particles emitted by americium-241 ionize the air inside a detector's chamber, creating a small electrical current.

3. Dual Sensor Technology: Some smoke sensors combine both photoelectric and ionization detection methods to enhance sensitivity and reduce false alarms. By using multiple detection methods, these sensors can detect a wider range of smoke particles and provide more reliable detection.

Smoke sensors are commonly found in residential, commercial, and industrial buildings, also in vehicles and aircraft. They are often installed in areas prone to fire hazards, like kitchens, bedrooms, hallways, and electrical distribution panels.

Besides standalone smoke sensors, many modern fire alarm systems incorporate networked smoke detectors that communicate with a central control panel. These networked systems can provide advanced features such as remote monitoring, automatic notification of emergency services, and integration with building automation systems.

### *B. Fan (Cooling system)*

A DC fan, commonly used as cooling system in EV thermal management, was an electromechanical device designed to circulate air and dissipate heat from critical parameters such as batteries, power electronics, and motors.

A DC fan comprises a motor, blades, and a housing. The motor, typically a brushless DC motor, converts electrical energy into mechanical energy, rotating the blades to generate airflow. The blades are strategically designed to efficiently move air while minimizing noise and a power consumption. The housing surround the motor and blades, directing airflow in a specific direction.

In EVs, DC fans are often employed as part of a thermal management system to regulate a temperature of key components. When parameters such as batteries or power electronics generate excess heat in operation, a DC fan activates to draw in ambient air and facilitate heat transfer away from the components. This process helps to maintain optimum operating temperature, ensuring the efficiency, reliability, and longevity of a vehicle's critical systems.

DC fans used in electric vehicles are engineered for high performance, reliability, and energy efficiency. They designed to withstand the demanding operating conditions of automotive environments, including temperature variations, vibration, and moisture. Additionally, huge DC fans feature variables speed control to adjust airflow based on a temperature requirements, further optimizing thermal management efficiency.

### *C. Atmega328p Microcontroller*

The ATmega328P microcontroller is a versatile and widely used microcontroller within the Arduino ecosystem, known for its reliability, flexibility, and ease of use. In the context of an EV battery monitoring system, the ATmega328P can serve as the brain of the monitoring and control unit, facilitating efficient management of a battery pack.

Here's how the ATmega328P microcontroller can be utilized in an EV battery monitoring system:

1. **Data Acquisition:** The ATmega328P can interface with various sensors like voltage, current, and temperature sensors to monitor the state of a battery pack. It can sample sensor data at regular intervals to gather real-time details about the battery's voltage, current draw, temperature, and other relevant parameters.
2. **Data Processing:** With its built-in ADC (Analog-to-Digital Converter) and computational capabilities, the ATmega328P can process the acquired sensor data. It can perform calculations to determine the state of a charge (SoC), state of a health (SoH), and other key metrics of a battery pack. Additionally, the microcontroller can implement algorithms for battery balancing, cell voltage monitoring, and temperature compensation.
3. **Display and User Interface:** The ATmega328P can interface with LCD displays, LED indicators, and user input devices (such as buttons or touchscreens) to produce a user-friendly interface for monitoring the battery status. It can display relevant information such as a battery voltage, current, temperature, and remaining capacity, allowing the EV driver to detect the health and performance of a battery pack in real-time.
4. **Fault Detection and Protection:** The microcontroller can continuously monitor the battery parameters and detect any abnormalities or faults, such as overvoltage, under voltage, overcurrent, or overheating. In event of a fault condition, the ATmega328P can trigger appropriate protection mechanisms, such as disconnecting a battery pack from the vehicle's powertrain to prevent damage or fire hazards.
5. **Communication Interface:** The ATmega328P can communicate of other onboard systems in the EV, like the motor controller, onboard charger, and vehicle management system, using standard communication protocols like UART, SPI, or I2C. This allows for seamless integration and coordination between different components of the electric vehicle.

#### *D. Arduino UNO*

Arduino is an open-source electronic platform designed to make working with hardware and software more accessible. It enables Arduino boards to process various inputs, like sensor light, button presses, or Twitter messages, and convert them into outputs, such as activating motors, illuminating LEDs, or posting content online. Users program the board by sending instructions to its microcontroller using Arduino programming language, which is derived from Wiring, and an Arduino Software (IDE), which is built on Processing. Over the years, the Arduino plays an important role in several projects, ranging in everyday household items to sophisticated scientific instruments.

##### Pin configuration

- **GND (3):** This represents "Ground." You can ground your circuit using any of the Arduino's many GND pins.
- **5V (4) & 3.3V (5):** 5 volts are supplied by the 5V pin, while 3.3 volts are supplied by the 3.3V pin. The majority of fundamental Arduino-compatible components function well at either 3.3 or 5 volts.
- **Analog (6):** This portion, which has the label "Analog In," contains pins A0 through A5 on the UNO. Temperature sensors and other analog sensor signals might be read by these analog input ports, which could then translate them into digital values for processing.
- **Digital (7):** The UNO's digital pins (0 to 13) are situated across from the analog pins and can be used for both digital input and digital output.
- **PWM (8):** A tilde (~) symbol is present next to a few digital pins on the UNO, namely 3, 5, 6, 9, 10, and 11. In addition to serving as standard digital pins, these pins are capable of pulse-width modulation (PWM).
- **AREC (9):** Analog Reference is what this stands for. This pin usually doesn't need to be used. Occasionally, it's used to set the top limit of the analog input pins to an external reference voltage, which usually ranges from 0 to 5 volts.

#### *E. LCD Display*

In an EV battery monitoring system, an LCD display serves as the interface between the user and the system, providing real-time details about the battery's status and performance. It can display important metrics such as a battery voltage, current, temperature, state of a charge, and remaining capacity. By presenting this information in a clear and easily readable format, the LCD display allows the driver to detect the health and conditions of a battery pack while driving.

Additionally, LCD displays can include backlighting technology to improve visibility in low-light conditions, ensuring the screen remains readable even in dark environments. Some LCD displays also come with touchscreen capabilities, enabling users to interact directly with the display and access further information or settings.

### IV. SIMULATION & RESULT

Proteus is a powerful simulation software used for electronic circuit design and testing. It provides a virtual environment where users can design, simulate, and prototype electronic circuits. With its extensive library of components, Proteus enables engineers and designers to create complex circuits and test their functionality before physical implementation. Its user-friendly interface and comprehensive features make it a popular choice among electronics enthusiasts and professionals alike. Simulation Diagram

Fig.3 represent the simulation diagram of a temperature monitoring system which comprising various components. At the core of the system is a temperature sensor, specifically the LM35, tasked with sensing temperature and detecting smoke. Notably, two temperature sensors are integrated into the system to monitor

temperature variations before and after battery discharging. These sensors provide crucial data for assessing the thermal conditions within the system.

The temperature readings obtained from the sensors are then displayed on an LCD unit, offering real-time monitoring and visualization of the temperature levels. This enables users to promptly identify any abnormal temperature fluctuations and take appropriate actions to mitigate potential risks.

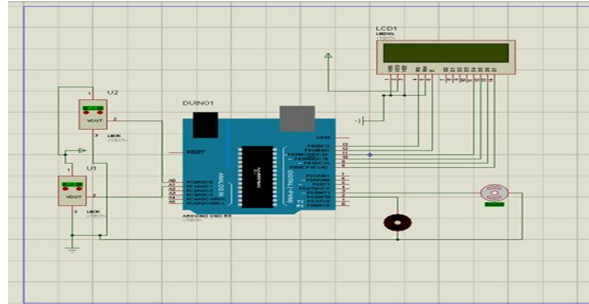


Fig.3 Simulation diagram of battery monitoring system

A. Result

When the motor operates normally, the system temperature and battery status are displayed on the LCD screen, indicating they are functioning within standard parameters. Below is the output from the simulation:

a) *Normal temperature:* Fig.4&5 shows the output in normal temperature. Upon initiating the operation of the vehicle's motor, the thermal monitoring system activates to oversee the battery's temperature. An established standard temperature of 39°C is considered normal. Consequently, given that the current temperature is within this range, the fan remains inactive.

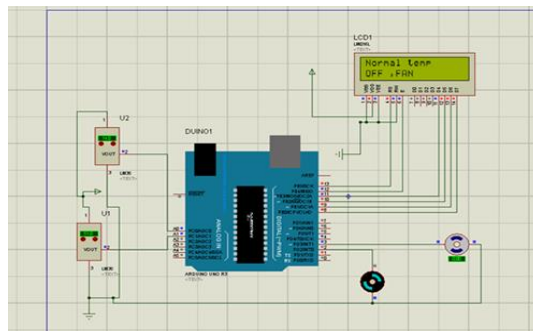


Fig.4 Output at normal temperature

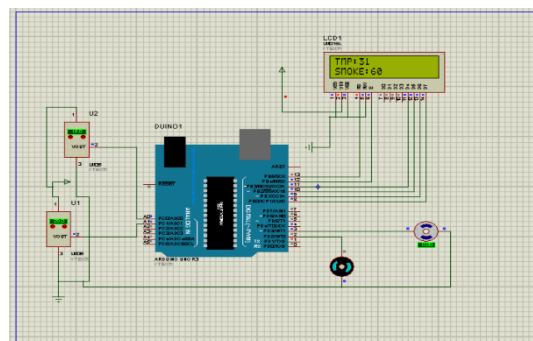


Fig.5 Output of the battery temperature below 39°

b) *High temperature:* Fig.6&7 shows the temperature of the battery is above 39°. In the event that the temperature exceeds the predefined normal threshold, it indicates a potential risk of overheating, which could ultimately result in the battery catching fire. As a precautionary measure, the system is equipped to detect the

presence of smoke, which often accompanies excessive heat. This dual monitoring approach ensures that any signs of overheating or smoke are swiftly identified and addressed. In response to such detections, the system activates a fan mechanism. The fan serves as a vital cooling component, swiftly dissipating heat and reducing the temperature of the battery to within safe operating limits. By promptly initiating the fan in such scenarios, the system effectively mitigates the risk of battery damage, ensuring optimal performance and safety of the overall system.

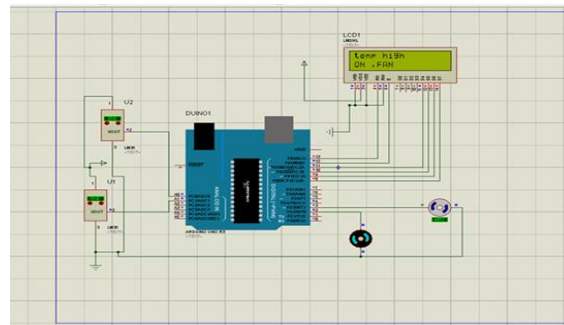


Fig.6 Output at high temperature

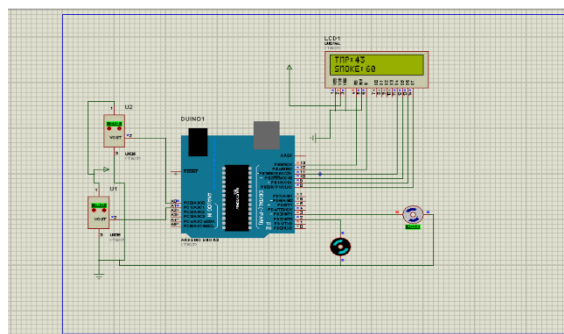


Fig.7 Output of the battery temperature above 39°

## V. PROTOTYPE

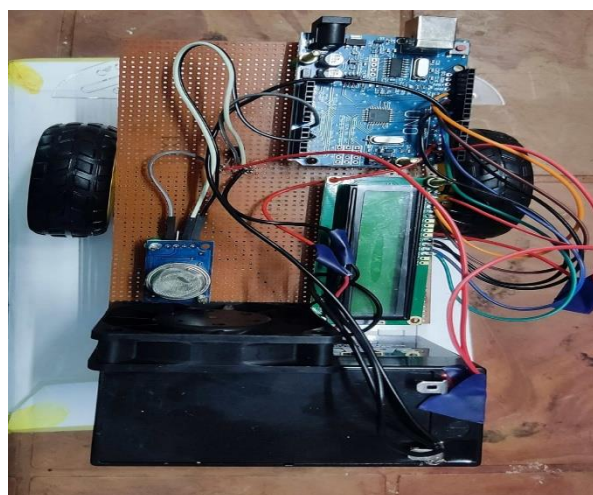


Fig.8 Prototype of Electric vehicle battery monitoring system

The prototype undergoes rigorous testing to ensure its functionality and reliability. This includes testing under various temperature and smoke level conditions to verify the accuracy of sensor readings and the effectiveness of control logic in fan and motor operation.

Battery Temperature	Smoke	Fan (ON/OFF)	DC Motor
20°	29	OFF	Run
25°	37	OFF	Run
29°	41	OFF	Run
31°	49	ON	Stop
34°	55	ON	Stop
36°	59	ON	Stop

Table 2 Observation of battery monitoring system

## VI. CONCLUSION

The eventual depletion of fossil fuels will lead to fully electrically operated automobiles, which will have an impact on everyone's lives. At this point, battery management systems will be a significant development that all manufacturers of electric vehicles will be searching for. A battery serves as the energy source for an electric car. In order to facilitate direct monitoring, the concept of employing simulation to track vehicle performance is put forth in this work. When a battery's performance declines, the system can identify it and notify the user so they can take appropriate action. The research presented here contributes to the evolving landscape of electric vehicle technology by providing insights into the design considerations and optimization strategies for thermal management systems. The successful implementation of advanced EV-TMS not only addresses thermal challenges but also contributes to the overall sustainability and reliability of electric vehicles in the pursuit of a cleaner and more energy-efficient transportation future.

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