

Arduino-Based EV Battery Monitoring And Protection System

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Abstract:

One of the most important solutions for sustainable transportation is electric vehicles. The condition and maintenance of electric vehicles' batteries have a major impact on their performance and safety. Serious problems including overheating, deep discharge, and battery damage can result from improper monitoring of battery parameters like voltage, current, and temperature.

The design and development of an Arduino-based EV battery monitoring and protection system is presented in this paper. Battery voltage, current, and temperature are all measured in real time by the system via sensors. An Arduino microcontroller is used to process the collected data, which is then shown on a 16x2 LCD display. Additionally, when abnormal battery conditions are detected, the system incorporates protective mechanisms such relay cutoff, buzzer alert, and cooling fan activation. The Proposed System Is Low-Cost, Simple, And Suitable For Prototype Electric Vehicles And Educational Applications. The Results Demonstrate That The System Can Effectively Monitor Battery Parameters And Provide Protection Against Unsafe Operating Conditions.

Keywords: Electric Vehicle, Battery Monitoring System, Arduino, Voltage Sensor, Current Sensor, Temperature Sensor, EV Safety

1.INTRODUCTION

Electric vehicles, or EVs, are becoming more and more popular as an eco-friendly and sustainable form of transportation. However, EVs' dependability and safety are heavily dependent on how well their battery systems are managed. Operating conditions that affect batteries include temperature rise, high current flow, and voltage fluctuations.

In order to guarantee safe and effective operation, a battery monitoring system (BMS) is in charge of continuously monitoring battery parameters. Commercial BMS solutions are frequently costly and complicated, making them challenging to use in academic projects or small-scale EV prototypes. In This Project, An **Arduino-Based EV Battery Monitoring System** Is Developed To Measure Battery Voltage, Current, And Temperature In Real Time. The system gathers data and displays it on a 16x2 LCD screen using sensors that are connected to the Arduino microcontroller. Furthermore, in the event of

abnormal conditions, the system activates safety mechanisms including relay cutoff and alerts.

The Proposed System Provides A Cost-Effective Solution That Improves Battery Safety, Performance, And Lifespan.

2.Problem Statement

Electric Vehicles Rely Heavily On The Performance And Safety Of Their Battery Systems. However, Many Small-Scale EV Systems And Prototypes Lack A Real-Time Battery Monitoring Solution.

Without Proper Monitoring, Batteries May Experience:

- Overcharging
- Deep Discharge
- Overcurrent Conditions
- Overheating

These Issues Can Reduce Battery Lifespan And Cause Safety Hazards.

Commercial Battery Management Systems Are Often Expensive And Complex, Making Them Unsuitable For Small Projects. Therefore, There Is A Need For A **Low-Cost And Reliable Monitoring System** That Can Measure Battery Parameters In Real Time And Provide Protection Mechanisms.

3.Objectives

The Main Objectives Of This Project Are:

1. To Design And Develop A Real-Time EV Battery Monitoring System Using Arduino.
2. To Measure Important Battery Parameters Such As Voltage, Current, And Temperature.
3. To Display The Monitored Data On A 16×2 LCD Display.
4. To Provide Warning Alerts During Abnormal Battery Conditions.
5. To Improve Battery Safety And Lifespan.
6. To Create A Low-Cost Monitoring Solution Suitable For Educational And Prototype EV Systems.

4.System Architecture

The Proposed System Consists Of Several Sensors And Electronic Components Connected To The Arduino Microcontroller. These Components Work Together To Monitor Battery Parameters And Protect The Battery From Unsafe Conditions.

Working Principle

1. The voltage sensor measures the battery voltage.
2. The current sensor measures the current flowing from the battery.
3. The temperature sensor measures battery temperature.
4. The arduino processes this data and displays it on a 16×2 lcd.
5. If the voltage exceeds the safe limit (e.g., above 6v), a **fan and buzzer are activated**.
6. A relay module disconnects the battery during critical faults.

5.Materials And Methods

Arduino uno: this system uses arduino uno as the main controller for controlling and processing data from different sensors. it reads the voltage, current, and temperature values and controls components such as the relay module, buzzer, cooling fan, and lcd display.

voltage sensor: the voltage sensor is used to measure the battery voltage. it helps the system monitor the battery condition and detect overvoltage or low-voltage situations.

acs712 current sensor: the acs712 current sensor is used to measure the current flowing from the battery to the load. it helps in detecting overcurrent conditions in the system.

ds18b20 temperature sensor: the lm35 temperature sensor is used to measure the temperature of the battery. it helps detect overheating and ensures safe battery operation.

16×2 lcd display: the 16×2 lcd display is used to show real-time values of voltage, current, and temperature so that the user can easily monitor the battery status.

relay module: the relay module works as an electrically controlled switch. it disconnects the battery from the load when unsafe conditions such as overvoltage or overheating occur.

buzzer: the buzzer is used as an alert system. it produces a sound when the battery parameters exceed safe limits.

cooling fan: the cooling fan is used to reduce the temperature of the battery when overheating is detected by the temperature sensor.

dc motor: the dc motor is used as a load in this project to simulate the operation of an electric vehicle motor.

Lithium-Ion Battery: the lithium-ion battery is used as the main power source of the system. it provides electrical energy to the motor and other components.

6.System Block Diagram:

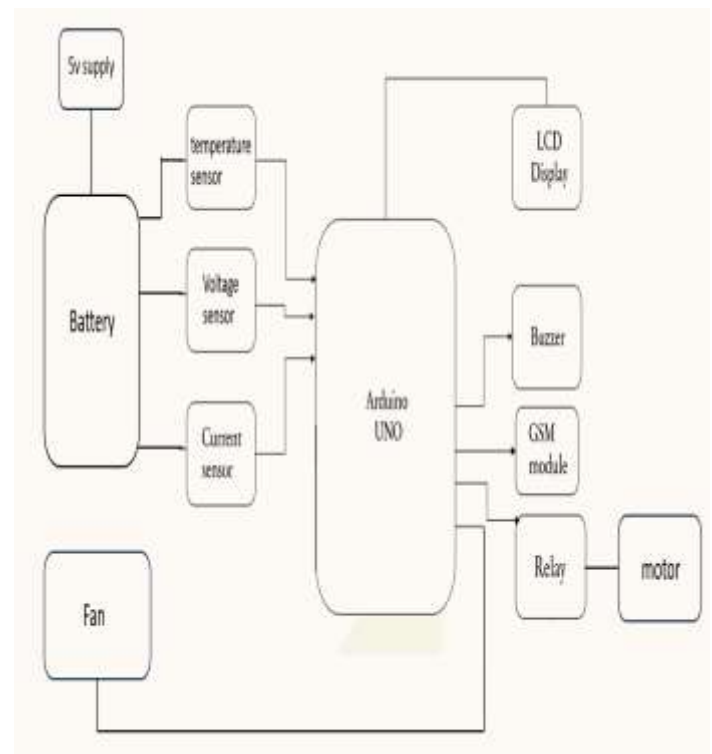


Figure 1 . System Block Diagram

7.Methodology:

The proposed **arduino-based ev battery monitoring and protection system** is designed to continuously monitor the battery voltage and provide protection through a **three-stage protection mechanism**. the system uses an arduino uno as the main controller to process the sensor data and control different protection components such as the cooling fan, buzzer, relay module, and gsm communication module.

the battery voltage is measured using a voltage sensor and the data is sent to the arduino through the analog input pins. the arduino continuously ompares the measured voltage value with predefined threshold values programmed in the system.

stage 1: initial warning stage (6v)

in the first stage, when the battery voltage rises **above 6v**, the system identifies that the battery is approaching an unsafe condition. at this stage, the arduino activates the cooling fan and buzzer.

the cooling fan helps reduce the temperature of the battery and maintain safe operating conditions, while the buzzer provides an audible alert to notify the user about the abnormal voltage condition. this stage acts as an **early warning system** to prevent further increase in voltage.

stage 2: alert and communication stage (9v)

in the second stage, when the battery voltage increases **above 9v**, the system activates additional protection measures. along with the cooling fan and buzzer, the system also activates the gsm communication module.

The System Uses The Sim800l Gsm Module To Send A Warning Message Or Alert Signal To The User's Mobile

Phone. This Ensures That The User Is Immediately informed about the unsafe battery condition even if they are not physically near the system.

this stage provides **remote monitoring capability** and allows the user to take necessary action before the situation becomes critical.

stage 3: critical protection stage (11v)

in the third stage, when the battery voltage reaches **11v**, the system considers it a critical condition that may damage the battery or connected devices. at this stage, all protection mechanisms are activated.

the cooling fan and buzzer remain active, and the gsm module continues to send alerts to the user. in addition, the arduino activates the relay module to disconnect the motor from the battery.

the relay acts as an automatic switch that stops the motor immediately, preventing further power draw and protecting the battery from severe damage. this stage ensures **maximum protection of the battery and the connected system**.

Overall System Operation

System ensures gradual and intelligent response to abnormal battery voltage conditions. the first stage provides an early warning, the second stage adds remote notification through gsm communication, and the third stage performs automatic system shutdown to protect the battery and connected components.

8.Result :

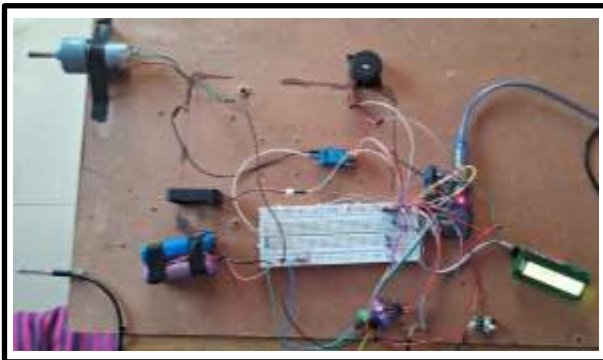


Figure 8.1 Actual Circuit of System.

The developed **Arduino-based EV Battery Monitoring and Protection System** was tested under different voltage conditions to verify the operation of the three-stage protection mechanism. The system successfully monitored the battery voltage and activated the appropriate protection components according to the programmed threshold levels.

The monitoring and control operations were performed using an Arduino Uno which processed the voltage readings from the voltage sensor and controlled the output devices such as the fan, buzzer, relay, and GSM module.

Stage 1: Warning Condition (Voltage > 6V)

When the battery voltage increased above **6V**, the system entered the first protection stage. At this stage, the Arduino activated the cooling fan and buzzer.

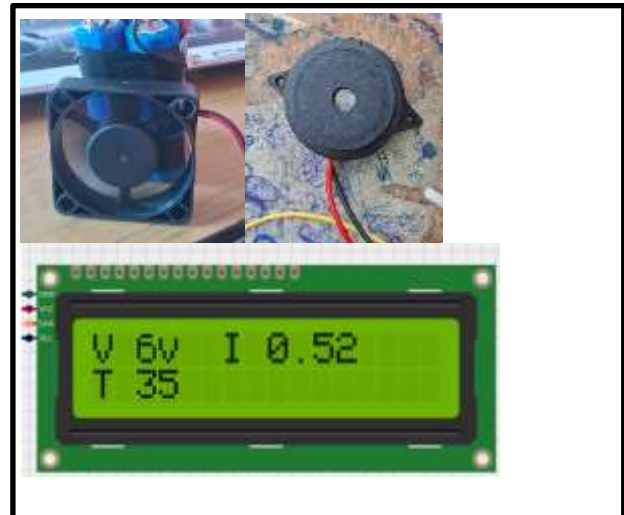


Figure 8.2 Stage 1: Warning Condition (Voltage > 6V)

Stage 2: Alert and Notification Condition (Voltage > 9V)

When the battery voltage increased above **9V**, the system activated the second protection stage. In this stage, the fan and buzzer remained active, and an additional communication function was triggered.

The system used the SIM800L GSM Module to send an alert signal to the user's mobile phone. This GSM-based communication allows the user to receive notifications even when they are not physically present near the system.

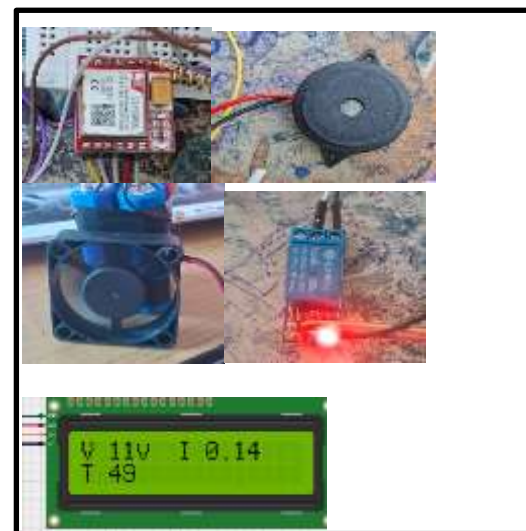
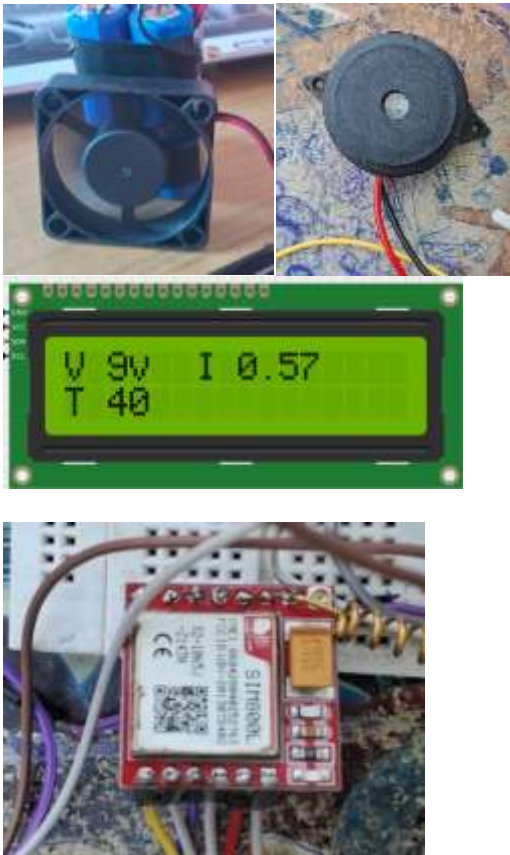


Figure 8.4 Stage 3: Stage 3: Critical Protection Condition (Voltage $\geq 11V$)

Conditions0++	voltage	current	tempreature	Fan	buzzer	Gsm module	relay
Normal	5v	0.50	30 °C	OFF	OFF	OFF	OFF
Stage 1	6v	0.52	31 °C	ON	ON	OFF	OFF
Stage 2	9v	0.57	36 °C	ON	ON	ON	OFF
Stage 3	11v	0.60	41 °C	ON	ON	ON	ON

Figure 8.3 Stage 2: Alert and Notification Condition (Voltage $> 9V$)

Stage 3: Critical Protection Condition (Voltage $\geq 11V$)

When the battery voltage reached **11V**, the system entered the third and most critical protection stage. At this level, the system considered the battery condition unsafe for continued operation.

In this stage, the cooling fan and buzzer continued to operate, and the GSM module continued sending alert notifications. Additionally, the Arduino activated the relay module to disconnect the motor from the battery.

The system's response to battery voltage, current, and temperature is displayed in our table. The fan, buzzer, GSM module, and relay turn ON or OFF in response to the various battery/motor system conditions represented by each stage.

1. Normal situation :

The voltage is below 6volt that means The motor and batteries are operating as they should. There is no need for cooling or warning because the temperature is low and safe.

2.Stage 1 (Initial Warning Stage)

The voltage is above 6volt and below 9volt that means

Both the load and the temperature are beginning to rise. Steps: To cool the system, the fan is turned on. A local warning is given by a buzzer. Since GSM is not yet critical, it is still turned off. The motor is kept running by the relay.

3. Stage 2 (Serious Condition)

The voltage is above 9volt and below 11volt that means The temperature of the system is rising dangerously. Steps: the fan is turned on. A local warning is given by a buzzer. Since GSM is turned ON to send the signal to the user. The motor is kept running by the relay.

4. Stage 3 (Critical Condition)

A hazardous temperature was achieved by the system. Steps: The fan attempts to cool the system. The buzzer issues a serious warning. An emergency alert message is sent using GSM. To stop damage or fire, a relay shuts off the motor and battery.

8. Conclusion:

The design and execution of an Arduino-based EV battery monitoring and protection system were reported in this work. The battery voltage, current, and temperature were successfully measured in real time by the system, and the results were shown on an LCD panel. Relay cutoff, buzzer alarm, and cooling fan activation are examples of protection systems that have improved safety and prevented battery damage. The system is inexpensive, simple to use, and appropriate for educational and small-scale EV prototypes.

Overall, the proposed solution demonstrates an effective approach for improving EV battery monitoring and safety.

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