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Student Project Review and Assessment Committee

Project Report

Batch No: 12 **Date:**

Subject Name & Code: Vth Sem Mini-Project- BEE506

Area of Specialization: Battery Management

Guide: Dr. N Ramarao

Project Title: ELECTRIC VEHICLE'S BATTERY MONITORING AND TEMPERATURE CONTROLLING SYSTEM

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Abstract:

The developed prototype uses thermoelectric cooling and forced air cooling for a battery thermal management system. The liquid coolant methods have some adverse effects on the battery life and electric functionality of the overall charging system. There may be the possibility of liquid coolant getting in contact with the battery during the heat extraction operation. Heat is removed from the condenser side of the thermoelectric liquid casing using a motor-operated ted fan. The entire cooling operation is automatic as it involves Arduino microcontroller for switching of the thermoelectric cell. LCD display enables data acquisition for future developments. The fast and accurate switching is possible using an Arduino microcontroller. The use of green energy is becoming increasingly important in today's world. Therefore, electric vehicles are currently the best choice for the environment in terms of public and personal transportation. Because of its high energy and current density, lithium-ion batteries are widely used in electric vehicles. Unfortunately, lithium ion batteries can be dangerous if they are not operated within their Safety Operation Area (SOA). Therefore, a battery management system (BMS) must be used in every lithium-ion battery, especially for those used in electric vehicles. In this work, the purpose, functions, and topologies of BMS are discussed in detail. In addition, early battery models along with the hardware and system designs for BMS are covered in a literature review. Then, an improved battery model is introduced, and simulation results are shown to verify the model's performance. Finally, the design of a novel BMS hardware system and its experimental results are discussed. The possible improvements for the battery models and BMS hardware are given in the section on conclusions and future work.

Parts of the Synopsis

Introduction:

• The quick improvement of worldwide industrialization has expanded the ozone depleting substance emanations and nonrenewable vitality deficiency, which are pressing worries for the whole society.

• To viably address genuine ecological issues, unadulterated electric vehicles (EVs) and half-and-half EVs as green force hardware and condition neighborly vehicle instruments contrasted with conventional diesel trains are created.

• Lithium-particle batteries have numerous favorable circumstances, for example, high force thickness, high vitality thickness, long lifetime, and less self-release; they assume a significant job in the fields of EV and vitality stockpiling stations.

• In any case, lithium-particle batteries overheat during activity, which truly thwarts their application in EV/HEV. Specifically, the battery module displays a potential well-being risk under a high-temperature condition, along these lines shortening the battery life expectancy.

• To reduce this problem we are introducing this EV battery temperature controlling system.

• According to previous research [1], 18% of the suspended particulates, 27% of the volatile organic compounds, 28% of Pb, 32% of nitrogen oxides, and 62% of the CO of air-borne pollution in America are produced by vehicles with internal combustion engines. In addition, 25% of energy-related CO2 (the principle cause of the greenhouse effect) of all the CO2 in the atmosphere is released from traditional vehicles. As an increasing number of people use public and personal transportation, the amount of air pollution increases every single day. Consequently, electric vehicles are becoming more and more popular.

• An electric vehicle generally contains the following major components: an electric motor, a motor controller, a traction battery, a battery management system, a plug-in charger that can be operated separately from the vehicle, a wiring system, a regenerative braking system, a vehicle body and a frame. battery management system is one of the most important components, especially when using lithium-ion batteries.

• Currently, three types of traction batteries are available: lead-acid, nickel metal hydride and lithium-ion batteries. Lithium-ion batteries have a number of advantages over the other two types of batteries, and they perform well if they are operated using an effective battery management system.

Motivation:

The motivation to take up this project on developing a thermal management system for electric vehicle (EV) batteries is rooted in the pressing need to enhance the safety, efficiency, and longevity of EVs, which are pivotal in the transition to sustainable transportation. As the adoption of electric vehicles continues to rise globally, the performance and reliability of EV batteries have become critical factors that directly impact consumer acceptance and the overall viability of electric transportation. EV batteries are subject to significant thermal stress due to high power demands and environmental conditions, which can lead to overheating, reduced efficiency, and even hazardous situations like fires. Therefore, effective thermal management is essential to ensure that these batteries operate within safe temperature ranges, thus enhancing their performance and extending their operational life. This project addresses these challenges by leveraging the advanced capabilities of the ESP32 microcontroller in conjunction with a suite of sensors, including temperature, current, voltage, and smoke sensors, to create a comprehensive monitoring and management system. The ability to monitor real-time data and automatically trigger cooling mechanisms or alarms not only ensures optimal battery performance but also provides an added layer of safety. This is particularly crucial in preventing potential hazards associated with battery overheating and failures, which can have serious implications for both users and manufacturers.

LITERATURE SURVEY :

- Mobility has to be CO_2-neutral in future and vehicle technologies have to ensure that eco-friendly, efficient and quiet vehicles will be on our road. Therefore, the future belongs to battery electric vehicles (BEVs).
- However, there are still certain challenges to be overcome so that the many advantages of the electronic power train can be leveraged. One challenge is the thermal management system in BEVs.
- In contrary to ICE vehicles, the electric motor in BEVs produce little (waste) heat which is a challenge for BEVs at low temperature. It means that additional heating is required to warm the passenger compartment and this comes at the cost of reduced available range since it increases the efforts for the battery management.
- Additionally, the ability to Fast charge has been a big driver for thermal management. Many network providers offer DC fast charging stations with up to 350kW of power now.
- As a consequence, batteries need to be at an even narrower temperature window than general operation to make the most of the available charging power. This requires pre-heating or cooling the battery. As cells charge faster, there is a greater requirement for thermal management. If greater power than 350kW start to be adopted, then this could bring emerging thermal management strategies to the fore.
- Therefore, thermal management system plays a critical role in BEVs. The thermal management system is responsible to keep the electric motor, the power electronics and the battery at right temperature while ensuring the passenger comfort in the cabin. For instance, a failure of thermal management will result in demagnetization of magnets, aging of the insulation materials, decrease of efficiency, shorter lifetime and even burnout of electric motors. Also, an efficient thermal management system helps to increase the longevity of the battery cells but is also a major safety feature to prevent thermal runaway.
- As provided INFINEON ,OLA Electrics ,Ather.

RESEARCH GAP

The field of electric vehicles (EVs) has seen significant advancements in recent years, particularly in battery technology and vehicle efficiency. However, there are still several research gaps in the area of EV battery cooling systems. Some of these gaps include:

Thermal management strategies: While EV battery cooling systems exist, there is ongoing research to develop more efficient and effective thermal management strategies. This includes exploring advanced cooling techniques, such as active cooling using liquid cooling systems or phase-change materials, to enhance battery performance and extend its lifespan.

Optimal cooling system design: There is a need for further research to determine the optimal design of battery cooling systems for different types of EVs. Factors such as battery chemistry, size, and placement within the vehicle can impact the cooling system's effectiveness. Developing design guidelines specific to different vehicle architectures and battery technologies would be valuable.

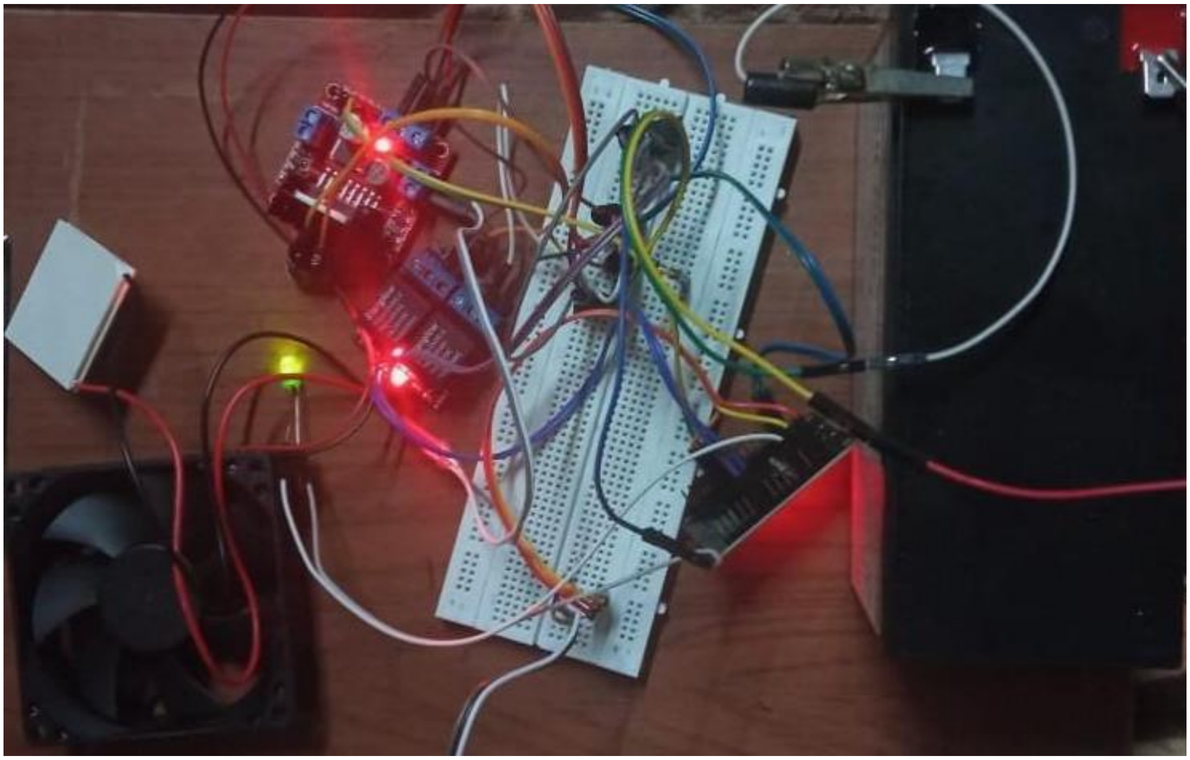
Modelling and simulation: Improved modelling and simulation techniques can help in optimizing battery cooling systems. Advanced simulation tools can assist in predicting temperature distribution, heat transfer, and fluid flow within the battery pack, enabling engineers to design and optimize cooling systems with greater precision.

Thermal characterization of battery cells: Understanding the thermal behavior of battery cells under different operating conditions is crucial for designing effective cooling systems. More research is needed to characterize the thermal properties of different battery chemistries and cell designs, including heat generation rates, thermal conductivity, and heat dissipation characteristics.

Safety considerations: EV battery safety is of paramount importance. Research gaps exist in studying the effects of cooling system failures, such as coolant leaks or pump malfunctions, on battery performance and safety. Developing robust safety mechanisms and fail-safe designs to mitigate potential risks is an area that requires further exploration.

Integration with vehicle HVAC systems: Integrating the battery cooling system with the overall vehicle heating, ventilation, and air conditioning (HVAC) system can improve energy efficiency and occupant comfort. However, optimizing the coordination and control algorithms between these systems is still an ongoing research area.

Proposed System:



Our Project's main aim is to maintain the temperature of Electric Vehicle's Battery between 15 degree Celsius and 28 degree Celsius. We are going to consider 3 scenarios for the proposed system.

1. Moderate Temperature: When LM35 module senses the temperature between 15 degrees Celsius to 28 degrees Celsius on the Electric Vehicle's Battery it will send the signal to the ESP32 to not activate any components.
2. High Temperature: As Electric Vehicle's Battery is used results in an increase in the temperature of the battery due to this increase in temperature the LM35 module sends signals to the ESP32 to activate the Peltier module to cool through the motor driver and to turn on the DC fan for dissipation of cool air to the battery.
3. Low Temperature: In extremely cold areas the Electric Vehicle's Battery may reach a negative temperature which may damage the Electric Vehicle's Battery to avoid this damage the LM355 module as soon as it senses that the temperature falls below 15 degrees Celsius sends signals to the ESP32 to activate Peltier module to heat through the motor driver and to turn on the DC fan for dissipation of hot air to the battery.

In all the above Scenarios the temperature of LM35 is monitored through the cell phone using IOT which uses a Software ADA Fruit to send the user the current temperature of the Electric Vehicle's Battery

OBJECTIVES OF PROPOSED SYSTEM

• To cool or heat the EV’s battery with the help of a thermistor temperature sensor.
• To avoid the batterie’s destruction through liquid cooling.
• To sense the temperature of the battery and control the surrounding temperature.
• Avoid the battery charging temperature changes complexity.
• To avoid the power loss in the battery due to increase and decrease in temperature.

PROBLEM STATEMENT

In some of the cases, the Electric Vehicle's battery is getting heated and that leads to blasts, fire incidents, charging leakage and accidents. Liquid cooling for Electric Vehicle's battery may cause leakage and damage battery.
This may lead to battery damage and reduce battery life.

1. **OBJECTIVES**

- To overcome the complications of fast battery charging and heating in Electric Vehicles.
- To perform fast and reliable temperature-controlling system.
- Improve the life of the battery.
- To reduce the temperature in battery compartment.

2. **THERMAL MANAGEMENT CHALLENGES**

Leaks: Leaks can only occur in liquid cooling systems, whose pipe connections have risks of leaks as the battery ages. Any leaks will rapidly degrade the battery performance and life. They can even cause the EV to stop operating if humidity attacks the battery's electrical insulation. Battery modules, interconnections, pumps, and valves must all remain intact.

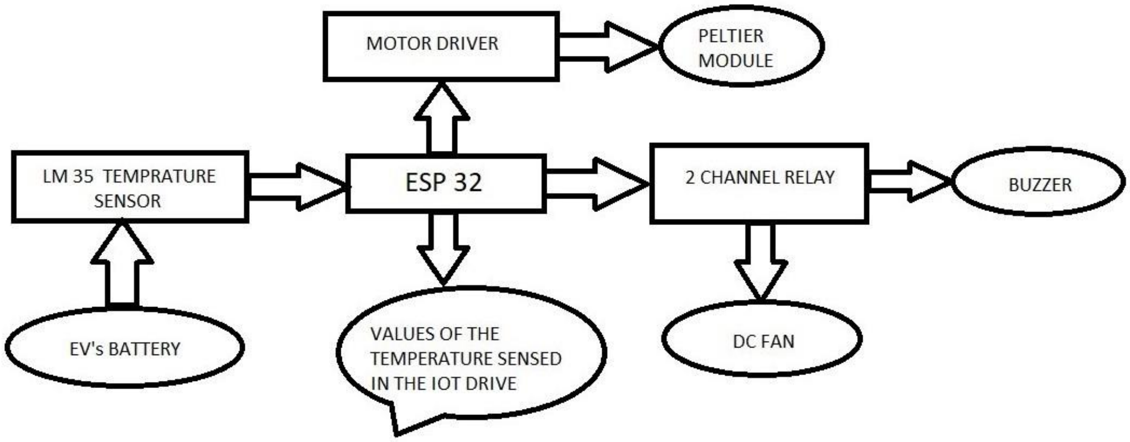
Corrosion: Corrosion can only occur in liquid cooling systems, whose cold plates can corrode as the liquid glycol gets older. Therefore, the cooling liquid must be replaced as part of the vehicle's maintenance.

Clogging: Clogging is a risk that is present in the hundreds of small channels where liquid travels in the battery.

Climate: Climates around the globe pose different thermal challenges for batteries. Examples include leaving the car under heavy sun for a long time, or living in a place where there are extremely low temperatures in winter. Batteries must be able to tolerate wide temperature ranges at all times. To achieve this, the battery cooling system must be active even when the vehicle is not in use.

Aging: Aging causes thermal management problems that must be planned for. As batteries get older, a larger portion of energy is loss as heat. The thermal management system must be built for these tougher conditions that occur later in the battery life, not just for typical conditions during the first years.

METHODOLOGY

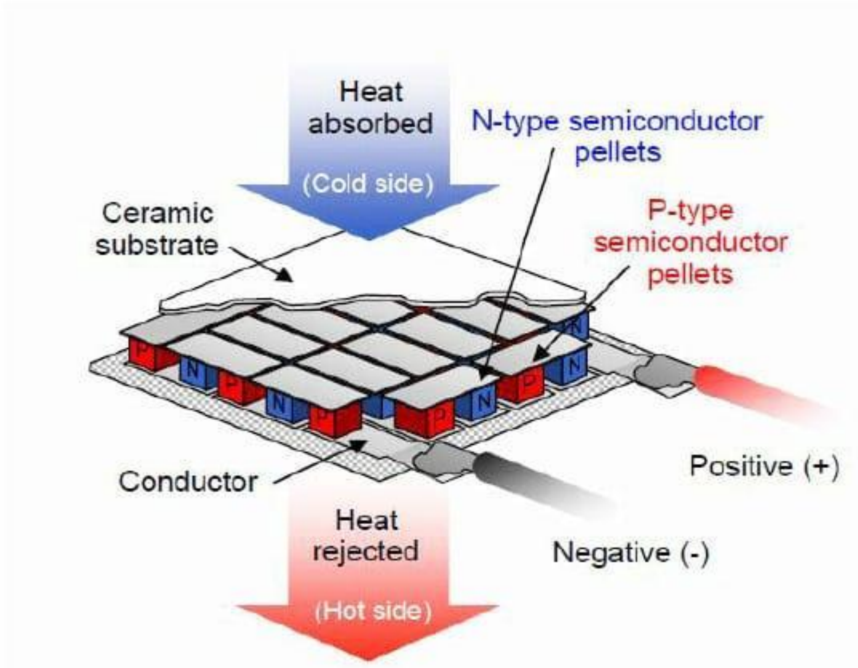


- Here the mains (ESP32) is connected to power supply.
- Current Temperature of the Electric Vehicle's Battery is displayed through IOT in the cell phone
- LM35 module is used as Temperature Sensor which senses the temperature of Electric Vehicle's Battery. DC fan connected to Peltier module which will help in conducting condensed air to the Electric Vehicle's battery.
- The temperature sensor is used to sense the temperature of the battery in accordance with the temperature of the battery LM35 module will send some interrupt signals to the ESP32 when the temperature crosses the ideal temperature mentioned in the code through a Buzzer.
- Which will Further turn on the cooling or heating process depending upon the signal sent by the LM35 module to ESP32. Through where the temperature of the Electric Vehicle's Battery is displayed in the cell phone and the temperature of the Electric Vehicle's Battery is brought back to the ideal temperature range.

SYSTEM REQUIREMENTS :

HARDWARE REQUIREMENTS:

i. Peltier module:



Peltier module (thermoelectric module) is a thermal control module that has both "warming" and "cooling" effects. By passing an electric current through the module, it is possible to change the surface temperature and keep it at the target temperature. Kyocera's Peltier module structure has two types of semiconductor elements arranged in tandem sandwiched between copper substrates. When electricity is passed through the module, electrons move in one element and positive holes move in the other element, this is called the "Peltier effect." This allows one side of the substrate to absorb heat and the other to radiate heat, so the hot and cold sides to be switched depending on the current direction. It can also be used as a thermoelectric power generation module using the "Seebeck effect" in which a current flows by applying a temperature difference on both sides of the Peltier module.

ii. DC Fan:

A DC, or direct current fan, uses a power source that is connected to a transformer. The transformer then converts the energy to direct current, or a one-way current. As a result, the quantity of power utilised is ultimately decreased. DC fans are widely regarded as the most efficient type of fans. They consume significantly less power than AC fans. In fact, DC fans consume up to 70 percent less energy to produce the same output as traditional AC fan types. This means, that a 25-watt DC-driven yields the same results as 100-watt AC

iii. ESP32(Espressif Systems):

ESP32 is a low-cost System on Chip (SoC) Microcontroller from Espressif Systems, the developers of the famous ESP8266 SoC. It is a successor to ESP8266 SoC and comes in both single-core and dual-core variations of the Tensilica's 32-bit Xtensa LX6 Microprocessor with integrated Wi-Fi and Bluetooth.The good thing about ESP32, like ESP8266 is its integrated RF components like Power Amplifier, Low-Noise Receive Amplifier, Antenna Switch, Filters and RF Balun. This makes designing hardware around ESP32 very easy as you require very few external components.

Specifications of ESP32:

• Single or Dual-Core 32-bit LX6 Microprocessor with clock frequency up to 240 MHz.

• 520 KB of SRAM, 448 KB of ROM and 16 KB of RTC SRAM.

• Supports 802.11 b/g/n Wi-Fi connectivity with speeds up to 150 Mbps.

• Support for both Classic Bluetooth v4.2 and BLE specifications.

• 34 Programmable GPIOs.

• Up to 18 channels of 12-bit SAR ADC and 2 channels of 8-bit DAC

• Serial Connectivity include 4 x SPI, 2 x I2C, 2 x I2S, 3 x UART.

• Ethernet MAC for physical LAN Communication (requires external PHY).

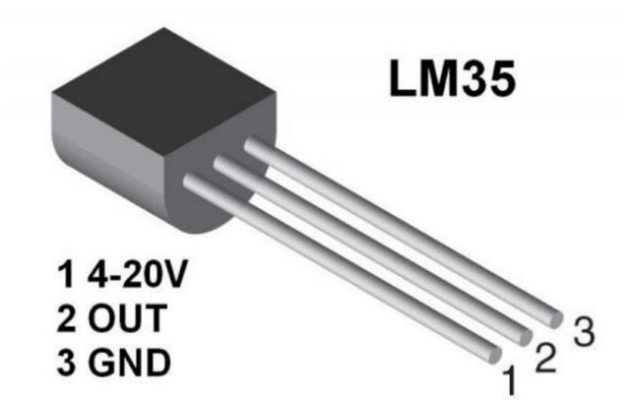
• 1 Host controller for SD/SDIO/MMC and 1 Slave controller for SDIO/SPI.

• Motor PWM and up to 16-channels of LED PWM.

• Secure Boot and Flash Encryption.

• Cryptographic Hardware Acceleration for AES, Hash (SHA-2), RSA, ECC and RNG

iv. LM 35 Temperature Sensor:



The LM35 series are precision integrated-circuit temperature devices with an output voltage linearlyproportional to the Centigrade temperature. The LM35 device has an advantage over linear temperature sensors calibrated in Kelvin, as the user is not required to subtract a large constant voltage from the output to obtain convenient Centigrade scaling. The LM35 device does not require any external calibration or trimming to provide typical accuracies of ±¼°C at room temperature and ±¾°C over a full −55°C to 150°C temperature range. Lower cost is assured by trimming and calibration at the wafer level. The low-output impedance, linear output, and precise inherent calibration of the LM35 device makes interfacing to readout or control circuitry especially easy. The device is used with single power supplies, or with plus and minus supplies. As the LM35 device draws only 60 µA from the supply, it has very low self-heating of less than 0.1°C in still air. The LM35 device is rated to operate over a −55°C to 150°C temperature range, while the LM35C device is rated for a −40°C to 110°C range (−10° with improved accuracy). The LM35-series devices are available packaged in hermetic TO transistor packages, while the LM35C, LM35CA, and LM35D devices are available in the plastic TO-92 transistor package. The LM35D device is available in an 8-lead surface-mount small-outline package and a plastic TO-220 package.

v. Dual-Channel Relay:

The dual-channel relay module is more or less the same as a single-channel relay module, but with some extra features like optical isolation. The dual-channel relay module can be used to switch mains powered loads from the pins of a microcontroller. The dual-channel relay module contains switching relays and the associated drive circuitry to make it easy to integrate relays into a project powered by a microcontroller. On the left are two terminal blocks, which are used to connect mains wires to the module without soldering. Next, come to the two relays. As marked on the body of the relay, the relay coil is rated for 5VDC, and the contacts are rated for 10A at 250VAC or 30VDC, or 125VAC or 28VDC. The switching transistors amplify the signal from the inputs enough to drive the relay. The freewheeling diodes prevent voltage spikes across the switching transistors. The status LEDs turn on when the relay is active and indicate switching. The optocouplers are used to provide additional isolation between the input and the relays. The isolation can be selected using the VCC/JDVCC jumper. The input jumper has two input and two power pins and can be easily used to connect to jumper wires and other microcontrollers and sensors.

Specifications of Dual-Channel Relay

- Supply voltage – 3.75V to 6V
- Trigger current – 5mA
- Current when relay is active - ~70mA (single), ~140mA (both)
- Relay maximum contact voltage – 250VAC, 30VDC
- Relay maximum current – 10

vi. Buzzer:

The buzzer is a sounding device that can convert audio signals into sound signals. It is usually powered by DC voltage. It is widely used in alarms, computers, printers and other electronic products as sound devices. It is mainly divided into piezoelectric buzzers and electromagnetic buzzers, represented by the letter "H" or "HA" in the circuit. According to different designs and uses, the buzzer can emit various sounds such as music, siren, buzzer, alarm, and electric bell. A buzzer or beeper is an audio signalling device,[1] which may be mechanical, electromechanical, or piezoelectric (piezo for short). Typical uses of buzzers and beepers include alarm devices, timers, training, and confirmation of user input such as a mouse click or keystroke.

SOFTWARE REQUIREMENTS:

• **ADA Fruit for IOT:**

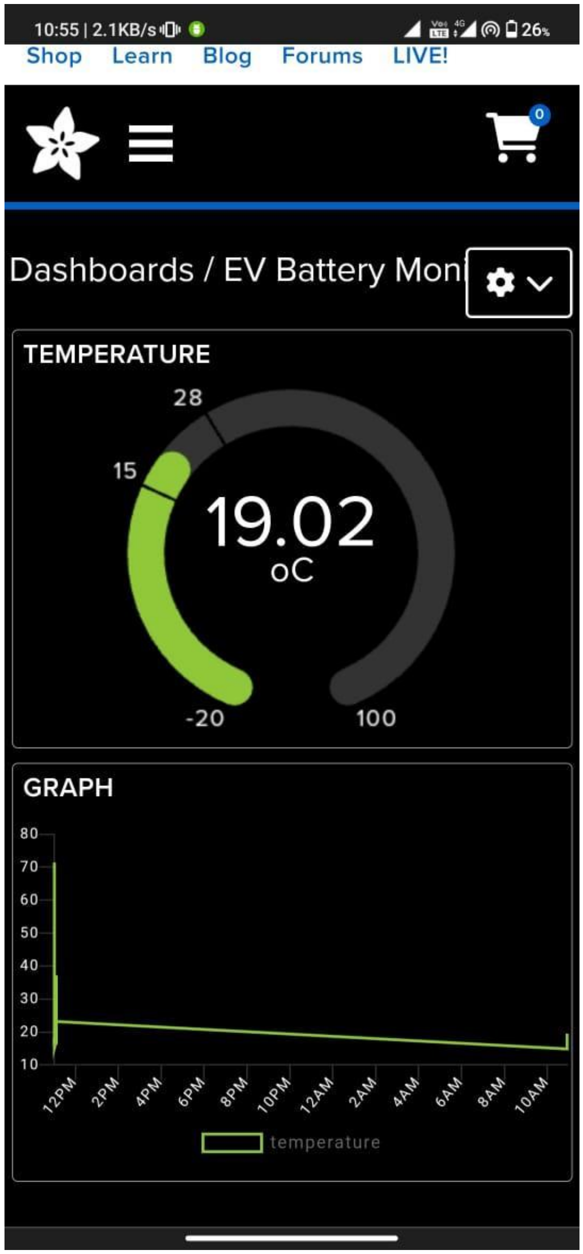
Using this software in order to display the current temperature through Cell phone and show the ideal temperature range for the battery mentioned in the code.

• **ARDUINO for ESP32:**

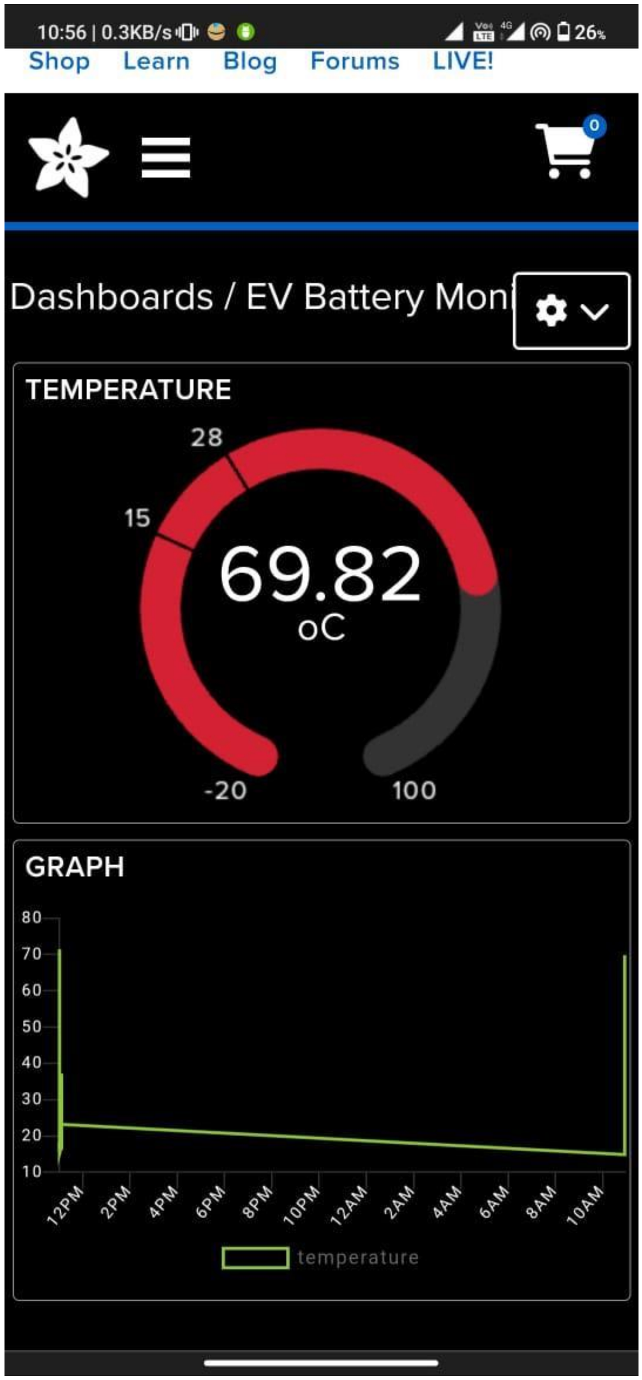
The necessary libraries for interfacing with the LM35 sensor module, Dual-Channel relay, and interrupts with respect to it.

RESULTS AND DISCUSSIONS

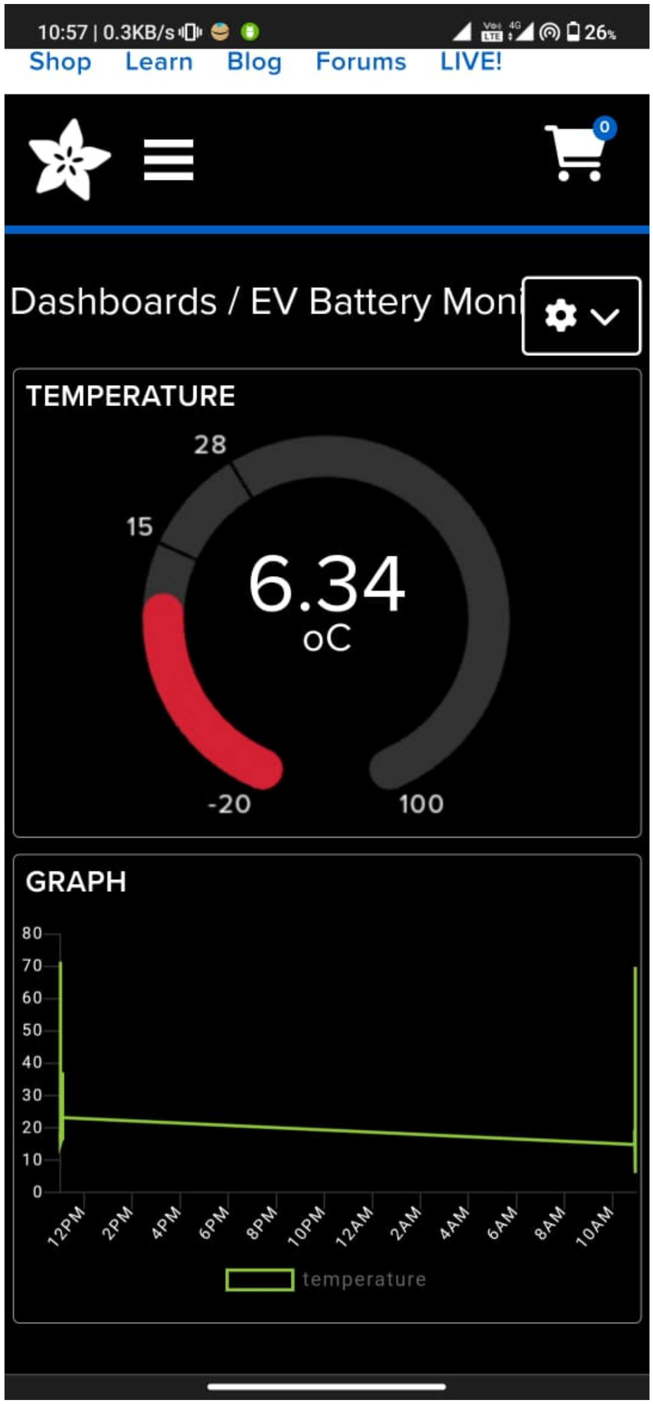
1. Moderate Temperature Status:



2. High Temperature Status:



3. Low Temperature Status:



• In this Project there are three Scenarios and for each scenario there will be different action taken by the ESP32.

• Moderate Temperature Status: When the LM35 module senses that temperature is fluctuating more than the ideal temperature range it tries to bring the temperature between 15 degrees Celsius to 28 degrees Celsius.

• High Temperature Status: When the LM35 module senses that the temperature is getting above 28 degrees Celsius it sends signals to ESP32 and it brings the temperature back to the ideal temperature range by using the Peltier module to send hot air through the DC fan.

• Low Temperature Status: When the LM35 module senses that the temperature is getting down below 15 degrees Celsius it sends a signal to ESP32 and it brings the temperature back to the ideal temperature range by using the Peltier module to send hot air through the DC fan.

Conclusion:

This project addresses a critical safety concern in electric vehicles (EVs) caused by battery temperature fluctuations. Unlike internal combustion engines, EV batteries can overheat, risking explosions, or freeze in cold climates, reducing efficiency. Our system continuously monitors battery temperature using the LM35 sensor and ESP32 microcontroller to detect and regulate heating or cooling as needed, ensuring the battery remains within a safe range. This solution not only prevents potential hazards but also enhances battery life, making EVs safer and more reliable.

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[4] "Y. H. Ren, Z. Q. Yu, and G. J. Song, "Thermal management of a Li-ion battery pack employing water evaporation," Journal of Power Sources, vol. 360, pp. 166–171, 2017.

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Department of Electrical and Electronics Engineering

Report for the Mini-Project

“ELECTRIC VEHICLE’S BATTERY MONITORING AND TEMPERATURE CONTROLLING SYSTEM”

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Under the Guidance of

Dr. N Ramarao Sir

2024-2025