WWW.IJRPR.COM

International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Battery Management System (BMS)

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A B S T R A C T

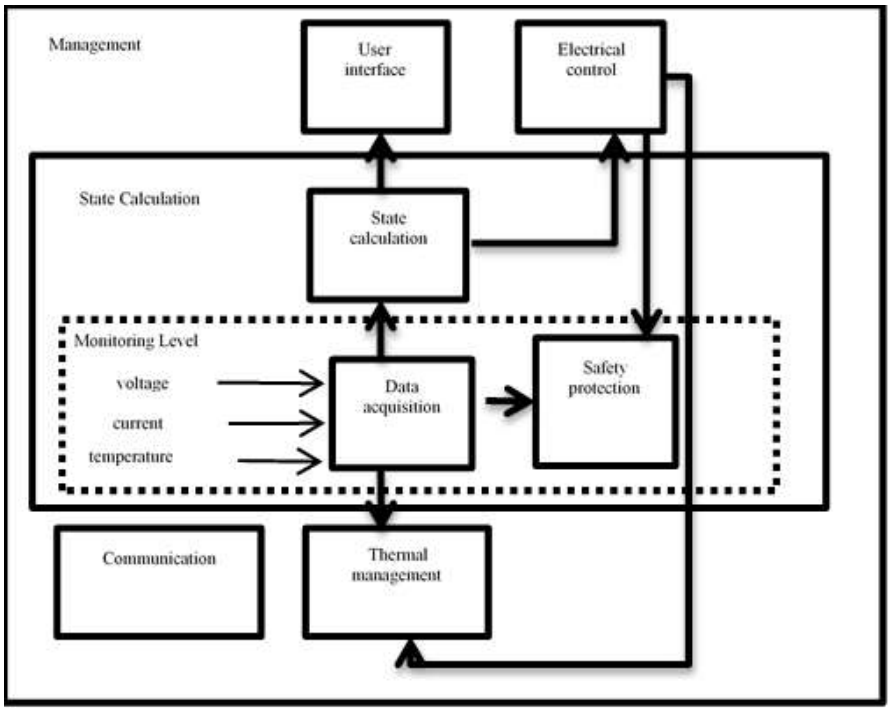
This paper proposes the problem faced in electric vehicle related to battery and solution for it. Battery management systems (BMS) is used in electric vehicle to monitor and control the charging and discharging of rechargeable batteries which makes the operation more economical. It is very essential part in Electric Vehicle to ensure safe operation and to obtain maximum output of battery pack. The primary source of electricity in EV's is batteries. Battery management system keeps the battery safe, reliable and increases the quality without entering into damaging state. In order to maintain the state of the battery, voltage, current, ambient temperature different monitoring techniques are used. For monitoring purpose different sensors with micro controllers are used. This paper addresses state of charge estimation, over temperature, over current, hybrid charging and optimization of discharging operation modes and state of life and also maximum capacity of a battery.

Keywords: Battery management system, state of charge, charging and discharging, sensors and Micro controllers.

1. Introduction

Electric vehicles frequently employ lithium-ion batteries due to their high working voltage, high power and energy density, prolonged charge and discharge lives, and absence of memory effect. The lithium-ion battery packs, however, will generate a lot of heat during the charging and discharging procedure. Lithium-ion batteries have drawbacks that make it challenging for the heat that accumulates over time to escape, which could result in battery aging. These factors can significantly impair performance, shorten the battery's life, and cause safety incidents like spontaneous combustion. Lithium-ion batteries in electric cars must be monitored for temperature accurately.

Lithium-ion battery (LiB) technology is one of the most popular battery types for EVs. Heat management problems impair LiB efficiency, health, and safety. Low temperatures result in less active anode material, which results in capacity and power decline and speeds up the battery's deterioration. High temperature operation reduces lithium stock, which causes capacity fade. High temperatures can also cause damaging processes like swelling, fire, and explosion that can forever damage a vehicle's components or a battery.



Block diagram of BMS

Methodology

The two most important issues in the area of battery technology are battery heat and the best charging method. For batteries to function at their peak and last a long period, these problems must be fixed. Users frequently complain about battery heat, which can result in decreased efficiency and a shorter battery life. However, for the battery to be charged effectively, to its maximum capacity, and to prevent damage to the battery, optimal charging is important.

Battery Cell Monitoring: The BMS monitors each battery cell to make sure the voltage and temperature are within proper limits.

State of Charge (SOC) and State of Health (SOH) Monitoring: To determine the battery's remaining capacity and general health, the BMS constantly checks its SOC and SOH.

Charge Control: The battery charging procedure is regulated by the BMS to keep the battery's charge within safe bounds and avoid overcharging.

Discharge Control: The BMS controls the battery's discharge process to avoid over-discharging, which can harm the battery.

Temperature Control: The BMS regulates the battery's temperature to avoid burning or overcooling, which can harm the battery

3. Temperature control using Fan:

High charging currents, hotter surrounding temps, and higher discharge rates are a few of the causes of battery heat. As a result, the battery may experience thermal runaway, a condition in which the heat it produces sets off a series of events that ultimately lead to the battery's failure. High battery temperatures can also shorten the battery's lifespan and cause internal harm like dendrite growth. In rechargeable batteries, battery heat is a frequent problem, particularly in devices that are used frequently or for long stretches of time. Heat from batteries can cause a number of issues. Reduced battery life: Excessive heat can cause damage to the internal components of the battery, reducing its overall lifespan.

Safety hazards: High temps can be dangerous because they can cause thermal runaway, which can result in fires or explosions.

Performance degradation: Overheating can decrease performance and battery life, which lowers user satisfaction and shortens the device's lifespan.

It's crucial to use the right charger, refrain from overcharging, and avoid charging in hot environments if you want to avoid these problems. Additionally, using suitable cooling techniques, like a heat sink or fan, can lessen cell heat and increase battery life.

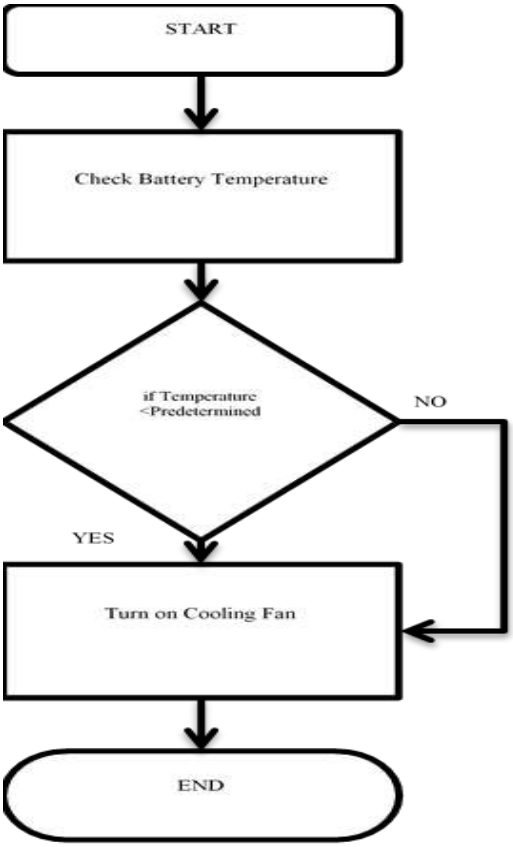


Figure 1 Flowchart for temperature control using fan

The above flowchart explains about the control the battery temperature by using cooling fan. First it checks the temperature if it is greater than predetermined temperature then immediately cooling fan will turn on then it is used to cool down the battery temperature.

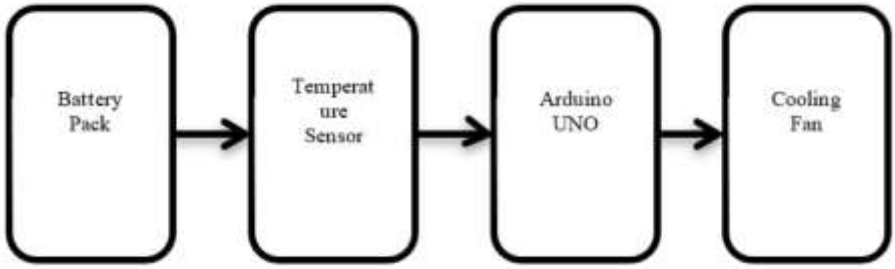


Figure 2 Block diagram for temperature control

4. Temperature control using Arduino

In our project, we have made the decision to create an automatic temperature cooling system based on the battery pack's temperature. We use an Arduino Uno micro controller to regulate the battery's temperature, and it provides instructions for cooling the battery pack. We are using a DHT11 temperature sensor to regulate the battery pack's temperature. The sensor measures the battery pack's temperature, which is read by the Arduino uno. Based on the battery's temperature, the controller lowers the pack's temperature by turning on a cooling fan to provide cooling to the pack.

CODE:

```
#include "DHT.h"

#define DHTPIN 2     // Digital pin connected to the DHT sensor

#define DHTTYPE DHT11   // DHT 11
```

```
DHT dht(DHTPIN, DHTTYPE);
int fan=5;
void setup()
 {
  Serial.begin(9600);
  pinMode(fan,OUTPUT);
  dht.begin();
 }
void loop()
 {
float temperature = dht.readTemperature();
Serial.print("Temperature: ");
  Serial.print(temperature);
  Serial.println(" *C");
 if(temperature>30)
{
 digitalWrite(fan,HIGH);
 Serial.print("HIGH");
}
 else
{
 digitalWrite(fan,LOW);
 Serial.print("LOW");
}
delay(2000);
}
```

5. Simulation Model:

Charging a battery from a solar panel is an application of renewable energy systems, especially in remote areas where grid electricity is not available. However, the voltage output of a solar panel is often lower than what is required to charge a battery, which means that a boost converter is needed to increase the voltage to a level that is suitable for charging.

A boost converter is an electronic circuit that can increase the voltage of a DC power source by controlling the duty cycle of a switch. In the case of solar charging, the boost converter is connected between the solar panel and the battery, and it steps up the voltage from the solar panel to a level that is appropriate for charging the battery.

Solar charging of the battery is depended on the state of charge of the battery when the battery SOC is reached predetermined value then only battery will be charging by solar.

Here's how it works:

Solar panel: For the purpose of harnessing solar energy, a solar panel is placed. Direct current (DC) electricity is created from the produced energy, and it is then delivered to a charge controller.

Charge Controller: The charge controller controls how much energy is transferred from the solar screen to the battery. The battery's lifetime is increased because it prevents overcharging or undercharging.

Inverter: The DC electricity from the charge controller is then converted into alternating current (AC) electricity by an inverter.

Battery: The AC electricity is stored in a battery for later use.

Overall, a solar battery charging system allows you to take advantage of solar power, providing a reliable and cost-effective solution for charging your battery.

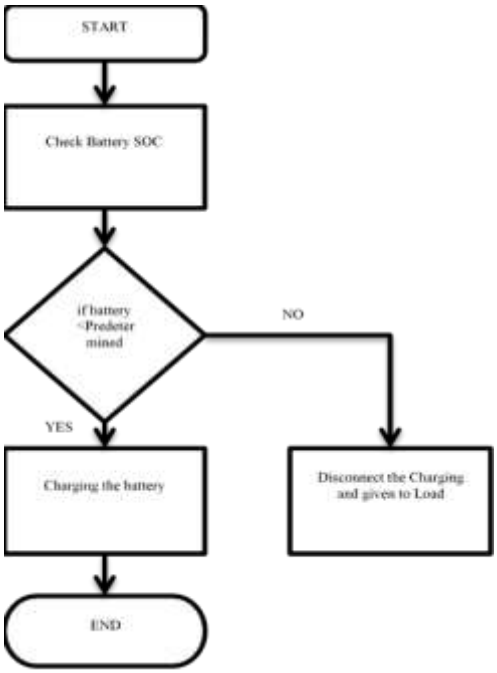


Figure 3 Flowchart for charging the battery

The below flowchart describes about, if battery SOC is very low that means if it is less than 20% then the battery is charging from solar by using boost converter which is used to step-up the input voltage as per requirement of battery and if battery SOC is full that means if it is greater than 80% then the battery power is giving to load and disconnect the charging of battery from solar and process is continuously repeated.

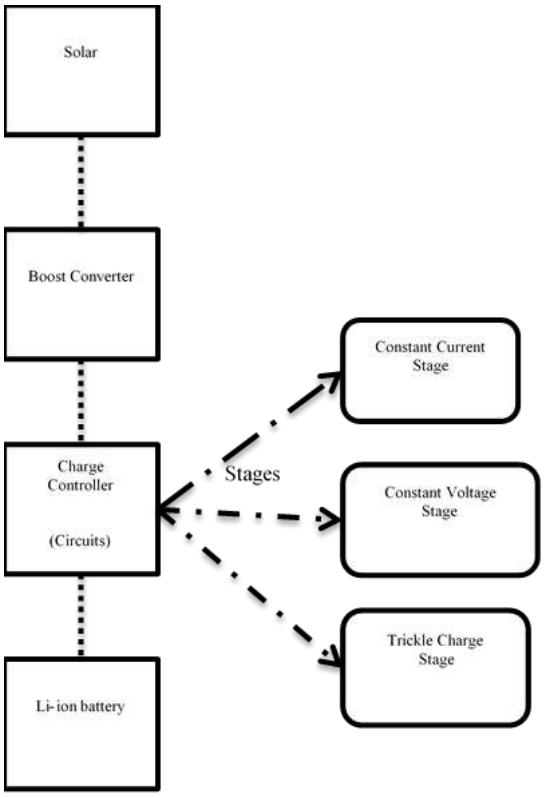
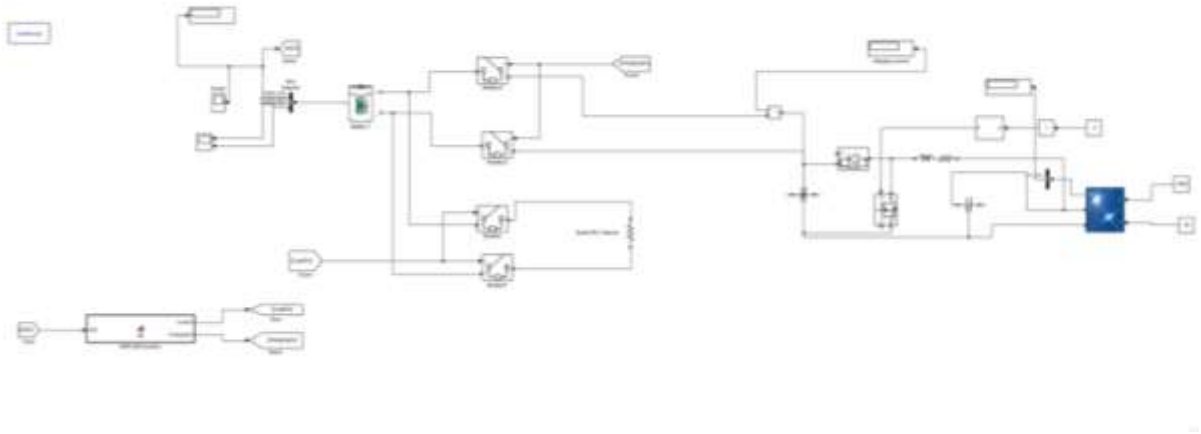


Figure 4 Block diagram for charging the battery

6. SIMULATION DIAGRAM:

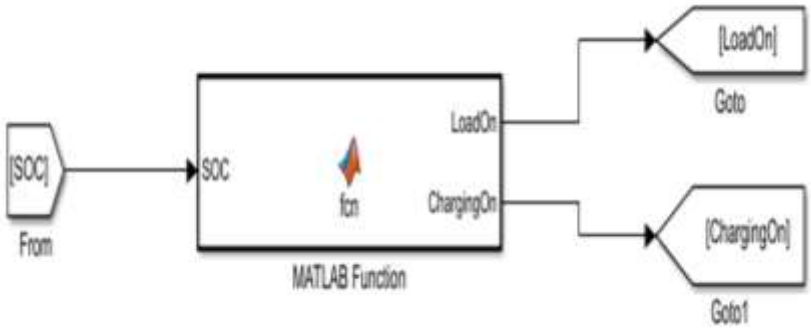


Simulation Model

7. WORKING OF SIMULATION:

Initially battery is connected to a battery as well as solar panel. by using circuit breakers first battery power is discharging through load whenever battery percentage reaches below or equal to 20% then battery is charging directly from solar using boost converter which is used to step up the voltage as per battery requirement. Then it will continuously process.

In the below graphs firstly soc curve is rapidly decreasing because of discharging then at time period soc battery reaches below or equal to 20% then the soc curve will increase then it will process continuously.



Working of Simulation

The above MATLAB function is major tool which is used to control the charging based on conditions. Below condition programmed is example for above simulation platform.

```
Function [LoadOn,ChargingOn] = fcn(SOC)
LoadOn=1;
ChargingOn=0;
if(SOC>=80)
   LoadOn=1;
   ChargingOn=0;
end
if(SOC<79.99998)
```

```
    LoadOn=0;
    ChargingOn=1;
end
```

For clear visibility of graph we take soc is less than 79.99998 so you can take as per your requirement. Generally all are take 20 percentage if condition is true then automatically charge from solar by using boost converter and circuit breakers.

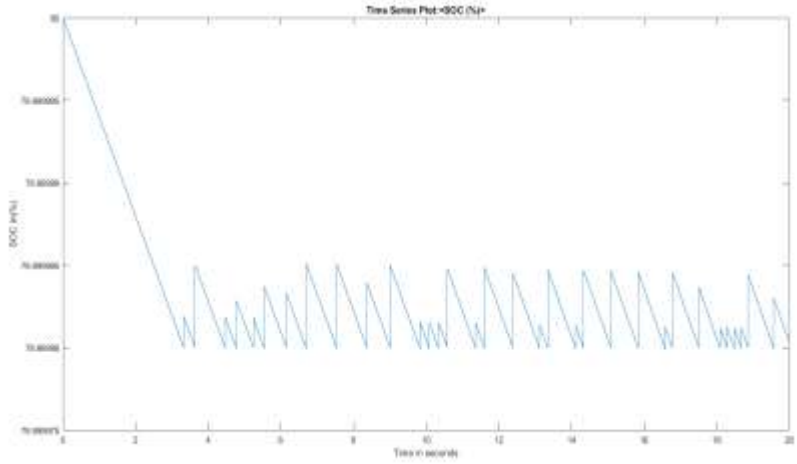


Fig 6.5 Matlab graph Charging

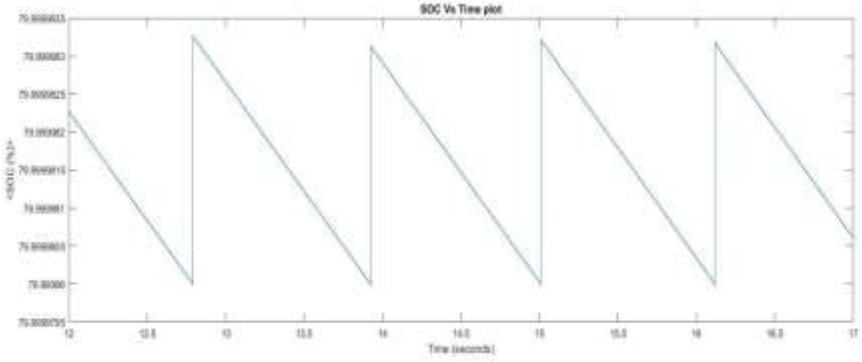


Fig 6..6 matlab graph

7. State of Charge:

State of charge of the battery is one of the most important parameters to ensure the long life of the battery and it can be calculated by various methods. Accurate estimation of battery SOC not only helps to provide information about the real-time remaining capacity and energy of the battery, but also gives assurance of a reliable and safe vehicular operation. SOC of a battery is defined as the percentage of the remaining capacity in its maximum available capacity.

SOC = (Remaining Capacity/Rated capacity) * 100

The rated capacity of the battery is the maximum capacity of the battery and it is given in the data sheet of the battery and it is expressed in milli Ampere hour and the rated capacity is also known as nominal capacity of the battery.

The remaining capacity of the battery can be measured by various methods and there by the state of charge of the battery. The remaining capacity gives information about the how much charge left in the battery.

There are various methods to estimate the state of charge of battery and here we are using the current based soc estimation by using the current sensor and the energy contained in an electric charge is measured in Coulombs and is equal to the integral over time of the current which delivered the charge.

The remaining capacity in a cell can be calculated by measuring the current entering (charging) or leaving (discharging) the cells and integrating (accumulating) this over time and estimating the SOC is measured using Arduino UNO micro controller.

Algorithm for estimating the SOC of battery using Arduino UNO:

a. Initialize the system and set up the necessary sensors and micro controllers for monitoring the battery.

b. Read the battery voltage using an analog pin read and convert it into a decimal value.

c. Read the battery output current using a current sensor and convert it into a current value in mA.

d. Time is calculated using the millis() function in hours. There is inbuilt function in Arduino UNO to measure the time and it is stored in the Arduino memory

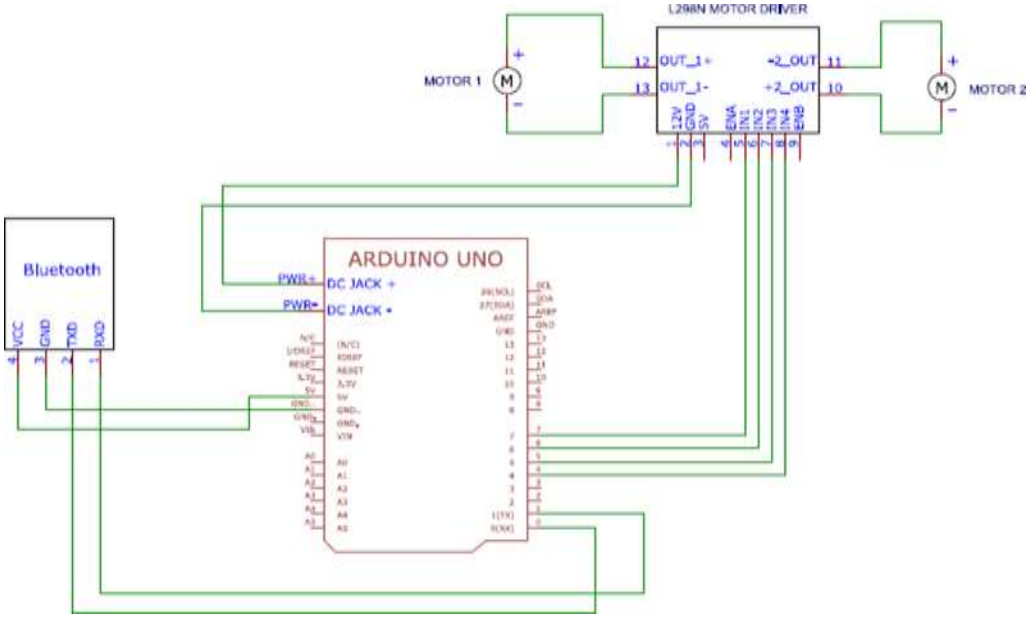
e. Then the charge can be calculated by the product of the current and time.

f. Then Calculate the state of charge (SOC) of the battery using the formula as stated before

g. Where Remaining Capacity = Rated Capacity - (Current x Time) and there by the SOC can be calculated

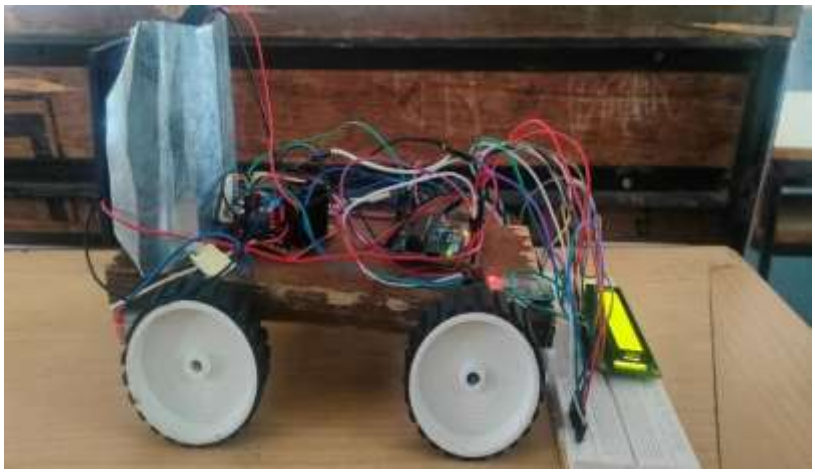
8. Hardware model

In this project we are build a Bluetooth control car along with automatic temperature cooling system to the battery pack. The Bluetooth control car can operate by mobile by connecting it to the car and the automatic temperature cooling system is activated according to the temperature of the battery pack.

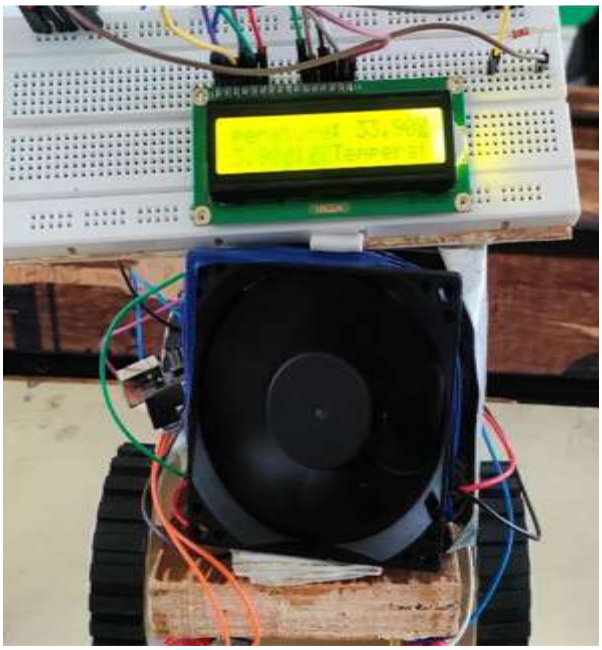


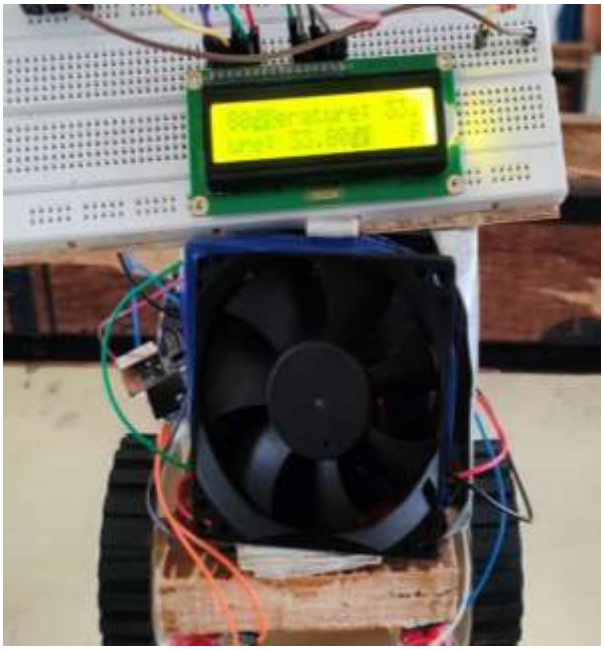
The above figure shows the circuit diagram for Bluetooth control car and it shows the clear circuit for the Bluetooth control car and here the motor means the wheel which is connected to the motor and the Bluetooth module is connected to our mobile by that way one can operate the car by using the mobile.

In this project, we have made the decision to create an automatic temperature cooling system based on the battery pack's temperature. We use an Arduino Uno micro controller to regulate the battery's temperature, and it provides instructions for cooling the battery pack. We are using a DHT11 temperature sensor to regulate the battery pack's temperature. The sensor measures the battery pack's temperature, which is read by the Arduino uno. Based on the battery's temperature, the controller lowers the pack's temperature by turning on a cooling fan to provide cooling to the pack and the algorithm and the circuit.



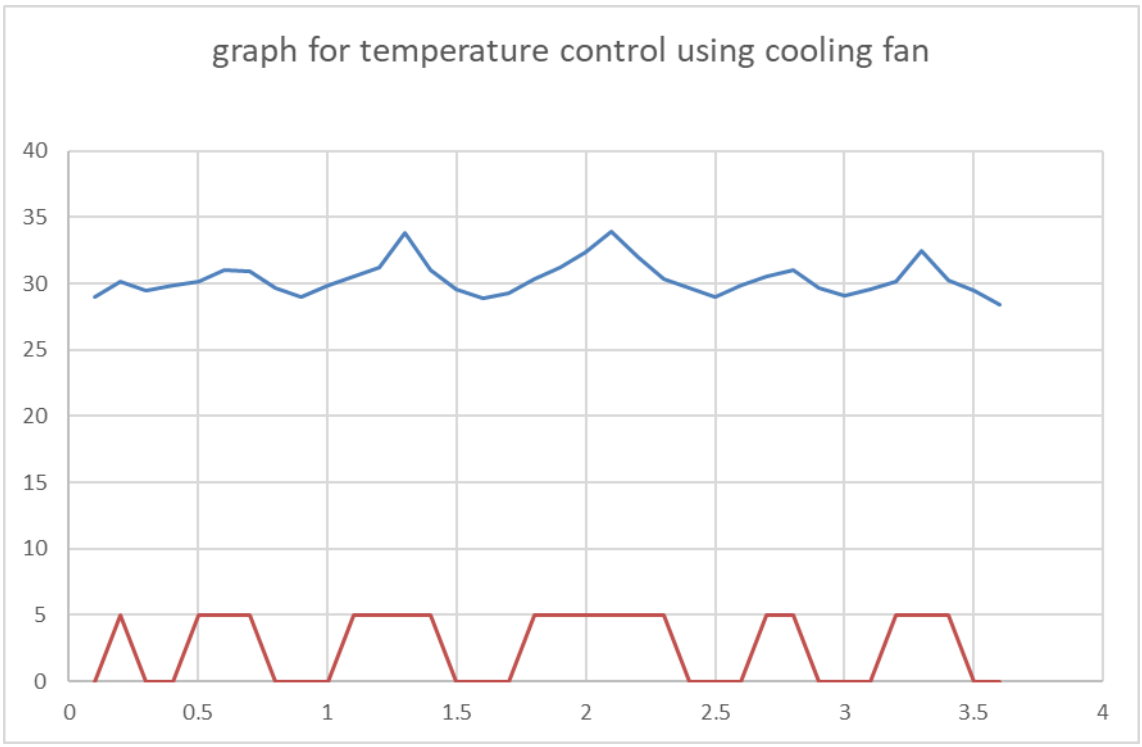
The above Figure shows the hardware model of bluetooth control car and it can driven by mobile by connecting the car through bluetooth to the mobile and arduino bluetooth control app.





The above figure shows the hardware setup of the Temperature control of battery and it monitors the temperature of the battery and the temperature is displays on the lcd and it shows the temperature is high or low and accordingly the fan will on and off .

The below figure shows the serial monitor values of the temperature display on the arduino ide and it shows that temperature is decreases gradually.



9.Conclusion

This paper explains about the explains about the temperature control is an essential aspect of managing the performance and longevity of an electric vehicle battery. Temperature management can be achieved through the implementation of cooling technique to maintain the battery within its optimal operating temperature range. Additionally, simulation models have proven to be valuable tools for the design and optimization of battery performance by operating the battery based on the State of charge of battery.

Furthermore, this explains about the state of charge (SOC) estimation is critical for monitoring the energy level of a battery and ensuring that it operates within safe limits. There are various SOC estimation methods and explains about the algorithm we are used using the Arduino UNO and operating the battery within the safe limits to ensure the health of the battery.

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