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Research Paper

Thermal Management System for Electric vehicle

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ABSTRACT: *A crucial element of electronic motors that ensures the efficient operation and durability of the car's electric components is the thermal management machine. The machine can be charged to maintain the battery, power electronics, and electric motor's ideal operating temperature range. A powerful thermal environment is created by a well-designed thermal management device, which can increase the efficiency of conventional cars, lengthen battery life, and increase vehicle variety. This essay will give a general summary of the various thermal control device additives, their purpose, and the difficulties in creating a potent thermal management system for digital motors. This article will also go over the most recent developments in the creation of thermal control devices as well as the future course of the industry.*

KEYWORDS: *Battery thermal management, electronic vehicle, ESP32.*

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I. INTRODUCTION

The automotive sector has seen tremendous transformation as a result of the rise of electric cars (EVs). Unlike conventional vehicles, which run on internal combustion engines, EVs are powered by batteries, electric motors, and power electronics. Thermal management systems, however, are an essential part of EVs because the effective operation of these components is strongly dependent on temperature regulation [1]. The thermal management system is in charge of preserving the electrical components of the vehicle within their ideal operating temperature range. The battery, power electronics, and electric motor are all guaranteed to operate effectively and to last a long time within this range. The thermal management system is essential for preventing overheating, which can harm electrical components and shorten their lifespan.

The numerous parts of the thermal management system, their purpose, the difficulties in creating an efficient system, and the most recent developments in thermal management system technology will all be covered in this paper.

Fig. 1. Electronic vehicle caught fire due to overheating.

Nowadays electric vehicles have increased over the past decade as consumers demand more eco-friendly solutions to combat climate change. Recently SomeElectric bikes caught fire due to the failure of the battery Management system, and bad battery design. Due to the Absence of a Thermal Management system Notification Alert (Battery Temperature), some people has lost their life.

Unfortunately, this feature is not available in most of the existing Electric vehicles. So, here the project is to

Monitor the Battery Temperature & Smoke Detection to Alert the Electric Vehicle user's via Smartphone Notification, Alarm the Buzzer and also to Auto Cut off the Electric Vehicle to Avoid Further Damages.

II. WORKING PRINCIPLE

The battery, power electronics, and electric motor are only a few of the electrical components of an electronic vehicle's thermal management system that are regulated in temperature. In order to preserve these components' optimum performance, longevity, and safety, the system strives to keep them within a certain temperature range.

Lithium-ion Battery has a specified allowed operational Temperature of -20 'C to +60C, it will provide the longest service life if temperatures are kept within approximately10 C to 40 C at all times. This system is powered by 12V Portable Battery and it is regulated into 5V and P3V3 power sources. The temperature sensor (DS18B20), Smoke Sensor (MQ135), SPDT Switch & Potentiometer are inputs to ESP32 Controller.I2C 16×2 LCD Display, Buzzer, Relay & Arduino Blue Control Application are outputs of ESP32 Controller. An SPDT S1-switch is placed in the system for mode selection to display the current temperature or to configure the threshold temperature with the help of potentiometer. ESP32 monitoring the Temperature & Smoke Detection inputs for every millisecond, the same thing should be displayed in LCD Display and also in smart Phone via Bluetooth Arduino Blue Control Application. When riding or charging Electric vehicle, If the battery temperature exit above threshold value of 40°C or Detecting Smoke from the Battery unit means ESP32 Controller will alert the Electric vehicle user via Output Buzzer, Providing Alarm Notification to Smart Phone and also Cut-off the Electric Vehicle power from battery with the Help of Relay Module.

Overall, the efficient operation and longevity of electronic vehicle components depend greatly on the thermal management system. The system can increase vehicle range, boost overall effectiveness, and guard against overheating-related damage by maintaining a steady temperature range[3].

Overall, the thermal management system plays a significant role in the longevity and effective operation of electric vehicle components. By keeping a constant temperature range, the system can extend the range of the vehicle, improve overall effectiveness, and protect against overheating-related damage [2]. The battery pack, power electronics, and electric motor are just a few examples of the components in an electric car that have their temperatures controlled and regulated by the thermal management system. The thermal management system's operating principle normally incorporates a number of important parts and procedures. The system, for starters, has temperature sensors that gauge the temperature of various car parts. The control system employs algorithms to decide the best course of cooling or heating after receiving this data.

III. BLOCK DIAGRAM

According to the block diagram, the battery monitoring system is utilized to indicate the system's battery health. This is used as a way of continuous monitoring to examine the battery system's temperature, charge, and health. By using a temperature sensor, this BTMS is used to maintain the thermal state of the battery.

The DS18B20 temperature sensor is used to detect the temperature range of the battery. The battery operates normally between 20 and 35 degrees Celsius. When the temperature of the battery reaches the determined threshold then the buzzer triggered to inform the user and relay halt the power supply which is connected with the battery system comes to operation [4].

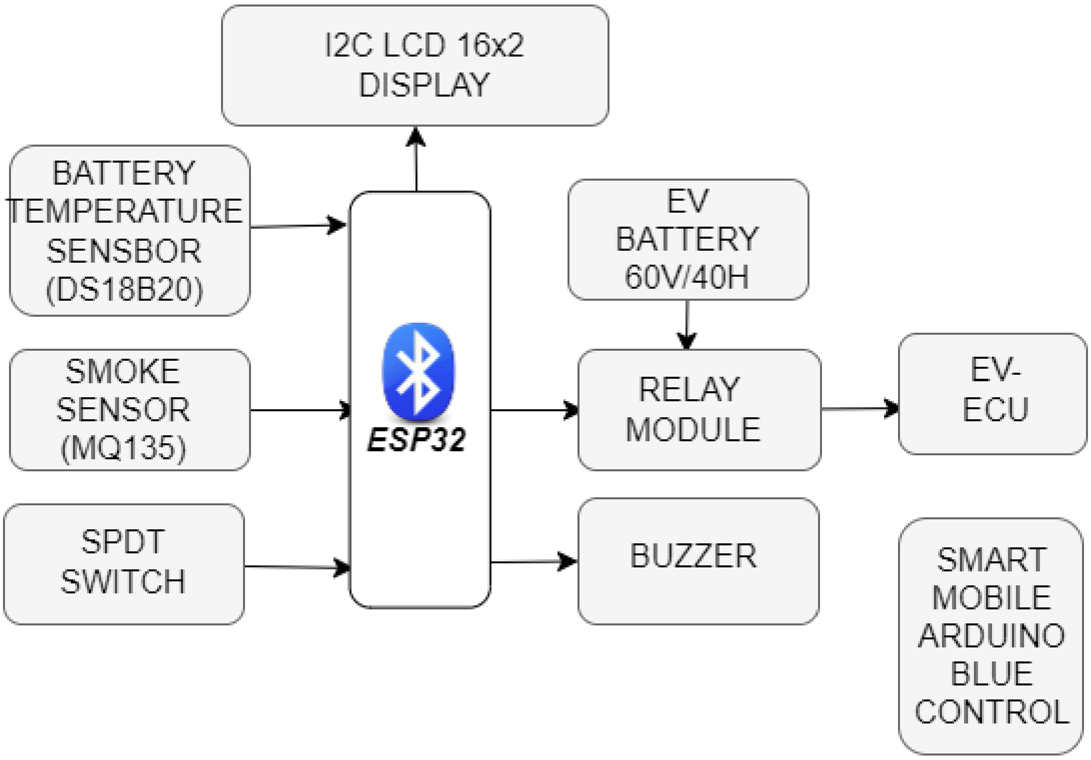
The purpose of the DS18B20 Temperature and Smoke Sensors is to protect the user against battery fires that may result from overheating or overcharging. They are linked to the battery. All of these are functional thanks to the esp32 development board. The esp32 is interfaced with the DS18B20, MQ135 and relay module, and the proper programme is utilized to run the battery management system.

The continuous operation of the battery is monitored by this battery thermal management system, and the values are saved in the gadget. For the purposes of this system, the battery is permitted to operate normally. In order to charge and discharge the battery level, this battery is connected to the loads. When the temperature exceeds the battery's operational temperature range, the battery is used to disperse heat. To prevent additional battery or vehicle damage, the relay module, which is attached to the ECU of the car, is employed [5].

The 10K potentiometer, which is connected to the esp32 board and used to modify the temperature reference value, is also a part of this system. This is carried out because occasionally the ambient circumstances do not favors the battery management system. Similar to hot days, the typical temperature exceeds the battery-friendly temperature range. Therefore, it should be adjusted for temperature [11]. Therefore, the battery temperature should be managed using a 10K potentiometer in accordance with the weather. The relevant programme is interfaced with the esp32 board to run this battery management system.

Now, the user should be shown everything that is happening in the system so that they may make decisions or acquire information on the battery temperature, battery health, etc. The esp32 board and I2C LCD 16x2 display module are connected for this. Knowing the battery's temperature, PPM value, and the user-set reference value is helpful to the user. The data sent by the DS18B20 and MQ135 sensors is shown in this module

[13]. This is additionally connected to the SPDT switch in this instance to change the information that is displayed on the LCD module. All of this connects to the esp32 board, which is controlled by the right programme for the battery management system.



IV. METHODS & MATERIALS

In this project, the ESP32 takes the data as input from the DS18B20 (Temperature Sensor) and MQ135 (Smoke Sensor). The DS18B20 sensor take reading every second from the battery so That if there is overheating or any hazardous activity in the battery so that it can send the data to esp32 module for the further process and also it can send the alert notification to the user mobile and by making the buzzer so that user can get the notification the there is a hazardous activity in electronic vehicle[7]. The MQ135 sensor is used so that if there is anything like smoke in battery or if battery caught fire so that it can send data to ESP32 so that it can disconnect the battery from the power source to reduce the further damage in an electronic vehicle [14].

All these readings taken from the DS18B20 sensor and MQ135 sensor will also be available on the LCD 16*2 module so that the user can also see the temperature of the battery in an electronic vehicle.

Now all these connected to the ECU (Electrical Control Unit) of an electronic vehicle.

There is also an Android Bluetooth Control App which has to be downloaded by the user which has to be connected by the ESP32 development board used in this project over Bluetooth [9]. Now if there is any hazardous activity happening in an electronic vehicle, a user directly monitors the electronic vehicle as the app start pushing the alert notification to the user regarding the electronic vehicle.

I. Materials used are:

- ESP32 (Development Board)
- DS18B20 (Temperature Sensor)
- MQ135 (Smoke Sensor)
- RG1602A (I2C 16X2 LCD Display)
- LM7805 (Regulator)
- 10K (POT)
- 1K (1/4 Watt)
- 1N4007 (Diode)
- 100nF (Capacitor)
- 10V Buzzer
- GU-SH112D (High Power Switching Relay)

- BC547 (Transistor)
- SPST Switch
- 12V Lithium-ion Battery
- 60V/40A/2.4KW Electric Vehicle Battery
- Smart Mobile
- Arduino Blue Control App
- IDE Arduino Software

V. PROS & CONS

Thermal management systems are essential parts of electronic vehicles that keep the battery, power electronics, and electric motor at the ideal temperature. The benefits and drawbacks of thermal management systems in electronic vehicles are as follows:

5.1PROS

- Enhances performance: Thermal management systems aid in maintaining the battery, power electronics, and electric motor's ideal operating temperatures, which can enhance the vehicle's performance, effectiveness, and range.
- Increases battery life: Thermal management systems can help to increase the battery's lifespan by minimizing overheating, which reduces the need for frequent replacements.
- Safety is ensured by the fact that overheating of the battery and power electronics might result in potentially hazardous fires. Thermal management systems aid in preventing overheating, assuring the security of the vehicle and its occupants.

5.2 Cons

- Costs more to produce: The addition of a thermal management system raises the price of an electronic vehicle for the buyer because it costs more to produce.
- Weight gain: Thermal management systems frequently ask for extra parts and supplies, which might increase the weight of the car. The vehicle's efficiency and range may suffer as a result of the extra weight.
- Complex upkeep: Thermal management systems are intricate and need frequent, often costly and time-consuming, maintenance.
- Limited effectiveness in harsh situations: Thermal management systems may have trouble maintaining ideal temperatures in times of extreme cold or heat, which can have an impact on the vehicle's performance and range.

VI. APPENDIX

Arduino Code

```
#include <OneWire.h>
#include <DallasTemperature.h>
#include <LiquidCrystal_I2C.h>
#include "BluetoothSerial.h"

#if !defined(CONFIG_BT_ENABLED) || !defined(CONFIG_BLUEDROID_ENABLED)
#error Bluetooth is not enabled! Please run `make menuconfig` to and enable it
#endif

BluetoothSerial SerialBT;

String message = "";
char incomingChar;
String temperatureString = "";
String humidityString = "";

#define ADC_VREF_mV    4755.0
#define ADC_RESOLUTION 4096.0
#define MQ135       39
#define TEMP_REF       34

const int oneWireBus = 4;
```

```
LiquidCrystal_I2C lcd(0x27, 16, 2);
const int SW = 19;
const int BUZZAR = 17;
const int EV_ECU = 5;
const float threshold2=400.00;

OneWire oneWire(oneWireBus);

DallasTemperature sensors(&oneWire);

void setup() {
  lcd.init();
  lcd.backlight();

  Serial.begin(115200);
  SerialBT.begin("ESP32");
  Serial.println("Start pairing!");

  pinMode(SW, INPUT);
  pinMode(BUZZAR, OUTPUT);
  pinMode(EV_ECU, OUTPUT);
  sensors.begin();
}

void loop() {

  if (digitalRead(SW) == HIGH){
  int adcVal2= analogRead(TEMP_REF);
  float milliVolt2 = adcVal2 * (ADC_VREF_mV / ADC_RESOLUTION);
  float temp_r = milliVolt2 / 8.5;
  lcd.clear();
  lcd.setCursor(0, 0);
  lcd.print("REF_TEMP:");
  lcd.print(temp_r);
  lcd.print("C");
  SerialBT.println("Alarm_Temp_REF");
  SerialBT.println(temp_r);
  delay(500);
   }

  else if (digitalRead(SW) == LOW)
 {

    int adcVal1= analogRead(MQ135);
    int adcVal3 = analogRead(TEMP_REF);
    float milliVolt3 = adcVal3 * (ADC_VREF_mV / ADC_RESOLUTION);
    float temp_rr = milliVolt3 / 8.5;
    float milliVolt1 = adcVal1 * (ADC_VREF_mV / ADC_RESOLUTION);
    float AIR_PPM = milliVolt1 / 1;
    sensors.requestTemperatures();
    int temperatureD = sensors.getTempCByIndex(0);
    float temperatureC = sensors.getTempCByIndex(0);
    float temperatureF = sensors.getTempFByIndex(0);
    SerialBT.println(temperatureD);

if(temperatureC>temp_rr)
  {
    SerialBT.println("Temperature_Alarm");
```

```
  lcd.clear();
  lcd.setCursor(0, 0);
  lcd.print("Temperature_Alarm");
  digitalWrite(BUZZAR, HIGH);
  digitalWrite(EV_ECU, HIGH);
  delay(60000);

    }

    else if(temperatureC<temp_rr)
    {
      SerialBT.println(temperatureD);
      lcd.clear();
      lcd.setCursor(0, 0);
      lcd.print("T:");
      lcd.print(temperatureC);
      lcd.print("C");
      lcd.setCursor(0, 1);
      lcd.print("Air:");
      lcd.print(AIR_PPM);
      lcd.print("PPM");
      digitalWrite(BUZZAR, LOW);
      digitalWrite(EV_ECU, LOW);

      }

    else if(AIR_PPM>threshold2)
 {

  SerialBT.println("Smoke_Alarm");
  lcd.setCursor(0, 0);
  lcd.print("Smoke_Alarm");
  digitalWrite(BUZZAR, HIGH);
  digitalWrite(EV_ECU, HIGH);
  delay(60000);

    }

}
}
```

VII. CONCLUSION

Unexpected battery fire accidents in electric vehicles can result in fatalities and damage to the vehicles if the owners are not warned right once. The analysis of this issue and the prompt notification of Electric Vehicle users will help to prevent the loss of human life and damage to Electric Vehicles. The following lists the goals and milestones we were able to reach thanks to the system we designed**.** Overall, the operating conditions, performance specifications, and financial limitations of the vehicle must all be carefully taken into account when designing and implementing a thermal management system for an electronic vehicle. Manufacturers may increase the effectiveness and dependability of electronic vehicles as well as the overall driving experience for consumers by optimizing the heat management system.

- Monitoring the Battery Temperature and smoke to alerting users via buzzer and smartphone notification all the time.
- Auto cut-off the battery power from the Electric Vehicle to avoid further damages.

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