Tire Pressure Sensor

MINI PROJECT FINAL REPORT

Automobile Electronics

TEE3310

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January 2024

CONTENT

KEY WORDS

Esp 32 micro controller, BMP 180 pressure sensor, dot board, Arduino, programming, LED Display.

ACKNOWLEDGEMENT

We express our sincere gratitude to all those who contributed to the successful completion of this tire pressure monitoring project. First and foremost, we extend our heartfelt appreciation to our project supervisor for their guidance, invaluable insights, and unwavering support throughout the entire duration of this endeavor. We would like to thank the faculty members who provided assistance and resources, fostering an environment conducive to learning and innovation. Special thanks go to our peers and colleagues for their collaboration and shared enthusiasm, creating a dynamic and inspiring atmosphere.

Furthermore, we are grateful for the technical expertise and support received from professionals in the field, as well as for the facilities and equipment provided that were integral to the project's execution. Last but not least, we extend our deepest appreciation to our family and friends for their encouragement and understanding during the project, as their unwavering support played a significant role in the successful realization of this endeavor.

ABSTRACT

This project introduces an innovative Tire Pressure Monitoring System (TPMS) designed to enhance vehicle safety and maintenance. The system incorporates a BMP180 pressure sensor to measure both tire pressure and temperature, with data relayed to an ESP32 microcontroller. Utilizing Wi-Fi connectivity, the ESP32 transmits these values to an LED display in real-time, offering users a convenient means of monitoring tire conditions. A crucial safety feature includes an alert mechanism triggered when pressure values fall below a predefined threshold, signaling a potential tire leak. The project aims to contribute to road safety by providing immediate feedback to users and facilitating timely maintenance interventions. Future work may involve the integration of additional sensors, exploration of advanced communication protocols, and the incorporation of machine learning algorithms for predictive maintenance enhancements. This tire pressure monitoring system stands as a promising solution in the pursuit of safer and more reliable automotive technologies.

CHAPTER 01

BACKGROUND TO THE PROJECT

In modern automobiles, maintaining proper tire pressure is critical for safety, fuel efficiency, and overall performance. The use of Tire Pressure Sensors has become a regular element in vehicle technology. This project intends to create and improve a Tire Pressure Sensor system that not only monitors tire pressure but also sends real-time data to the vehicle's central control unit.

PROJECT DESCRIPTION

This project involves the design, development, and implementation of an advanced sensor system. The system will be capable of accurately measuring tire pressure and communicating this data to the vehicle's onboard computer. The project will encompass both hardware and software components, ensuring seamless integration with existing vehicle systems.

PROJECT AIM

The aim of this project is to design and implement a tire monitoring system that continuously measures and analyzes tire sensor data to detect and alert users to the presence of any leaks. The primary goal is to enhance vehicle safety and performance by providing real-time, proactive information on tire conditions. The system will employ advanced sensor technology to monitor tire pressure, temperature, and other relevant parameters, ensuring early detection of leaks that may go unnoticed by conventional visual inspections. Through continuous data analysis and timely notifications, the project aims to prevent potential tire-related incidents, reduce the risk of unexpected breakdowns, and contribute to overall road safetyy.

OBJECTIVES

- Achieve a precision level of tire pressure measurement within a $\pm 1\%$ margin of error. Establish a communication range of at least 10 meters between sensors and the central control unit.
- Calculate if the tire is having an undetectable leak to the naked eye.

CHAPTER 02

TRADITIONAL DIRECT TPMS

The Traditional Direct TPMS employs a methodology wherein pressure sensors situated within each tire wirelessly transmit data to a central receiver located in the vehicle. This system utilizes piezoelectric pressure sensors and radio frequency (RF) communication technology, enabling highly accurate and real-time monitoring of tire pressure, along with individual tire identification capabilities. Despite its strengths in providing precise data, the Traditional Direct TPMS has notable weaknesses, including relatively high costs, the need for installation, and periodic battery replacements. Furthermore, it is susceptible to signal interference. Insights from recent literature highlight ongoing research efforts focused on optimizing sensor size and power consumption, refining communication protocols, and incorporating additional diagnostics such as temperature and tread wear into the system for a more comprehensive monitoring approach.

INDIRECT TPMS

Indirect TPMS operates by utilizing the existing Anti-lock Braking System (ABS) sensors to monitor variations in wheel rotation speed, indirectly deducing changes in tire pressure. This system relies on the technology of existing ABS sensors and involves the analysis of wheel speed data. Notably, its strengths lie in being a cost-effective solution that requires no installation or ongoing maintenance, and it remains operational even in the presence of flat tires. However, it comes with inherent weaknesses, including lower accuracy in comparison to direct TPMS, an inability to identify individual tire pressure issues, and susceptibility to external factors such as road conditions. Current literature insights in this domain focus on developing algorithms to enhance pressure estimation accuracy, integrating additional sensors like accelerometers into the system, and exploring ways to integrate Indirect TPMS with traditional TPMS for a more comprehensive and reliable tire monitoring approach.

ADVANCE TPM

Advanced TPMS integrates direct pressure sensors with additional sensors to measure parameters such as temperature, tread depth, and occasionally vibration. This system relies on multi-sensor modules and employs advanced data analysis algorithms for a comprehensive assessment of tire health. Offering valuable insights, Advanced TPMS enables predictive maintenance, contributing to enhanced safety and fuel efficiency. However, it comes with certain drawbacks, including being the most expensive option in the TPMS spectrum and requiring complex installation and data management. Recent literature in this field emphasizes research on miniaturizing and seamlessly integrating sensors into tire systems, developing self-healing tire materials, and harnessing AI- powered predictive models for early detection of potential issues, showcasing the ongoing efforts to refine and optimize Advanced TPMS technologies.

COMMUNICATION TECHNOLOGIES

Various communication technologies play crucial roles in tire pressure monitoring systems (TPMS). Bluetooth, with its short-range and low-power attributes, facilitates data transmission between sensors and receivers within the vehicle. On the other hand, Radio Frequency (RF) offers a longer range, making it reliable for both in-vehicle and short-range remote monitoring applications. Cellular connectivity emerges as a powerful option, allowing remote monitoring and alerts even when the vehicle is parked, which proves invaluable for fleet management scenarios. Current literature trends in this domain focus on enhancing the security of communication protocols, integrating TPMS with cloud platforms for efficient data storage and analysis, and exploring the potential of low-power, wide-area network (LPWAN) technologies to extend range and achieve cost-effectiveness in tire monitoring systems. These insights underscore the ongoing efforts to advance the communication aspects of TPMS for improved functionality and reliability.

EMERGING TECHNOLOGIES

Innovative technologies are driving the forefront of TPMS development, promising substantial advancements in tire safety and management. Solar-powered sensors represent a notable breakthrough, eliminating the need for battery replacements and significantly extending the system's lifespan. This not only reduces maintenance efforts but also contributes to sustainable and eco-friendly practices. Another groundbreaking feature is the integration of self-healing punctures, where the system autonomously seals small punctures, enhancing safety and convenience for vehicle operators. Additionally, the incorporation of AI-powered predictive maintenance is transforming the landscape by analyzing sensor data to foresee potential issues and provide timely recommendations for preventative actions. These cutting-edge developments underscore the potential for a future where TPMS technologies not only ensure tire safety but also contribute to overall efficiency and longevity in vehicle maintenance.

CHAPTER 03

In this methodology, the initial step involves the utilization of the BMP180 pressure sensor to measure both the pressure and temperature within the tire. This sensor gathers accurate data reflecting the internal conditions of the tire [1]. Subsequently, the gathered pressure and temperature values are transmitted to the ESP32 microcontroller, which acts as the central processing unit for the system [3].

The ESP32, equipped with Wi-Fi capabilities, facilitates the wireless transmission of these values to an LED display. This real-time display allows users to monitor the current pressure and temperature status of the tire conveniently. The system is designed with a safety feature wherein if the measured values decrease beyond a predetermined threshold, indicating a potential leak in the tire, the ESP32 triggers an indication mechanism.

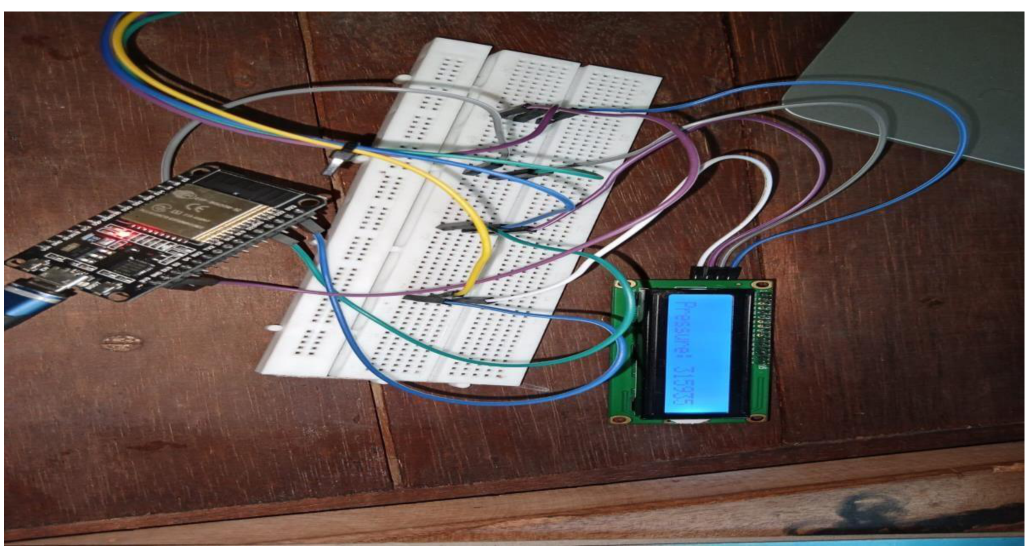
This alert will be visual through and LED light, to promptly notify the user of the tire's compromised condition, enabling timely intervention and maintenance. In essence, this integrated system offers a comprehensive solution for monitoring tire pressure and temperature, ensuring user awareness and enhancing overall vehicle safety [2].

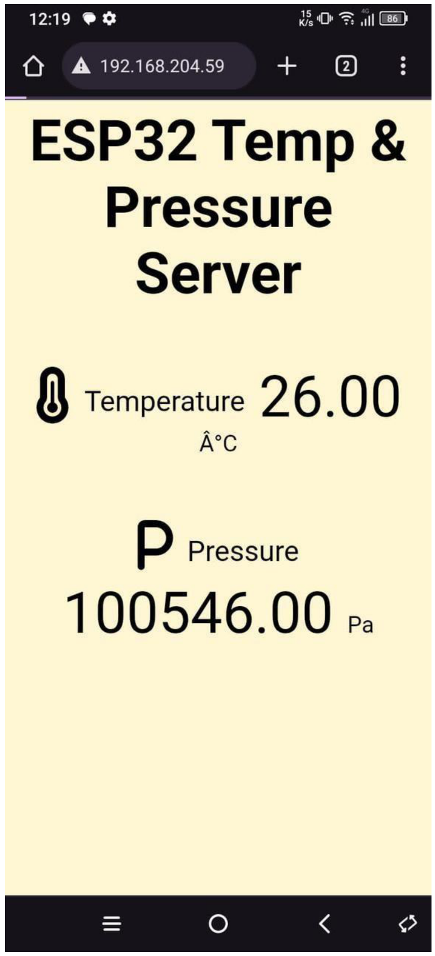
CHAPTER 04

IMPLEMENTATION

Connect the tire pressure sensors to the ESP32 development board. The specific wiring will depend on the type of sensor you are using (analog or digital).Connect any additional components, such as a display unit or power supply. Ensure that the power supply can provide sufficient power for both the ESP32 and the tire pressure sensors. Write code to read data from each tire pressure sensor. This may involve using analog or digital pins on the ESP32, depending on the sensor type. Convert the sensor readings to actual pressure values using the sensor's specifications. Implement code to transmit the tire pressure data wirelessly using the ESP32's Wi-Fi or Bluetooth capabilities. For Wi-Fi communication, you might consider setting up a simple web server on the ESP32 to serve the tire pressure data. If using a display unit, write code to display the tire pressure data. This could be an LCD display connected to the ESP32. Test the system by deploying it on a vehicle and monitoring the tire pressure readings. Calibrate the system if necessary to ensure accurate pressure readings. Ensure that the system does not interfere with the normal operation of the vehicle. Implement safety features to handle any failures or errors gracefully. Document the system, including the hardware and software components, wiring diagrams, and any calibration procedures.

RESULTS AND ANALYSIS




12:19
192.168.204.59
ESP32 Temp & Pressure Server
Temperature 26.00 Â°C
Pressure 100546.00 Pa

CHAPTER 05

CONCLUSION

In conclusion, the tire pressure monitoring system presented here, incorporating the BMP180 pressure sensor, ESP32 microcontroller, and LED display, offers a robust solution for real-time monitoring of tire conditions. By accurately measuring pressure and temperature within the tire, the system provides users with immediate feedback through a wireless connection to the LED display. The implementation of an alert mechanism ensures timely detection and notification in the event of a tire leak, contributing to enhanced safety and preventive maintenance. The integration of such technology into vehicles aligns with the broader goal of improving road safety and reducing the risks associated with underinflated or damaged tires.

FUTURE WORK

Moving forward, there are several avenues for future work and improvement in this tire pressure monitoring project. One potential focus is the exploration of additional sensor functionalities, such as incorporating accelerometers or tread wear sensors to provide a more comprehensive view of tire health. Enhancements in communication protocols could be pursued to enable integration with mobile applications for remote monitoring and alerts. Moreover, the integration of machine learning algorithms could further refine predictive maintenance capabilities, allowing the system to adapt and improve its accuracy over time. Additionally, efforts could be directed toward optimizing power consumption, exploring energy-efficient components, and possibly investigating alternative power sources beyond the solar-powered sensors. Continuous research and development in these areas will contribute to the evolution of tire pressure monitoring systems, ensuring they remain at the forefront of automotive safety technology.

APPENDICES

```
#include <Wire.h>
#include <Adafruit_BMP085.h>
#include <WiFi.h>
#include <WiFiClient.h>
#include <WebServer.h>
#include <ESPmDNS.h>
#include <LiquidCrystal_I2C.h>
#include <WiFiMulti.h>
Adafruit_BMP085 bmp;
#define ssid1 "XS"
#define password1 "123456789"
WiFiMulti wifiMulti;
#define echoPin 2
#define trigPin 4
long temperature, pressure;
int i = 1;
LiquidCrystal_I2C lcd(0x27, 16, 2);
WebServer server(80);
void handleRoot() {
char msg[1500];
float temp = readTemperature();
float press = readPressure();
```

```
snprintf(msg, 1500,
"<html>\
<head>\
<meta http-equiv='refresh' content='5'/>\
<meta name='viewport'content='width=device-width,initial-
scale=1'>\
<script src='https://kit.fontawesome.com/3e6ef2b5ef.js'
crossorigin='anonymous'></script>\ <title>ESP32 Distance
Server</title>\
<style>\
html { font-family: Arial; display: inline-block; margin: 0px
auto; text-align: center;}\ body {background: #FFF7D4;}\
h2 { font-size: 3.0rem; }\
p { font-size: 3.0rem; }\
.units { font-size: 1.2rem; }\
.dht-labels{ font-size: 1.5rem; vertical-align:middle;
padding-bottom: 15px;}\
</style>\
</head>\
<body>\
<h2>ESP32 Tire pressure sensor</h2>\
<p>\
<i class='fa-solid fa-temperature-three-quarters'></i>\
<span class='dht-labels'>Temperature</span>\
<span>%.2f</span>\
<span class='units'> °C</span>\
</p>\
<p>\
```

```
<i class='fa-solid fa-p'></i>\
<span class='dht-labels'>Pressure</span>\
<span>%.2f</span>\
<span class='units'> Pa</span>\
</p>\
</body>\
</html>",
temp, press
);
server.send(200, "text/html", msg);
}
void setup(void) {
Serial.begin(9600);
lcd.init();
lcd.backlight();
lcd.clear();
pinMode(trigPin, OUTPUT);
pinMode(echoPin, INPUT);
if (!bmp.begin()) {
Serial.println("Could not find a valid BMP180 sensor, check
wiring!"); while (1);
}
WiFi.mode(WIFI_STA);
wifiMulti.addAP(ssid1, password1);
Serial.println("Connecting to WiFi");
lcd.setCursor(0, 0);
lcd.print("Connecting...");
```

```
// Wait for connection
while (wifiMulti.run() != WL_CONNECTED) {
Serial.print(".");
lcd.setCursor(0, 1);
lcd.print("Attempt " + String(i));
i += 1;
delay(500);
}

// Reset attempt counter
i = 1;
lcd.clear();
Serial.println("Connected to WiFi");
Serial.print("IP address: ");
Serial.println(WiFi.localIP());
lcd.setCursor(0, 0);
lcd.print(WiFi.SSID().c_str());
```

```
lcd.setCursor(0, 1);
lcd.print(WiFi.localIP());
if (MDNS.begin("esp32")) {
Serial.println("MDNS responder started");
}
server.on("/", handleRoot);
server.begin();
Serial.println("HTTP server started");
}
    void loop(void) {
    server.handleClient();
    // delay(2); // You might not need a delay here
    }
    float readTemperature() {
    temperature = bmp.readTemperature();
    return temperature;
    }
    float readPressure() {
    pressure = bmp.readPressure();
    return pressure;
    }
```

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