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Tire Pressure Monitoring System with ESP8266 and HX710B Sensor

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CERTIFICATE

This is to certify that Mini Project entitled

Tire Pressure Monitoring System with ESP8266 and HX710B Sensor

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The project allowed us to express our creativity. It provided us a sense of purpose and fulfillment by enhancing our problem- solving skills, as we encountered challenges and find solutions.

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ABSTRACT

Maintaining optimal tire pressure is essential for vehicle safety, fuel efficiency, and tire longevity. This project develops a Tire Pressure Monitoring System (TPMS) using the ESP8266 microcontroller and HX710B pressure sensor to monitor tire pressure in two-wheelers. The system displays real-time pressure data on an LCD screen and a web-based dashboard, allowing users to track tire conditions remotely.

The setup involves interfacing the HX710B sensor with the ESP8266 to read and display pressure values while triggering alerts for abnormal levels. This report outlines the hardware connections, working principles, and applications of the system, emphasizing its benefits in enhancing safety, improving efficiency, and preventing tirerelated issues.

1.1 INTRODUCTION

The project aims to develop a compact and efficient Tire Pressure Monitoring System (TPMS) for two-wheeler vehicles. Maintaining proper tire pressure is crucial for safety, performance, and fuel efficiency, and this system provides a convenient and real-time monitoring solution using readily available components.

In modern digital bikes, integrating a tire pressure monitoring system has become increasingly important to enhance rider safety and vehicle efficiency. Traditional methods of manually checking tire pressure can be inconvenient and do not provide real-time updates while riding. Digital TPMS addresses these limitations by offering continuous monitoring and instant alerts for abnormal pressure levels.

Digital tire pressure monitoring systems utilize sensors to measure tire pressure and transmit this data to a central display unit or dashboard. This allows riders to monitor pressure in real-time and take prompt corrective actions, ensuring better vehicle performance and reducing the risk of tirerelated issues.

1.2 Need/Purpose of the project

Maintaining the correct tire pressure in vehicles, especially in two-wheelers, is essential for safety, performance, and fuel efficiency. However, most two-wheeler riders still rely on manual pressure checks, which are not only time-consuming but also often inaccurate and infrequent. This lack of regular monitoring can lead to several critical issues, including:

- Reduced Road Safety: Under-inflated or over-inflated tires can cause poor grip on roads, reduced braking performance, and instability while turning, leading to a higher risk of accidents.
- Poor Fuel Economy: Incorrect tire pressure increases rolling resistance, resulting in inefficient fuel consumption and higher operational costs for daily commuters.
- Uneven Tire Wear: Inconsistent tire pressure causes abnormal tread wear, shortening the tire lifespan and increasing maintenance costs.
- Delayed Detection of Leaks or Punctures: Without real-time monitoring, slow leaks or punctures often go unnoticed until they lead to sudden tire failure.

Despite the importance of maintaining proper tire pressure, most two-wheelers do not come equipped with Tire Pressure Monitoring Systems (TPMS). While such systems are increasingly found in four-wheelers and premium vehicles, affordable and compact TPMS solutions for twowheelers are limited or non-existent in the consumer market.

2.1 Literature Survey

To understand the scope and challenges of developing a real-time Tire Pressure Monitoring System (TPMS), a review of existing research was conducted. One significant study that closely aligns with the goals of this project is detailed below:

Title: *Design and Development of IoT-Based Tire Pressure Monitoring System*

Authors: K. M. Prasad, R. Bhargav, M. G. Reddy
Published in: *International Journal of Engineering Research & Technology (IJERT)*, Vol. 9, Issue 7, July 2020
Link: https://www.ijert.org/research/design-and-development-of-iot-based-tire-pressuremonitoring-system-IJERTV9IS070384.pdf

Summary of the Paper:

The research focuses on designing a low-cost IoT-based TPMS using an ESP32 microcontroller, analog pressure sensors, and Wi-Fi connectivity. The system measures tire pressure and transmits the data to a mobile application, which displays real-time readings and sends alerts for under- or over-inflation. The proposed system enhances road safety and tire life through proactive monitoring.

Relevance to Current Project:

This paper provides a foundational understanding of how microcontrollers like ESP32 (similar to ESP8266) can be used in tire pressure monitoring systems. It also validates the feasibility of using wireless communication for real-time pressure data transmission. However, this project aims to simplify the approach by targeting two-wheelers, using a smaller, more compact sensor (HX710B), and displaying readings on a built-in LCD and web dashboard, without the need for a separate mobile app.

2.2 Problem Statement

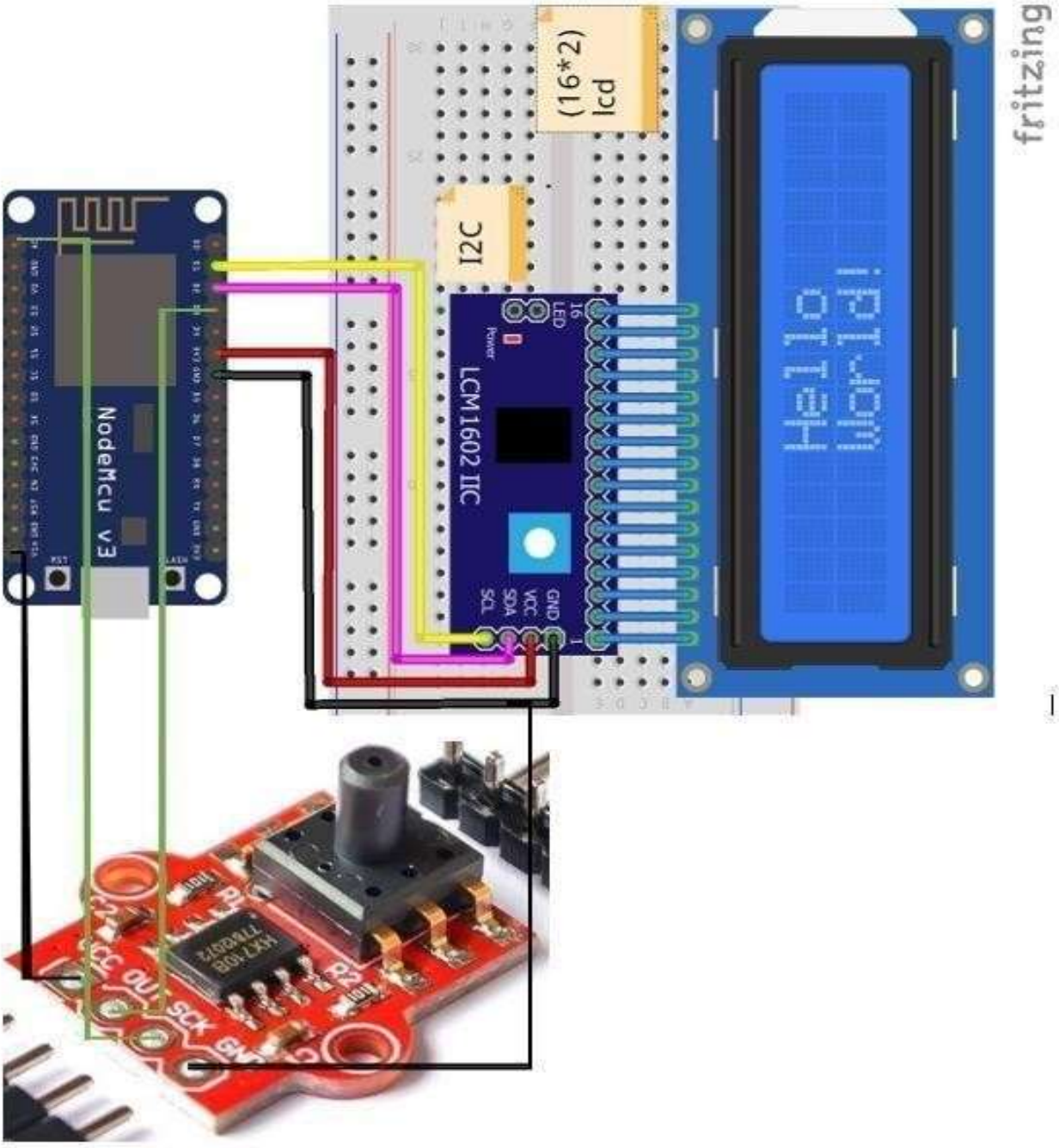
To design and develop a **real-time tire pressure monitoring system** for two-wheelers using an **HX710B pressure sensor** and **ESP8266**, capable of detecting pressure variations and displaying alerts via **LCD and web dashboard**, thereby enhancing safety and maintenance.

2.3 Objectives

- Monitor tire pressure in **real-time**.
- Display pressure readings on **LCD** and **web dashboard**.
- Generate **alerts** for under/over-inflation.
- Use **low-cost components** to keep the system affordable.
- Ensure easy integration with existing two-wheeler systems.

3.1 System Description

- **Circuit Diagram**



3.2 Working Principle of the Project

The Tire Pressure Monitoring System (TPMS) is designed to continuously measure and display real-time tire pressure using the HX710B pressure sensor and ESP8266 microcontroller. The system operates based on the principle of strain gauge measurement, where pressure-induced strain leads to variations in electrical resistance. These variations are converted into a digital signal, processed by the ESP8266, and displayed on an LCD screen.

The working principle of the project consists of the following steps:

1. Pressure Sensing with HX710B Sensor

- The HX710B is a strain gauge-based pressure sensor that detects variations in pressure applied to its surface.
- As pressure changes, the strain gauge undergoes deformation, causing a proportional change in its electrical resistance.
- This change is converted into an analog electrical signal, representing the current tire pressure.

2. Interfacing with ESP8266 Microcontroller

- The ESP8266 microcontroller is programmed to interface with theHX710B sensor for data acquisition and processing.
- It communicates with the sensor using digital pins (DT_pin and SCK_pin) for data transmission.
- The ESP8266 reads pressure data by toggling the clock (SCK) pin, collecting a 24bit digital output from the sensor.

3. Data Processing

- The ESP8266 microcontroller receives the 24-bit digital signal from the HX710B sensor.
- It processes the signal to reconstruct the pressure value using an internal algorithm.
- The measured pressure is then formatted for display.

4. Displaying on LCD

- The ESP8266 sends the processed pressure value to an LCD (Liquid Crystal Display) for real-time visualization.
- The LCD is initialized and controlled using the Liquid Crystal I2C library, ensuring efficient data transmission.
- The pressure readings are updated on the screen at regular intervals.

5. Continuous Monitoring

- The microcontroller runs a continuous loop (loop() function) to repeatedly measure and update the tire pressure readings.
- Data is refreshed at regular intervals (e.g., every second) to provide real-time feedback.
- If an abnormal pressure level is detected, alerts can be triggered to notify the user.

4. WORKING OF COMPONENTS

The project is designed to implement a tire pressure monitoring system using an HX710B pressure sensor and an ESP8266 microcontroller, with output displayed on an LCD screen. Let's break down how each component works within this setup:

1. **HX710B Pressure Sensor:**

- **Principle**: The HX710B is a loadcell amplifier that interfaces with strain gauge-based sensors like the pressure sensor used in this project.

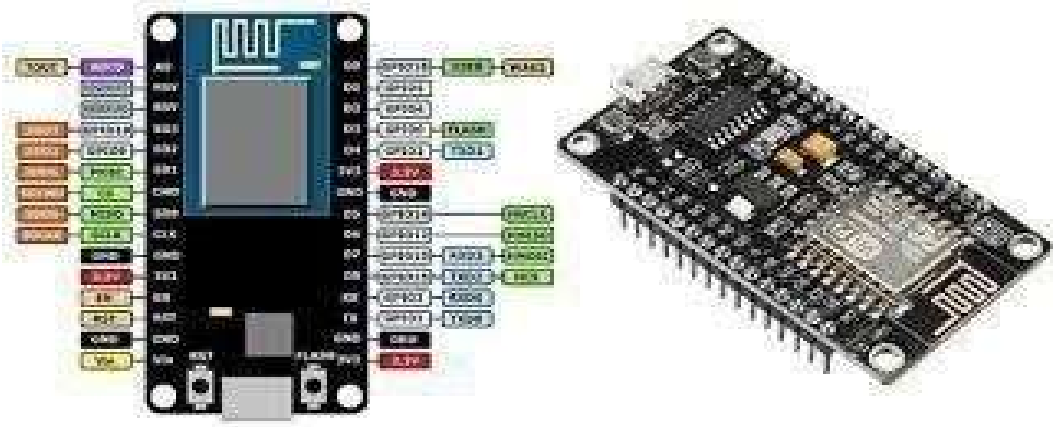
- **Connection**: The sensor's DT (Data) pin is connected to a digital input pin (D2) on the ESP8266 for reading data, while the SCK (Clock) pin is connected to a digital output pin (D3) for clocking data bits out of the sensor.

- **Data Acquisition**: The sensor outputs digital data representing the pressure reading through the DT pin, which the ESP8266 reads using a clocked serial communication method.

2. **ESP8266 Microcontroller:**

- **Initialization**: The ESP8266 is initialized in the `setup()` function configure pin modes and set up the LCD display.

- **Data Reading:** In the `loop()` function, the ESP8266 reads data from the HX710B sensor by toggling the SCK pin to clock in 24 bits of digital data from the DT pin.



- **Data Processing**: Each bit read is sequentially combined to form a 24-bit digital word, representing the pressure reading from the sensor.

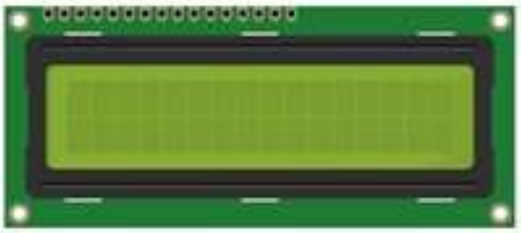
- **Error Handling**: The code checks if the reading is valid (non- negative) and proceeds to display the pressure value on the LCD.

3. **LCD Display (I2C):**

- **Initialization:** The LCD is initialized using the `LiquidCrystal_I2C` library, which communicates with the LCD screen over the I2C (Inter-Integrated Circuit) protocol.

- **Output:** Once the pressure reading is obtained from the sensor, the ESP8266 sends commands to the LCD to display the pressure value in a specific format (e.g., "Pressure: xxx units").

- **Update Rate:** The LCD display is updated every second (`delay(1000)`) to provide a continuous real-time view of the tire pressure.



4. **Data Flow:**

- The ESP8266 controls the HX710B sensor to collect pressure data.
- Digital data bits are sequentially read and assembled to form the pressure reading.

- The ESP8266 processes this reading and sends formatted data to the LCD for visual representation.
- In summary, the code orchestrates the interaction between the HX710B pressure sensor, ESP8266 microcontroller, and LCD display to create a functional tire pressure monitoring system. The ESP8266 acts as the central processor, handling data acquisition from the sensor and displaying the results on the LCD screen in a user-friendly format for monitoring tire pressure in real-time.
- HX710B pressure sensor detects changes in pressure applied to it and outputs corresponding electrical signals. These signals are read by the ESP8266 microcontroller, which processes the data and sends it to the LCD display.

5.ADVANTAGES

1. **Real-Time Monitoring:**
   The system continuously monitors tire pressure and provides live readings on both the **LCD screen** and a **web dashboard**, ensuring that riders are always aware of the current tire condition.

2. **Enhanced Safety:**
   By detecting underinflation or overinflation, the system **prevents accidents** caused by improper tire pressure, especially in high-speed or rough terrain conditions.

3. **Cost-Effective:**
   Utilizes **low-cost components** like the ESP8266 and HX710B sensor, making it an **affordable alternative** to commercial TPMS, especially for two-wheeler applications.

4. **Improved Fuel Efficiency and Tire Life:**
   Maintaining optimal tire pressure helps reduce rolling resistance, resulting in **better mileage** and **longer tire durability**.

5. **Wireless Connectivity:**
   The built-in **Wi-Fi functionality** of the ESP8266 allows remote access and monitoring through a simple web interface without the need for additional hardware.

6. **Compact and Easy to Install:**
   The system is designed to be **lightweight and minimal**, making it suitable for installation on two-wheelers without significant modifications.

DISADVANTAGES

1. **Sensor Calibration Required:**
   The HX710B pressure sensor needs **periodic calibration** to ensure accuracy, especially when used in different environmental conditions.

2. **Power Dependency:**
   The system requires a **continuous power supply**, typically from a battery or vehicle source. Power failure may lead to data inaccessibility.

3. **Environmental Sensitivity:**
   Since the sensor is exposed to outdoor conditions, it requires **weatherproof housing** to protect against dust, water, and temperature changes.

4. **Limited Range Without Internet:**
   Without internet access or router support, **web dashboard monitoring** may not be available, limiting remote access capabilities.

5. **Single Tire Monitoring (Prototype Stage):**
   The current design typically monitors **one tire**. Expansion to multiple tires requires additional sensors and processing logic.

APPLICATIONS

Enhanced Safety: Proper tire pressure is crucial for maintaining optimal traction, handling, and stability. Digital monitoring helps prevent issues like underinflation or overinflation, reducing the risk of accidents caused by tire-related failures.

Improved Performance: Maintaining the correct tire pressure ensures better fuel efficiency and longer tire life. With real-time monitoring, riders can optimize performance and improve fuel economy.

Convenience: Digital pressure monitoring eliminates the need for manual checks with pressure gauges. Riders can instantly view tire pressure data on the dashboard display, making it quick and hassle-free.

Early Issue Detection: The system can detect gradual pressure drops, indicating potential leaks or punctures before they become severe. This early warning system allows riders to take preventive action and avoid unexpected breakdowns.

User-Friendly Interface: Modern digital bike displays provide an intuitive interface that integrates tire pressure readings seamlessly with other information such as speed, RPM, and trip details, ensuring easy navigation.

6.1 CONCLUSION

The Tire Pressure Monitoring System (TPMS) using the ESP8266 and HX710B sensor provides an efficient solution for real-time tire pressure monitoring in two-wheelers. By integrating digital sensing technology, the system enhances safety, performance, and convenience while eliminating the need for manual pressure checks.

The project successfully detects pressure variations, processes data, and displays real-time readings on an LCD and web dashboard. Its continuous monitoring helps prevent issues like underinflation, overinflation, and leaks, ensuring better fuel efficiency, extended tire life, and improved vehicle stability.

Overall, this system offers a smart and reliable approach to tire pressure management, making it a valuable addition to modern digital bikes and IoTbased vehicle systems.

6.2 FUTURE SCOPE

The current TPMS prototype offers basic real-time monitoring for a single tire, but it holds strong potential for future development:

- Mobile App Integration: Connecting with smartphones via Wi-Fi or Bluetooth for remote monitoring and alerts.
- Multi-Tire Support: Expanding the system to monitor both front and rear tires simultaneously.
- Predictive Maintenance: Using AI to detect slow leaks or pressure patterns for early issue detection.
- GSM/GPS Integration: Sending SMS alerts and tracking location in case of emergencies.
- Solar/Battery Optimization: Enhancing power efficiency for longer, independent operation.
- Smart Dashboard Integration: Embedding the system into modern digital vehicle dashboards.

These enhancements can transform the project into a commercially viable solution for twowheeler safety and smart vehicle systems.

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