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"ULTRASONIC BASED IOT FUEL LEVEL INDICATOR"

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ABSTRACT

This project presents the design and implementation of an Ultrasonic-Based IoT Fuel Level Indicator powered entirely by solar energy. The system is developed to monitor the fuel level inside a storage tank using the HC-SR04 ultrasonic sensor, with real-time readings displayed locally on a 16×2 I2C LCD and remotely on an IoT-based webpage through the ESP8266 (Node MCU) microcontroller. By integrating wireless connectivity with renewable energy, the project offers a sustainable, low-cost, and maintenance-free solution for liquid level monitoring. The working principle relies on ultrasonic wave reflection, where the sensor measures the distance between the fuel surface and the sensor position. The ESP8266 processes this data to calculate the fuel level and transmits it via Wi-Fi for remote accessibility. A dedicated solar power system, consisting of a 6V solar panel, dual 3.7V Li-ion cells in series, a boost MPPT solar charge controller, and a DC-DC buck converter, ensures uninterrupted operation even in remote or off-grid environments. The prototype demonstrates reliable performance in monitoring fuel levels, with potential scalability for water tanks, generators, and industrial liquid storage systems.

Keywords: *MPPT, LCD, Wi-Fi, fuel level*

I. INTRODUCTION

Accurate and reliable monitoring of fuel levels is a persistent challenge across critical sectors such as logistics, industrial storage, and automotive fleet management. Current reliance on mechanical float gauges and manual inspections poses several significant drawbacks: low accuracy, the likelihood of frequent human error, and the failure to provide continuous, real-time data. These limitations often result in unexpected operational halts, inefficient refueling schedules, and revenue loss due to poor inventory management. This project directly addresses these issues by developing an Ultrasonic-Based IoT Fuel Level Indicator. Our solution is centered on utilizing an ultrasonic sensor to precisely measure the distance from the sensor to the fuel surface. This non-contact method delivers accurate, real-time volume data regardless of the tank's shape or the type of fuel. The measured data is immediately uploaded to a cloud platform via the Internet of Things (IoT) framework. This allows end-users to remotely track consumption patterns, receive low-level alerts, and optimize refueling schedules through a simple web or mobile interface. Furthermore, in a crucial consumer context, the system's high-precision volume data empowers vehicle owners to independently verify the exact amount of fuel dispensed.at petrol pumps, providing a direct check against metering errors or short-selling.

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Fig. 1. Ultrasonic Based Fuel Level Indicator

II. LITERATURE REVIEW

Fluid level sensing literature primarily focuses on two main categories: contact-based and non-contact methods. Traditional contact systems, such as mechanical float gauges and hydrostatic pressure sensors, are widely used but consistently present challenges related to mechanical wear, corrosion, and limited accuracy, especially in irregularly shaped tanks. This review highlights the critical move toward non-contact solutions, with ultrasonic sensing technology emerging as a superior alternative. Studies confirm that ultrasonic transducers provide high precision by calculating the time-of-flight of sound waves to the fuel surface, ensuring reliable readings that are unaffected by the fluid's chemical composition, temperature fluctuations, or tank wall material.

Concurrently, the rise of the Internet of Things (IoT) has fundamentally transformed data monitoring. Previous research demonstrates the efficacy of integrating embedded systems (like ESP32 and Arduino) with cloud platforms (such as Firebase or Thing Speak) to enable real-time remote access, automated reporting, and proactive low-level alerting, which is essential for optimized logistics. However, a significant gap remains in the focused development of a high-accuracy, cost-effective ultrasonic solution specifically tailored for verifying dispensed quantities—a consumer need—rather than just large-scale inventory.

Our project, therefore, synthesizes established ultrasonic measurement principles with a robust, scalable IoT architecture, while dedicating core efforts to developing a precise calibration methodology to ensure the verifiable accuracy required for both consumer trust and resource management efficiency Fuel monitoring and management have attracted considerable research interest in recent years due to increasing concerns over fuel theft, wastage, and inefficient manual monitoring methods. Various technological approaches such as GSM, GPS, and IoT have been explored to improve the accuracy and reliability of fuel level measurement systems. However, many of these existing solutions face limitations related to power consumption, lack of automation, and the absence of real-time theft detection features.

Sharma et al. (2019) developed an Internet of Things (IoT)-based fuel monitoring system utilizing an Arduino microcontroller and GSM module. The system could send fuel level information through SMS alerts, allowing users to remotely monitor fuel status. Despite this advantage, the absence of a real-time cloud interface and

renewable power source limited its efficiency and long-term sustainability.[1]

Patil and Kulkarni (2020) proposed an ultrasonic sensor-based liquid level detection system primarily designed for water tanks. The system achieved precise level measurement using ultrasonic wave reflection techniques. Nevertheless, the design lacked features for continuous data monitoring and theft detection, making it unsuitable for critical applications such as fuel management.[2]

Gupta et al. (2021) introduced a solar-powered IoT water level monitoring system that demonstrated the potential of renewable energy in achieving energy-efficient monitoring solutions. The study emphasized the benefits of solar integration in maintaining continuous operation without reliance on grid power. However, this work was confined to

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water level detection and did not address the specific challenges of measuring and managing fuel, such as safety precautions and rapid level changes due to theft or leakage.[3]

Mehta et al. (2022) designed a smart fuel theft detection system based on the ESP8266 microcontroller with IoT-based cloud connectivity. The system could successfully identify sudden drops in fuel levels and alert the user, thereb y addressing one of the key issues in fuel management. Nonetheless, the project relied on conventional electrical power, limiting its deployment in remote or off-grid locations.[4]

"In the paper titled **"ULTRASONIC BASED IoT FUEL LEVEL INDICATOR"** using IoT,' the authors propose a solution for detecting fuel levels and preventing fuel theft. The system stores fuel data in a Firebase database and sends it to a dedicated Android app designed for fuel monitoring.

III. EXPERIMENTATION

After completing the design and development phase, the prototype of the proposed Ultrasonic-Based IoT Fuel Level Indicator was constructed and tested in a controlled laboratory environment. The purpose of this testing was to verify the working, accuracy, and reliability of the system under practical conditions.

The experimental setup consisted of several major components. The ESP8266 (NodeMCU) microcontroller served as the core control unit, handling both data processing and Wi-Fi communication. The HC-SR04 ultrasonic sensor was used to measure the level of fuel inside the tank without making any physical contact with the liquid. The measured readings were displayed in real time on a 16×2 LCD display, allowing easy observation of the fuel level at the testing site. To ensure the system was energy-efficient and self-sustained, a 5V, 1A solar panel was used as the main power source. A rechargeable lithium-ion battery (3.7V/5V) was connected to provide backup power during low sunlight conditions, ensuring continuous operation.

For safety during testing, petrol or diesel was used, as it possesses

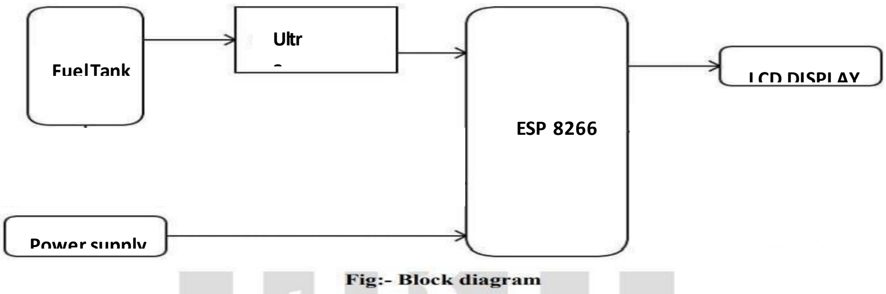

Fig. 2. Block Diagram

The experiments were conducted using a small plastic tank of about 40 cm in height, simulating a fuel tank.

In the setup, the ultrasonic sensor was fixed securely on the top cover of the tank. It was interfaced with the ESP8266 microcontroller, which processed the sensor's readings, converted the measured distance into a fuel level value, and transmitted this information to both the LCD display and the IoT cloud server. The entire circuit was powered through a regulated connection from the solar panel, ensuring safe and stable operation throughout the testing period.

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The research methodology outlines the systematic process followed for the design, development, and implementation of the proposed Ultrasonic-Based IoT Fuel Level Indicator system. The methodology involves multiple stages such as problem identification, system design, hardware selection, software development, testing, and performance evaluation.

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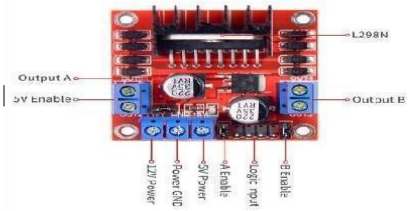
Components -



ESP 8226 Microcontroller   Ultrasonic Sensor   L298N Motor Driver

LCD Display   Push Button   Li-ion Battery

Programming: -

```
#include <ESP8266WiFi.h> #include <ESP8266WebServer.h> #include <Wire.h>
#include <LiquidCrystal_I2C.h> LiquidCrystal_I2C lcd(0x27, 16, 2);
// ===== CALIBRATION TABLE =====
// Add your actual measurements here: {distance_cm, actual_liters}
// Measure distance at 0L, 1L, 2L, 3L... and fill this table
const int CALIBRATION_POINTS = 11; // Adjust based on your tank capacity float calibrationTable[][2] = {
// {Distance(cm), Liters}
{16.0, 0.0},        // Empty tank - REPLACE WITH YOUR MEASUREMENT
{12.8, 1.0},        // 1 Liter - REPLACE WITH YOUR MEASUREMENT
{11.1, 2.0},        // 2 Liters - REPLACE WITH YOUR MEASUREMENT
{10.1, 3.0},        // 3 Liters - REPLACE WITH YOUR MEASUREMENT
{8.4, 4.0},         // 4 Liters - REPLACE WITH YOUR MEASUREMENT
{8.0, 5.0},         // 5 Liters
{7.0, 6.0},         // 6 Liters
{5.5, 7.0},         // 7 Liters
{4.0, 8.0},         // 8 Liters
{2.5, 9.0},         // 9 Liters{1.0, 10.0}    // Full tank (10L)lastMeasure = currentMillis;
// Measure and convert using calibration distanceCm = measureDistance();
```

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distanceCm = constrain(distanceCm, 0, MAX_TANK_HEIGHT); fuelLiters = distanceToLiters(distanceCm);

fuelChange = fuelLiters - previousFuelLiters; updateLEDs(fuelLiters);

// Theft Detection (only if fuel drops) if (fuelChange < -THEFT_THRESHOLD) {

theftDetected = true; showingAlert = true; alertStart = millis(); showTheftLCD(); shortBeep();

Serial.print("THEFT DETECTED! Lost: "); Serial.print(abs(fuelChange), 2); Serial.println(" L");

}

// Fuel Added Detection

else if (fuelChange > THEFT_THRESHOLD) { theftDetected = false;

showingAlert = true; alertStart = millis(); showFuelAddedLCD(); shortBeep();

Serial.print("Fuel Added: +"); Serial.print(fuelChange, 2); Serial.println(" L");

}

// After alert, return to normal display

if (showingAlert && (millis() - alertStart > ALERT_DURATION)) { showingAlert = false;

theftDetected = false; showNormalLCD();

}

// Normal display if no alert if (!showingAlert) {

showNormalLCD();

}

// Debug output Serial.print("Distance: "); Serial.print(distanceCm, 2); Serial.print(" cm | Fuel: "); Serial.print(fuelLiters, 2); Serial.print(" L | Change: "); Serial.println(fuelChange, 2);

previousFuelLiters = fuelLiters;}

IV. RESULTS AND DISCUSSION

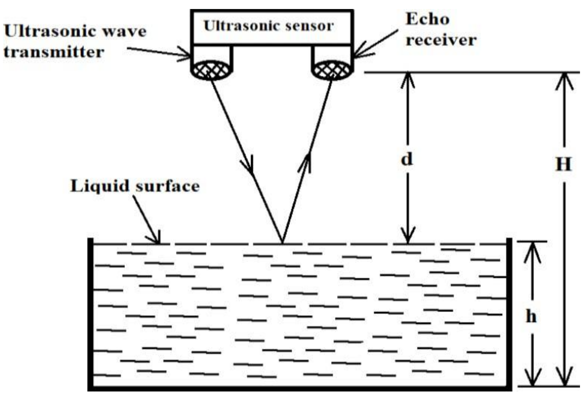

Fig. 3. Working Principle of the Ultrasonic Sensor-Based Liquid-Level Measurement System

Above figure shows working principle of ultrasonic sensor-based level measurement system

An ultrasonic wave transmitter is used in the ultrasonic sensor to send ultrasonic wave. Now after reflecting the reflected wave signal is received by the echo receiver of the ultrasonic sensor.

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If the ultrasonic sensor is placed at a height of' from the fuel surface then the distance travelled by the ultrasonic wave from the transmitter to the receiver is = 2d. Now if the time to travel the distance is 't' sec then in S.I. unit

$1 \times d = t \times 340$ __________(i)

[The speed of ultrasonic wave in air is 340 m/s]

Or, $d = (1/2) \times t \times 340$ ____(ii)

Now if the distance of ultrasonic sensor from the bottom surface of fuel container is 'H' then the level of fuel 'h' can be determined as,

$h = H - d$ _______________(iii)

This value of 'h' is continuously monitored by displaying it on a website using an ESP8266 NodeMCU. Let at time 't1' and 't2' the level heights are 'h1' and 'h2'the rate of change in level can be given as

$r = (h1 - h2) / (t1 - t2)$ ____(iv)

Now when the fuel is stolen, the value of 'r' is higher than at any other time. So, a threshold value can be set if the value of 'r' goes higher than that value a buzzer will be on and a message will be sent with the help of a GSM modem connected with the micro-controller. In case of fuel tracks, the level never remains fixed due to motion of the track equation (iv) is become

$r = |(h1 - h2)| / (t1 - t2)$ __(v)

While the track is to be emptied the system can be stopped manually.

V. CONCLUSION

The development of the Ultrasonic-Based IoT Fuel Level Indicator has provided a practical and efficient solution for modern fuel monitoring and management. Through this project, we successfully designed and implemented a system that can accurately measure the fuel level inside a tank, display it locally, and transmit the data to an IoT cloud platform for remote monitoring.

The use of the HC-SR04 ultrasonic sensor ensured non-contact measurement, which makes the system safe for use with fuels and other hazardous liquids. The ESP8266 microcontroller played a vital role in processing the sensor data and establishing Wi-Fi connectivity for real-time updates. The integration of a solar panel and rechargeable battery made the entire energy-independent and eco-friendly, allowing it to function even in areas without a stable power supply.

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