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Fuel Monitoring System

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Abstract: In recent times, there has been a significant increase in the number of vehicles, particularly those running on fuel. Unfortunately, the rising fuel prices have led to instances where some petrol pump owners attempt to deceive their customers. They manipulate the fuel data or display incorrect information when customers request fuel filling. To address this problem, we have developed a solution called the Smart Fuel Meter, which accurately measures the amount of fuel dispensed into the vehicle's tank and calculates the corresponding cost based on the current fuel price. The Smart Fuel Meter incorporates Internet of Things (IoT) technology, utilizing components such as the ESP12E and an embedded system to enable efficient fuel quantity measurement and fraud detection. To enhance user accessibility and transparency, we have also implemented a web-based interface that allows customers to view real-time data regarding the actual volume of fuel dispensed and the associated cost. This web application updates the fuel price regularly, ensuring accurate cost calculations based on the latest fuel prices.
Keywords: Internet of Things (IoT), ESP12E, Embedded System, Fuel meter, Fuel Fraud Detection.

I. INTRODUCTION

Nowadays, many vehicles are equipped with digital fuel meters. However, one significant drawback of this system is that it displays the fuel level using bars or symbols rather than showing the actual numeric value. Consequently, it becomes challenging to determine the exact amount of fuel present in the tank.

Moreover, fuel fraud and tampering often occur when consumers request a specific amount of fuel based on price (e.g., Rs 50 or Rs 100) rather than specifying the volume (e.g., 1 liter). Since fuel prices fluctuate daily, consumers often opt for convenient denominations. Unfortunately, this practice creates an opportunity for unscrupulous petrol pump owners to cheat customers by dispensing less fuel than what was paid for. Many consumers are unaware of this discrepancy, which allows pump owners to exploit the situation.

To address these issues and detect fuel fraud, we have developed an IoT-based smart fuel meter. This innovative meter accurately measures the volume of fuel dispensed and transmits the data to a custom Android app. The app, in turn, updates the fuel price on a daily basis and calculates the corresponding cost based on the latest price information. It also displays the quantity of fuel dispensed along with the cost, providing users with transparency and convenience.

In summary, the IoT-based smart fuel meter eliminates the ambiguity of bar-based fuel indicators by providing precise volume measurements. By integrating with an Android app, the system ensures regular price updates and empowers users to monitor fuel expenses effectively.

II. LITERATURE REVIEW

"In the paper titled 'Real-Time Fuel Monitoring and Theft Detection System 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 [1]. Shivashankar.S mentions the use of a flow sensor and an ultrasonic sensor to calculate fuel levels and detect potential accidents during travel [2]. Sayali A. Gayakwad describes a system called 'Fuel Level Indication and Mileage Calculation using IoT,' which utilizes an ultrasonic sensor and a YFS201 flow sensor to calculate fuel level and flow. The data is then displayed on a Blynk app [3]. Another paper titled 'Vehicle Fuel Theft Detection and Monitoring System' discusses a system that detects fuel theft using an ultrasonic sensor. When fuel theft occurs, the system generates alerts and sends a message to the registered phone number of the vehicle owner [4]. A paper titled 'Fuel Theft Detection Location Tracing using Internet of Things' presents a system that detects fuel fraud and theft, displays fuel level on a screen, and plots graphs on a mobile application [5]. The 'IoT Based Smart Fuel Monitoring System' utilizes an ATmega16 IC and an ESP8266 chip to send fuel volume data to a server, which is then displayed on an Android app [6]. Microcontroller-based systems have been designed for real-time fuel monitoring, where the level sensor transmits data over Bluetooth or WiFi to web or smartphone applications [7] [8] [12] [15] [16] [17].

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The paper 'Model Based Design of Digital Fuel Indication System' proposes a system that calculates fuel level using an ultrasonic sensor and displays the value on a 16x2 LCD display [9]. In the 'Fuel Theft Detection System,' based on a PIC 16F877A microcontroller, an IR sensor detects changes in fuel level and generates a sound from a buzzer [10]. The 'IoT based Smart Vehicles for Fuel Consumption' system incorporates a load cell, GPS module, and GSM module to calculate the weight of fuel and send the values to a database using the GSM module [11]. Installing additional sensors inside the fuel tank can pose challenges such as separate power supply and maintenance, as well as maintaining the minimum operating distance for accurate measurement [12]. In the 'Embedded System Based Intelligent Digital Fuel Gauge,' the system calculates the amount of fuel filled into the tank, displays it on an LCD, and sends a message to the registered mobile number of the consumer, including the amount, cost, location, and time of refueling [13]. The 'Digital Fuel Measuring System with Distance to Zero and Fuel Fraud Indicator' measures fuel levels using an ultrasonic sensor, allowing consumers to detect fuel fraud by comparing the actual fuel amount with the one displayed by the system [14]. Our project aims to digitize conventional fuel meters to display the fuel value digitally, such as 1 liter, 1.5 liters, 2 liters, and so on [18]."

III. COMPONENT

The Fuel Monitoring System comprises several components, namely sensors, a microcontroller, and a Wi-Fi module. Here's a breakdown of each element:

A. Microcontroller Arduino Uno

The Arduino Uno is a microcontroller board based on the ATmega328P. Arduino is a company that designs and sells circuit boards for microcontrollers, making them easy to use. They offer various Arduino boards with different functionalities for different applications. The Arduino Uno is a popular board that is economical and suitable for many projects. It can be used to control motors, cameras, lighting, or even build simple robotic systems. Arduino boards come with a programming language that allows users to configure the hardware easily. The Arduino Uno consists of two main microcontrollers. The first one is the ATmega328, which is the heart of the board. The second one is the ATmega16U2, which acts as a USB controller and allows the board to connect to a computer. The ATmega328 microcontroller operates at a frequency of 16MHz. Unlike the 8051 microcontroller, it doesn't have a fixed frequency level. It has an inbuilt RC phase shift oscillator that can generate frequencies ranging from 2MHz to 8MHz. The ATmega328 is an 8-bit microcontroller, meaning it can process 8 bits of data in a single clock pulse. It has built-in 32 kilobits of memory.

The ATmega328 features a voltage regulator and is a RISC (Reduced Instruction Set Computer) based microcontroller. It is known for its power efficiency and optimal set of instructions. The board includes various pins, including PWM outputs, I2C connectors, SPI ports, a power jack, an ICSP header, and a reset pin.

In summary, the Arduino Uno is a versatile microcontroller board that offers an easy-to-use platform for various projects. It is based on the ATmega328P microcontroller and comes with a range of pins and features that make it suitable for different applications.

Fig 1. Microcontroller Arduino Uno

B. ESP8266EX

The ESP8266EX by Espressif is a highly integrated Wi-Fi System-on-Chip (SoC) solution designed to meet the demands of the Internet of Things (IoT) industry. It offers efficient power usage, a compact design, and reliable performance. The ESP8266EX can function independently as a standalone application or as a slave to a host microcontroller (MCU).

When used as a standalone application, the ESP8266EX quickly boots up from the flash memory. It features an integrated high-speed cache, which enhances system performance and optimizes system memory usage. The ESP8266EX can also be utilized as a Wi-Fi adapter for any microcontroller design through interfaces like SPI/SDIO or UART.

The ESP8266EX incorporates various components into its design, including antenna switches, RF balun, power amplifier, low noise receive amplifier, filters, and power management modules. This integration results in a compact PCB size and reduces the need for external circuitry. In addition to Wi-Fi functionalities, the ESP8266EX features an enhanced version of Tensilica's L106 Diamond series 32-bit processor and on-chip SRAM. It offers GPIOs for interfacing with external sensors and devices.

To facilitate development, the ESP8266EX is supported by a Software Development Kit (SDK) that provides sample codes for various applications, enabling developers to utilize its capabilities effectively.

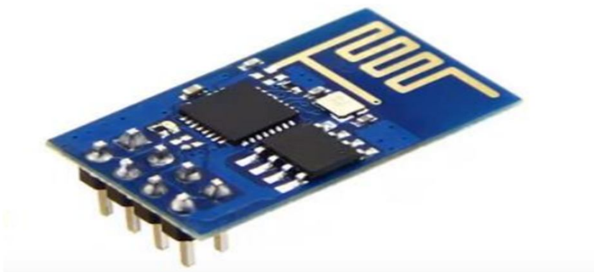

Fig 2 : Wifi Module ESP8266EX

C. HC-SR04 Ultrasonic Sensor

The HCSR04 is a commonly used component in robotics projects that utilizes ultrasonic sound to measure distances between itself and nearby solid objects. It consists of two ultrasonic transducers: one acts as a transmitter, and the other functions as a receiver. The transmitter emits a series of ultrasonic pulses, which are highly directional and not directly received by the receiver transducer.

When an electric pulse of high voltage is sent to the ultrasonic transducer, it vibrates within a specific range of frequencies, generating a burst wave of ultrasonic sound. When an obstacle is present in front of the ultrasonic sensor, these sound waves are reflected back, resulting in the production of an electric pulse. The time delay between the transmission and reception of the signal is then used to calculate the distance. A longer time delay indicates a greater distance, while a shorter time delay signifies a shorter distance.

Figure 3: Ultrasonic Sensor

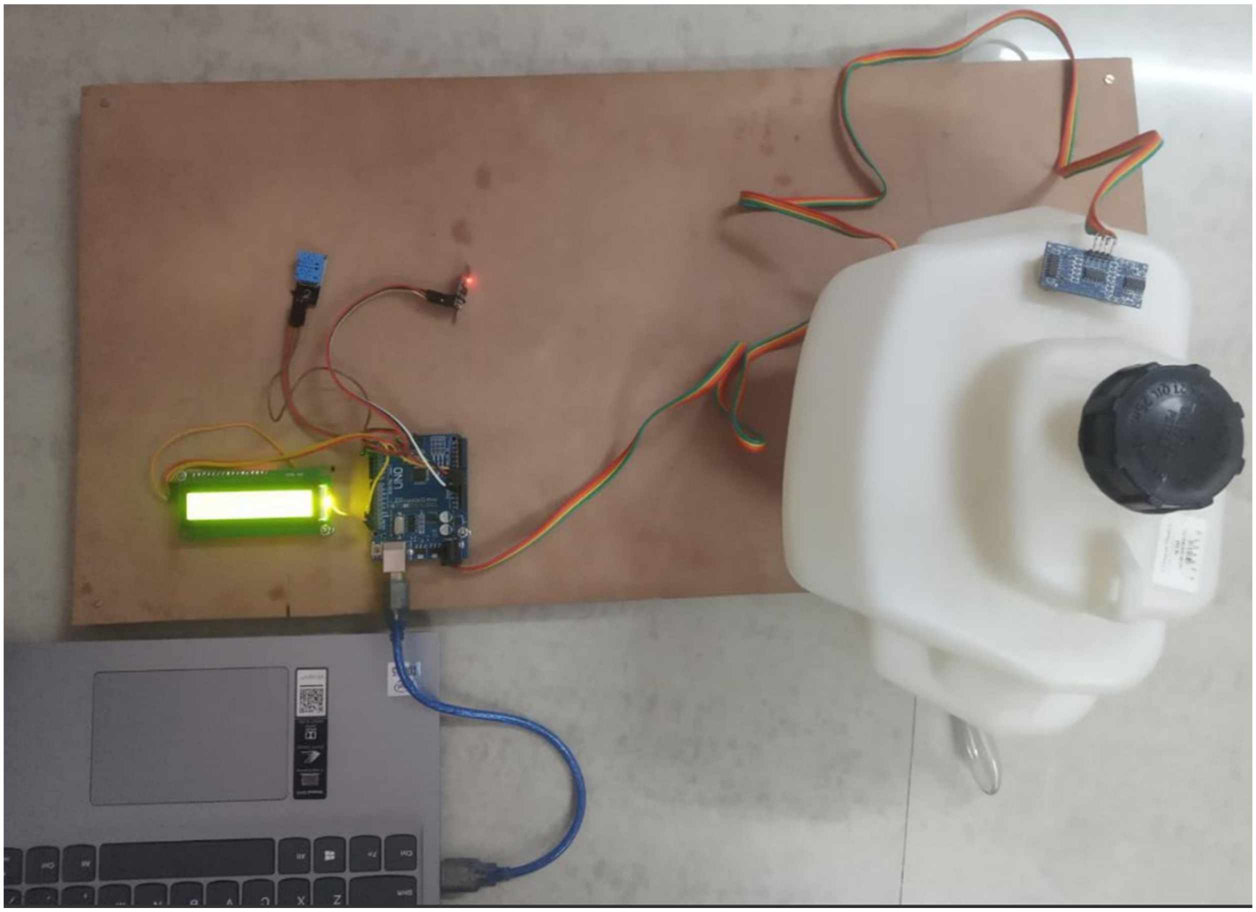

Fig.4: Physical Layout Component Set-up of the Proposed Model

IV. PROBLEM STATEMENT

The aim of this project is to develop a fuel monitoring system using an ultrasonic sensor. The system will accurately measure the fuel level in a tank and provide real-time monitoring and alerts. The current manual methods of monitoring fuel levels in tanks are time-consuming, prone to errors, and require frequent human intervention. Therefore, there is a need for an automated solution that can provide accurate and reliable fuel level monitoring.

The specific challenges to be addressed in this project include:

1. Accurate Fuel Level Measurement: Designing a system that can accurately measure the fuel level in a tank using an ultrasonic sensor. The system should be able to handle various tank shapes, sizes, and fuel types while providing precise measurements.
2. Real-time Monitoring: Developing a real-time monitoring system that continuously tracks the fuel level and provides timely updates. The monitoring system should be able to display the fuel level information in a user-friendly format, such as a digital display or a mobile application.

By addressing these challenges, the fuel monitoring system using an ultrasonic sensor will provide an efficient, accurate, and automated solution for monitoring fuel levels in tanks. This system will help businesses and organizations optimize their fuel management, reduce manual errors, prevent fuel shortages, and improve operational efficiency.

V. PROPOSED SYSTEM

Our project involves the conversion of an analog fuel detection meter into a digital display system. Instead of relying on a traditional analog meter, we utilize sensors to detect the fuel level. The detected fuel level is then used to calculate the mileage of the vehicle, which is displayed on an LCD screen. This digital display provides more accurate information to the user and helps prevent fuel theft.

VI. WORKING

The ultrasonic sensor is a key component of the fuel monitoring system, consisting of four pins: VCC, GND, Echo, and Trigger. The VCC pin is connected to the Arduino's 5V pin, the GND pin is connected to the Arduino's GND pin, and the Trigger and Echo pins are connected to the D7 and D6 pins on the Arduino, respectively.

To generate ultrasound, the Trigger pin is set to a high state, and the resulting sound waves are received by the Echo pin. In addition to the ultrasonic sensor, a GPS module is connected to the Arduino, featuring four pins: VCC, GND, Tx, and Rx. The VCC and GND pins are connected to the Arduino's 3.3V and GND pins, while the Rx and Tx pins are connected to the Arduino's D3 and D4 pins.

The fuel monitoring system using Arduino and IoT technology involves the following steps:

1) Hardware setup: Connect the ultrasonic sensor and GPS module to the Arduino board. The ultrasonic sensor measures the fuel level in the tank, while the GPS module provides location data. Additionally, connect a Wi-Fi module to enable internet connectivity.
2) Code implementation: Write the Arduino code to interface with the ultrasonic sensor, GPS module, and Wi-Fi module. Use appropriate libraries and functions to read the fuel level from the ultrasonic sensor and obtain GPS data. Send this information to the internet using the Wi-Fi module.
3) IoT platform integration: Choose an IoT platform such as Thingspeak or AWS IoT. Create an account and set up a channel on the platform. Configure the Wi-Fi module on the Arduino to send the fuel level and GPS data to the IoT platform.
4) Data visualization: Utilize the features provided by the IoT platform to visualize the received data. Create a dashboard on the platform to display the fuel level in the tank and the corresponding location information. Use visualization tools offered by the platform to generate graphs and charts representing the fuel level over time.

The Arduino-based fuel monitoring system, incorporating the ultrasonic sensor and IoT technology, offers an affordable and efficient solution for monitoring fuel levels. The system can be tailored to suit various applications and easily integrated with other IoT devices.

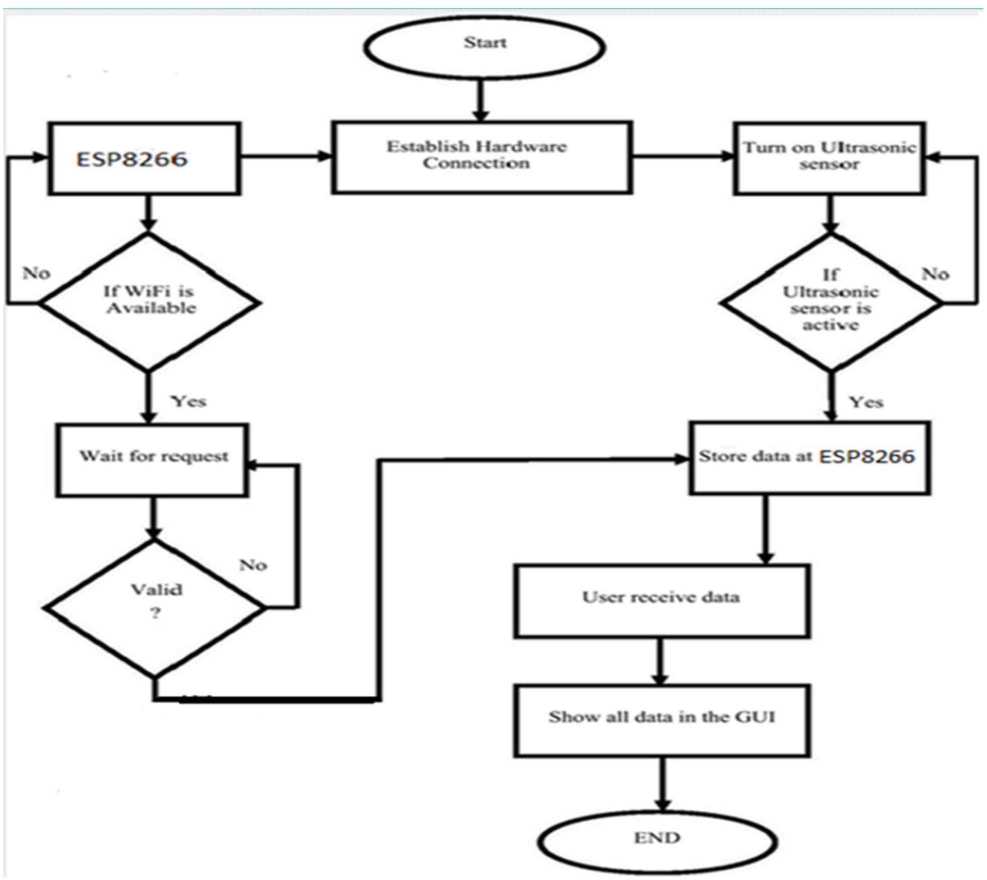

Figure. working flow diagram

VII. CONCLUSION

The Arduino-based fuel monitoring system utilizing an ultrasonic sensor and IoT technology offers a dependable and effective solution for fuel level monitoring in tanks. It enables real-time monitoring of fuel levels, remote access to data, and the capability to establish alerts for low fuel levels. By integrating IoT technology, data can be seamlessly transmitted to an IoT platform, enabling easy visualization and analysis. This system is adaptable to different applications and has the potential to significantly enhance fuel management in various industries.

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