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IoT Based Fuel Level Monitoring System for Curbing Business Theft

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ABSTRACT

The corruption tendencies of petrol filling stations' workers in the recent times challenged the potential of the ubiquitous and real-life applications of wireless technologies in businesses such as fuel stations. This work proposes a device that is capable of metering the underground tanks of filling stations and relay the readings through wireless technology in real time to the owner of the business anywhere in the world. The level of fuel in an underground tank in a filling station can be monitored wirelessly by a range finder HC-SR04 interfaced with an Arduino thereby replacing the mechanical and conventional practices that are prone to errors, theft and frauds common in this business places. This will help to curb vices perpetrated by the station attendants. The owner is kept abreast of the activities in the stations regardless of his location per time in the globe.

Keywords *:* underground tank, real-time application, microcontroller, wireless technology, station attendants

I. INTRODUCTION

Unquantified frauds are perpetrated by the workers of filling station when dispensing gasoline to the customers and when the underground tanks for fuel storage are to be refilled and gauge, thereby resulting to defrauding the customers and also cheating on the part of the owners of the filling stations. The measurements are falsified and inaccurate fuel level of fuel in the tank are always reported. Some attendants of the station sell and refill the tank without the knowledge of the owners [1,2]. The untold losses incurred by the business owner being a concern, challenged this research drive: an IoT based device capable of metering underground tank in real time and reporting the result wirelessly regardless of the location of the business owner is proposed. While the fuels dispenser is designed to meter the quantity of fuel being discharge per time, accurate record of the fuel level in the underground tanks are very crucial for the purpose of restocking and keep the business profitable and thriving. Some conventional methods of tracking the volume of fuel in the tank are Measuring Tape and Dipping methods. A measuring tape is inserted into the tank until its tip touches the

base of the tank, the level of the fuel is then read up by the level of wet part of the tape in comparison to an existing calibrating chat [3]. This method has a lot of limitations: gasoline gas being volatile makes it difficult to determine the wet part of the tape and also human error in reading up the wet part of the tape and when the tip of the tape actually touches the base of the tanks can be challenging [4,5,6].

This method is also prone to manipulation by the attendants who are quick to make illegal money at every available means. Fig 1 shows a petrol station attendant in operation using the measuring tape.

Fig 1: A Technician taking fuel measurement in underground tank with Measuring tape [6]

The other conventional method of gauging the fuel capacity level in the tank is the Dipping method shown in Fig 2, where a calibrated rod is inserted into the tank and the level is read up the rod[4]. This method is common in most of the petrol stations in Nigeria because it is simple to use and has a degree of accuracy, notwithstanding, there are some attended drawbacks with this method: This method is also liable to operator error and manipulation rate by the attendant is high when recording the figures, it is also cumbersome on the part of the operator while the business owner is

totally oblivious of the activities in the station when he is away.

Fig 2: Dipping Technique for Measuring the Fuel Level in Underground Tank [6]

In order to circumvent the challenges highlighted above and most importantly to keep the business owner abreast of the activities in the stations regardless of his location in the world, an IoT based digital meter for accurate real time measurement track of the fuel level in underground tank is proposed in this work. Also incorporated in this electronic device is the internet facility through which the readings taken can the uploaded to a database over the cloud. This will in turn help owners of filling stations to monitor their business from any part of the world. The loophole through which the station attendants are exploiting will be curbed and business will thrive.

II. RELATED WORK

A digital fuel level indicator for motor bikes using Arduino Microcontroller was proposed by [4]. The track record of the fuel entering the tank and the fuel present in the tank at any given time is sent for storage in the dynamic memory of the Arduino and displays on request by LCD. This device has application in the automobiles with a degree of precision. The device is capable of discovering petrol theft and help to equip the riders on a long trip. The level of accuracy while using this device is high and its cost effective on the business overall performance. [7] also reports a similar work on a digital fuel level indicator for motor bikes. They used magnetostrictive level sensor, a microcontroller and a liquid crystal display (LCD) unit to achieve the aim. The sensor determines the distance between the permanent magnet and the sensor head, while its analog output is fed into the MUC and the later uses mathematical analysis to compute the data value based on petrol level and tank dimension. The output of the programmed microcontroller is read out to give the height in meters and volume in litres via an LCD display. The design and implementation of of GSM Based Digital Fuel Meter and Fuel Theft Detection Using PIC Microcontroller was conducted in [8]. The track record of the quantity of fuel in the tank was achieved using digital approach. The device alarms whenever fuel theft is perpetrated and an SMS is also sent to the business owner reporting the theft in real time, this functionality being an advantage over the earlier work, this work is limited in that the level of fuel in the tank is not accounted for by the design. This method of monitoring fuel theft is not cost effective as fortunes may be spent on SMS, also instability in internet connection will truncate the reliability of the system, this is a serious drawback. [9] suggest in their work a load cell-based fuel measurement which gives exact level of fuel while fuel filling is in process and also in the travelling time. They used a transducer with strain gauge to construct a Fuel Measurement using LOADCELL that measures the weight of fuel tank based on the force applied and it has a bridge circuit to convert the change in resistance to electrical signals, the electrical signal is sent to MUC positioned at the base of the fuel tank. The estimation of the car speed as well as the mileage covered with the vehicle in relation to the available fuel can be monitored in case of hire and the report sent through GSM to the owner of the car for records. The location of the vehicle in real time can also be tracked by interfacing a GPS module with the MUC. Due to high cost of the load cells, this device is highly uneconomical especially in a developing country. Arduino Based Sensor for Fuel Tank Monitor was conducted in [1]. The device being a prototype is applicable in automobile industries where it can be used to determine the level of fluids using LED for the indication. Using discreet components for both sensing and indication places limitation on the accuracy and reliability of this device. [10] used MPX10 series devices called silicon piezoresistive pressure sensors to designed and implemented an Arduino Based Digital Fuel Gauge and Vehicle Monitoring SYSTEM. This device when placed at the base of the tank constantly keeps tracks of the level of fuel and send a digital numeric value to the display unit, these data are sent to the car owner through GPS and GSM. This device is effective but not applicable in existing underground tank due to difficulty in installation.

In this work, a 400mm maximum range, range finder HC-SR04 interfaced with an Arduino for the

non-mechanical measurement of the distance between the underground and the fuel content of the tank was developed. This effective, low cost homemade e-business cloud computing device was meant to curb theft in filling station by the station attendants by monitoring the fuel level in underground tanks of filling stations and wirelessly transmit the data in real time to the owner of the filling station regardless of his location.

III. SYSTEM DESIGN

The design and implementation of this IoT based smart metering device is in two parts: Hardware and software. The hardware consists of HC-SR04 ultrasonic range finder interfaced with a node microcontroller and a liquid crystal display is used to display the volume of the fuel.

A. Ultrasonic Sensor

Hcsr04 ultrasonic sensor which transmits ultrasound waves at 40,000Hz is composed of ultrasonic transmitter, ultrasonic receiver and a control circuit. A signal wave bounces back when there is an obstruction on the line of propagation, this is picked up by the receiver and report same to the control circuit of the Hscr04 ultrasonic. The round trip time between the sensor and the obstruction is calculated while the approximation of distance covered is determined. Two out of the four pins are power pins with 5V each for a positive output and the negative part is grounded, the remaining two pins are for trigger and echo. The component operates at 5V and 15mA power

Fig 3: Ultrasound range finder module [11]

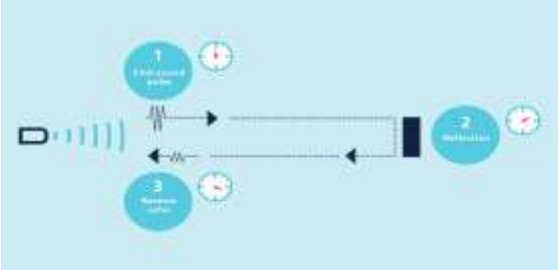

Fig 4: Ultrasound sensor in Operation.

Ultrasonic sensors when in operation emits low and high-frequency sound pulses at regular intervals, which propagates through the air at the velocity of sound. There is reflection of the sound wave in form of echo back to the sensor when encountered with obstruction on the propagation path[11].

B. Node MCU Board

Node MCU (Node MicroController Unit) built around a very inexpensive System-on-a-Chip (SOC) called the ESP8266 is used in this work .The ESP8266, designed and manufactured by Espressif Systems, contains all crucial elements of the modern computer: CPU, RAM, networking (wifi), and even a modern operating system and SDK and this feature make it useful for this research work [12].

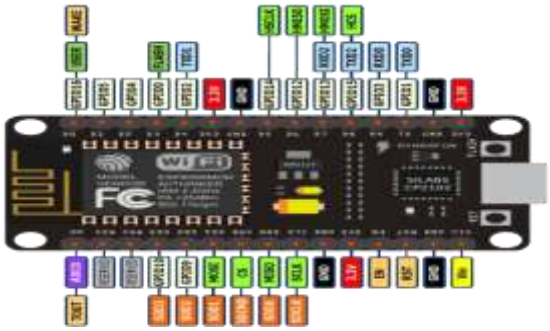

Fig 5: Node MCU module [12]

C. Liquid Crystal Display (LCD)

A liquid-crystal display (LCD) is a flat panel display or other electronically modulated optical device that uses the light-modulating properties of liquid crystals. Liquid crystals do not emit light directly, instead using a backlight or reflector to produce images in colour or monochrome. The LCD displays respond to the type of signal that is sent to it.

Fig 6: 16x2 Liquid Crystal Display.

IV. INTERFACE HC-SR04 WITH MCU

The ultrasonic range finder HC-SR04 is a 5V distance sensor breakout board (module), the trig and echo port can be connected to any digital pin of the Node MCU microcontroller but digital pin D1 and D2 are used for Trig and Echo connection as shown in Fig 7

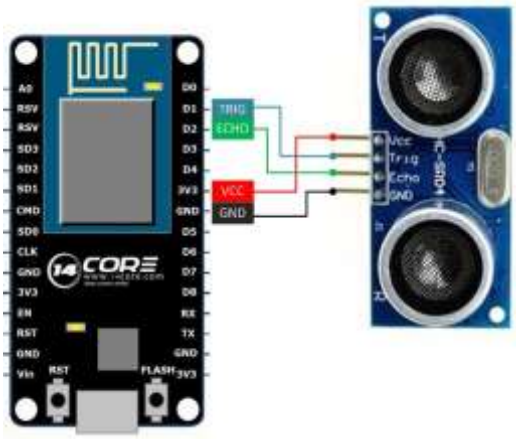

Fig 7: HC-SR04 interfaced with Node MCU

V. INTERFACE LIQUID CRYSTAL DISPLAY WITH NODE MCU

The SDA pin of the 16x2 i2c liquid crystal display is connected to pin D2 on the Node MCU and the SCL pin of the LCD is also connected to pin D1 on the Node MUC microcontroller wifi board as shown in Fig 8.

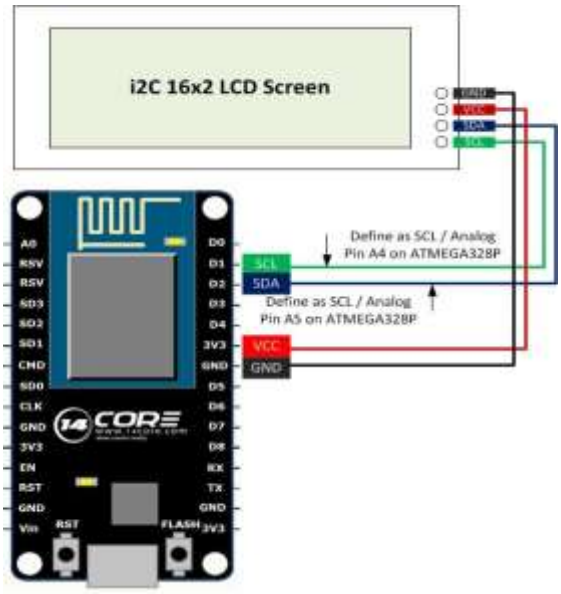

Fig 8: 16x2 i2c LCD interfaced with Node MCU

VI. DEVICE CONSTRUCTION

The Trigger pin of the HC-SR04 is used to trigger the transmitting port for the sending of ultrasonic sound of 42KHz, while the Echo pin is used for the triggering the Echo port for receiving back the Echo of the transmitted ultrasound. The 16x2 liquid crystal display and the HC-SR04 ultrasonic range finder are connected as shown in Fig 8. The software aspects of this device comprises of a program code that enables the Node MCU microcontroller wifi board to transmit ultrasound signal through its transmitting port and reception through the echo port . The Ultrasonic module mounted on the fuel tank checks the liquid level and reflects the sound back to the sensor. The measurement procedure is shown in Fig 9 and Fig 10 depicts the block diagram of the system setup.

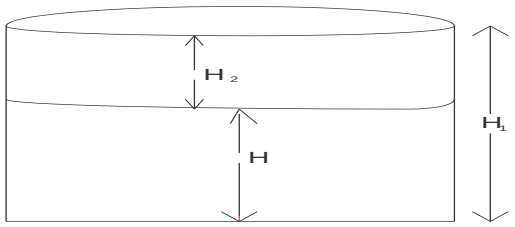

Fig 9: Tank illustration of showing the real height of the tank and the liquid level.

The Ultrasound module cannot stand alone so it is interfaced with a Microcontroller (Node MCU), the microcontroller is programmed to send a pulse through the transmitter end of the ultrasound module and check the time it will take for the receiver to receive the reflected sound back.

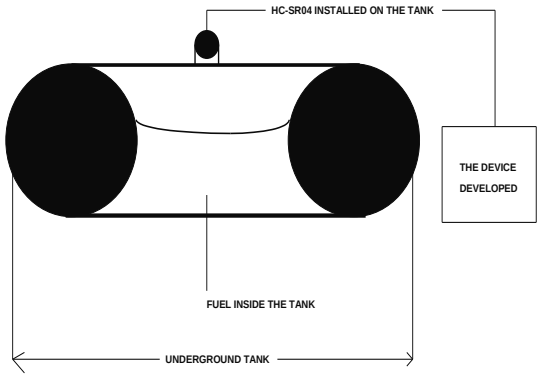

Fig 10: Block Diagram of the fuel level meter setup

The Node MCU microcontroller is programmed to determine "H" of the tank which is H_1-H_2, other parameters needed for the estimation of the fuel level in the tank are programmed into the Node MCU microcontroller. An increase or decrease in the volume of the fuel in the tank is estimated by the device developed and displayed on the 16x2 i2c LCD interfaced with the Node MCU as well as over the io adafruit cloud view platform used for this research work.

VII. RESULTS AND DISCUSSION

The HC-SR04 range finder was interfaced with the Node MCU board as described earlier and a simple program was written in C+ basic language which was uploaded to the Arduino microcontroller board for distance estimation. Fig 11 shows a typical reading made by the constructed device.

Fig 11: Readings uploaded to adafruit by the device

VIII. CONCLUSION

The successful implementation of this project has surely provided a solution to some of the key challenges with underground fuel level metering in filling stations. Thus, petrol stations owners can now access their underground tank fuel level from any part of the world.

It helps reduce occasion for theft as little or no human effort is required in the measurement of fuel hence the measurement cannot be manipulated. It's also readily available to the owner of filling station over the cloud for easy monitoring. It also brings underground tank readings to the very door step of filling station owners by ensuring the readings from the developed meter is readily available over the cloud. It also helps remove the stress associated with the crude method of gauging the tank, as this is done automatically.

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