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Design and Implementation of Smart Petrol Station

Zahraa M. Baqir [1, *], Mayasah R. Abdali [2], Heba Abdul-Jaleel Al-Asady [3,4]

[1] *Department of Electrical and Electronic Engineering, University of Thi-Qar, Thi-Qar, Iraq*
[2] *Department of Medical Instrumentation Techniques Engineering, Al-Mustaqbal University, Babylon, Iraq*
[3] *Department of Electrical Engineering, College of Engineering, University of Kufa, Kufa, Iraq*
[4] *Department of Computer Technical Engineering, College of Technical Engineering, the Islamic University, Najaf, Iraq*
E-mail addresses: zahraam.baqer@utq.edu.iq , mayasah.razzaq@uomus.edu.iq , hebaa.alasady@uokufa.edu.iq

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Abstract

The problem that still exists nowadays with the petrol station is the method of operation because the petrol station is currently operated manually. As it is a time-consuming process that increases manpower, other problems are related to accuracy, gasoline smuggling, fluctuations in global oil prices, sales, database management, environmental pollution and others. Traditional methods of monitoring fuel in petrol station by humans on site are unable to meet the expectations for efficiency, accuracy and cost. Therefore, this paper designs an intelligent system of three filling stations, where the three stations are simultaneously displayed on a single web application, and this IoT-based system is implemented to address all the problems. Therefore, this paper presents the design and implementation of three petrol stations in which we are going to measure the level of fuel and show it to central server. internet of things (IoT) based petrol station monitoring system is a good approach to improve monitoring efficiency and to improve management efficiency in stations remotely. simulation results presented in LabVIEW software showed the ability of the system to monitor levels of petrol, detect fire, evaporation and etc.

Keywords: Petrol station, Monitoring, ESP32, Sensors, Internet of things (IoT).

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1. Introduction

In common, designing a smart petrol pump is one way to judge the level of a fuel station system [1, 2]. The idea of a smart petrol pump comprises three central features. Firstly, surveillance is important through sensor networks to catch information or data relating the station. Secondly, mechanisms control the use of communication between devices to allow automation and faraway access. Lastly, user interfaces like personal computers and smart phones permit users to assign priorities add to existing information to persons around these priorities [3-8]. Regarding to this paper work, the research work will be divided into three categories. In first part, petrol station hardware which consist of an NFC RFID reader for cashless payment, sensors are going to be used in measurement of the petrol transferred to the customer’s tank, levels and the temperature of fuel in storage tank and sensors for fire protection and environmental monitoring. Calculations and programming are to be made through at Arduino mega 2560 and ESP-32S microcontrollers. For the second part, the ESP-32S module is used to enable wireless communication interface between the petrol station hardware system and the third part, which is the petrol station monitoring system, which is represented by the IoT ThingsBoard server that is downloaded to Raspberry Pi as a local server for data collection, processing, visualization, and system management. Arduino programming language is used in order to create a systematic software as the main control system for this petrol station system.

2. The proposed system

A design system of three smart petrol stations that are monitored and managed remotely from a single interface on IoT platform is proposed. The petrol station system connects to local server or cloud server over the internet. Online data can be visualized by a remote company office on ThingsBoard web user interface through chrome or Firefox web browser from desktop or smart phone or other devices. Figure 1, shows the flow chart of this system. The scheme offered consists of hardware part and software part.

- Hardware part: It contains the hardware parts listed in Table 1. More details about this hardware mentioned in [9-18].
- Software Part: The petrol station is controlled by a system to enable that it operates efficiently. As this petrol station is expected to be left standalone and managed wirelessly, a system to control and monitor it from a distance is necessary. Software that was used in this application are:

1. Arduino Software (IDE): The Arduino Integrated Development Environment (IDE) is a free and open-source cross-platform application (for Windows, macOS, and Linux) developed in C and C++ functions. The Arduino IDE makes it simple to develop code and upload it to the device [19].
2. LabVIEW program for simulation: LabVIEW (Laboratory Virtual Instrumentation Engineering Workbenches (where a national instruments platform and development environment for a visual programming language. The goal of this type of programming is to automate the use of laboratory decision-making and measurement equipment [20].

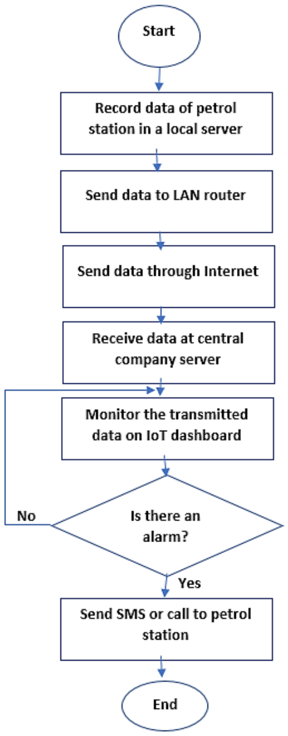


Fig. 1 Flow chart of the proposed system.

Table 1. Hardware of the proposed system.

No.	Component	No.	Component
1	Microcontroller (Arduino Mega 2560)	10	Dht 11 sensor
2	Node MCU ESP-32S	11	2- Push buttons
3	Liquid Crystal Display (LCD)	12	Main fuel tank
4	HC-SR04 Sensor	13	XL4015 power module
5	YF-S201(Flow Meter)	14	MicroSD Card Adapter
6	Buzzer	15	MR009-004.1 (Relay Module 2-Channel)
7	Keypad	16	Automated Nozzle
8	PN532 NFC RFID Module	17	RFID card
9	2-12V Water pumps	18	Wire connection
19	GPS	20	UART to I2C bridge
21	Tp-link router	22	Raspberry pi

3. Implementation of the proposed System

The designed system is divided into two main parts: the first part relates to the hardware on the board (control system) and the second part relates to the ThingsBoard web server. In Fig. 2, the arrows pointing toward the Arduino mega 2560 shows the input, while the arrows pointing from Arduino shows the output of the processor.

Figure 3 shows the connection map establishes by fritzing software for the hardware parts on the board. Figure 4 shows a section of the practical hardware of the designed and implemented system, which is installed outside the control system box.

The module inside the box is responsible for providing a direct connection to the server via a Wi-Fi router and it acts as a second microcontroller represent as second petrol station. Figure 5 shows the core components of the control system box.

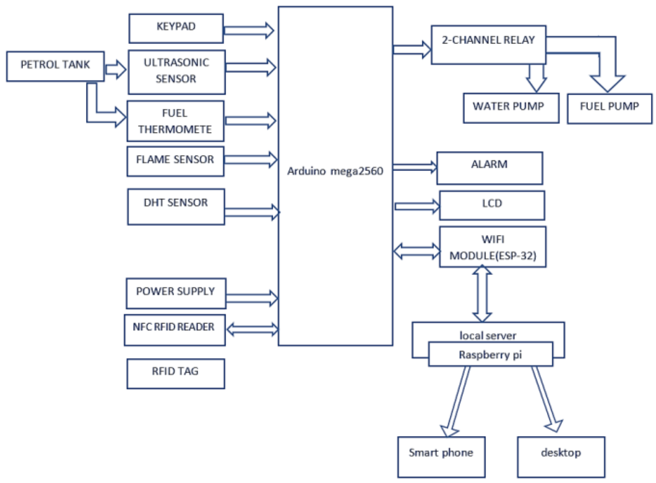


Fig. 2 The proposed smart petrol station.

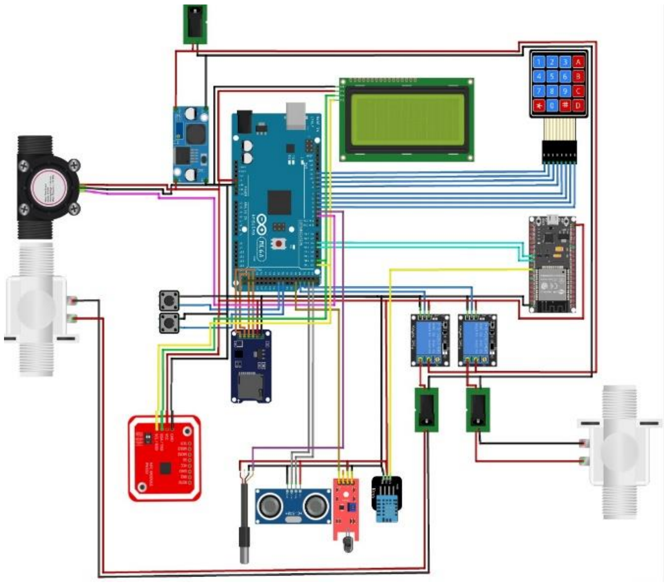


Fig. 3 Connection map on the board.

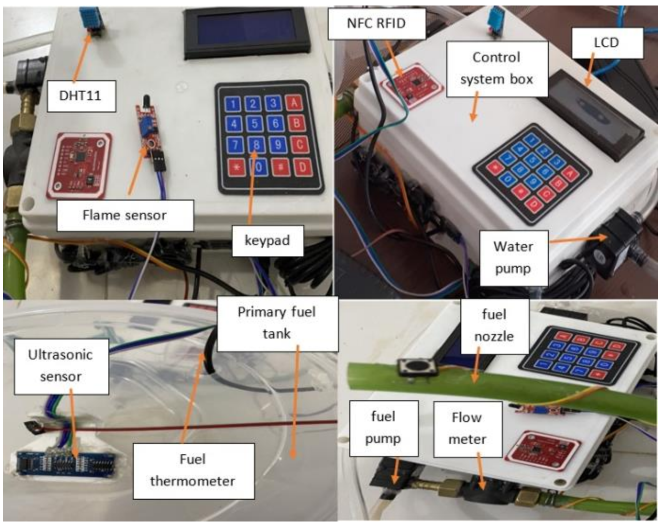


Fig. 4 Hardware section outside the box of the control system.

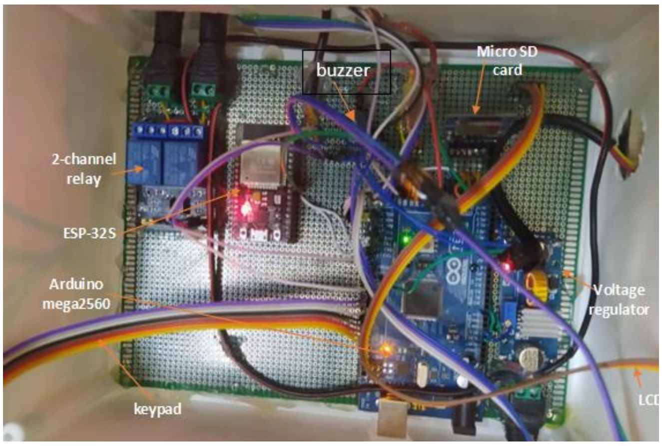


Fig. 5 Inside the control system box.

4. Methodology of the proposed system in LabVIEW

In LabVIEW software, the methodology of the system designed for a three-filling station has been simulated locally to simulate the following functions: level of fuel in the storage tank, the temperature of the fuel temperature and humidity of weather and fire alarm as shown in Fig. 6.

4.1. Alarm diagram by LabVIEW

A fire alarm circuit was made by connecting a thermometer for temperature and smoke and connecting them to a comparison circuit using logic gates as shown in the Fig. 7. As when the temperature crosses the threshold set for it, the temperature alarm is triggered, and the same applies to the smoke alarm. When both temperature and smoke cross their specified threshold, the station's main alarm is triggered.

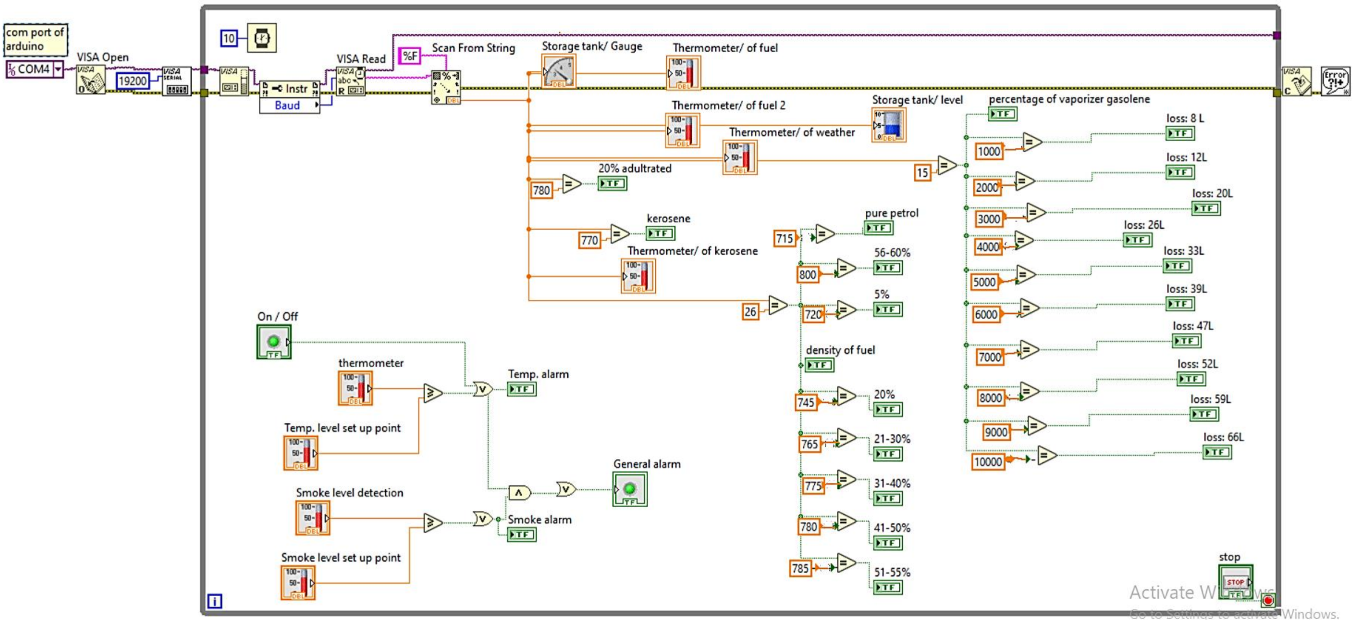


Fig. 6 Smart petrol station via LabVIEW.

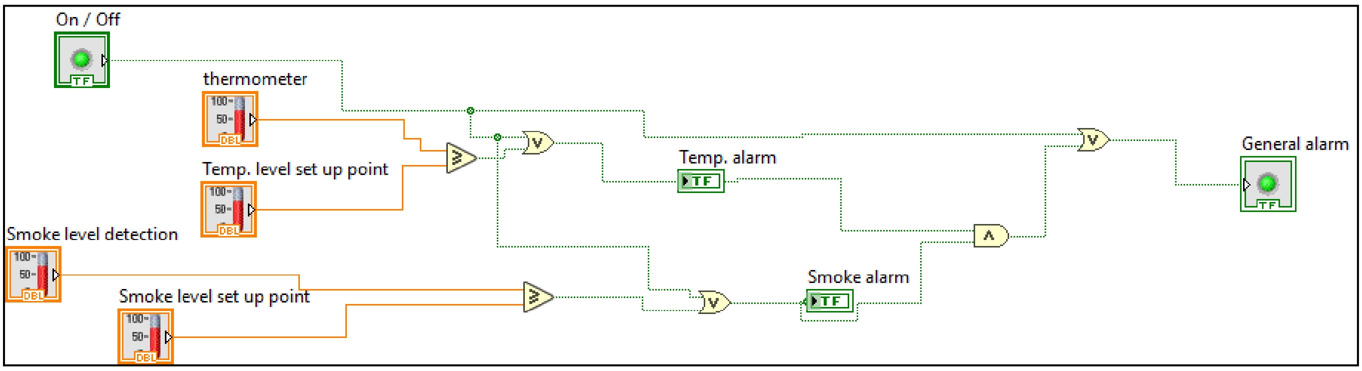


Fig. 7 The alarm circuit via LabVIEW.

4.2. Density diagram via LabVIEW

For three types of fuel (gasoline, diesel and kerosene) can detecting their density by made circuit construct from arithmetic operators to perform density equation as shown in Fig. 8.

4.3. Level of fuel

Figure 9 shows the diagram in LabVIEW to test the height level of gasoline, diesel and kerosene.

4.4. Quality of fuel

It can be detection about quality of fuel by test the density. Figure 10 shows comparing between the recording density and the density of fuel in 26 °C for gasoline, diesel and kerosene.

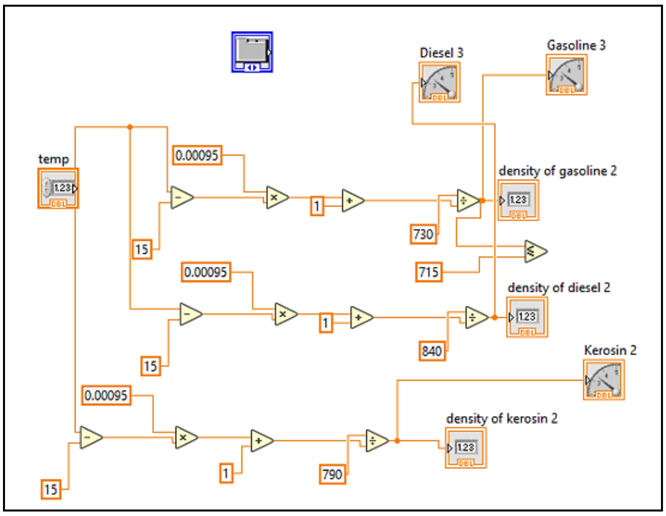


Fig. 8 The density circuit for three types of fuel.

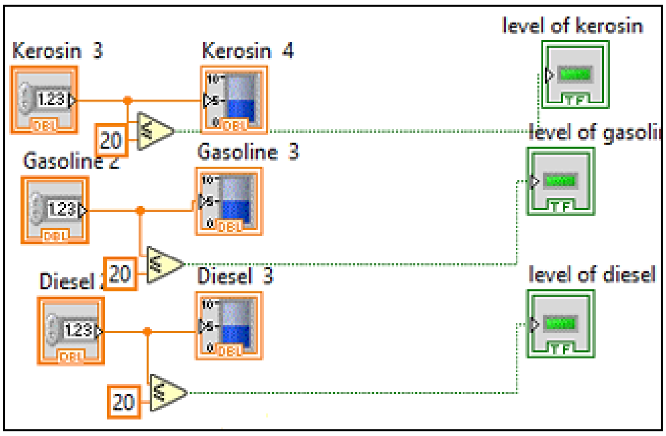


Fig. 9 Fuel level rise.

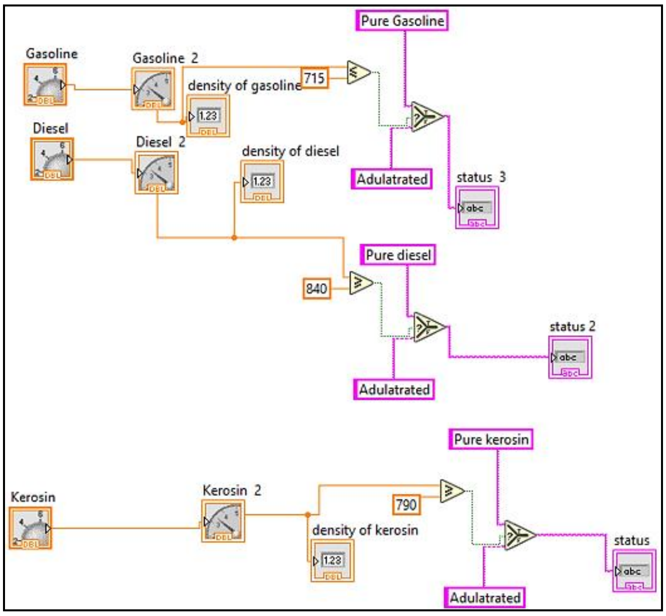


Fig. 10 Quality of fuel diagram.

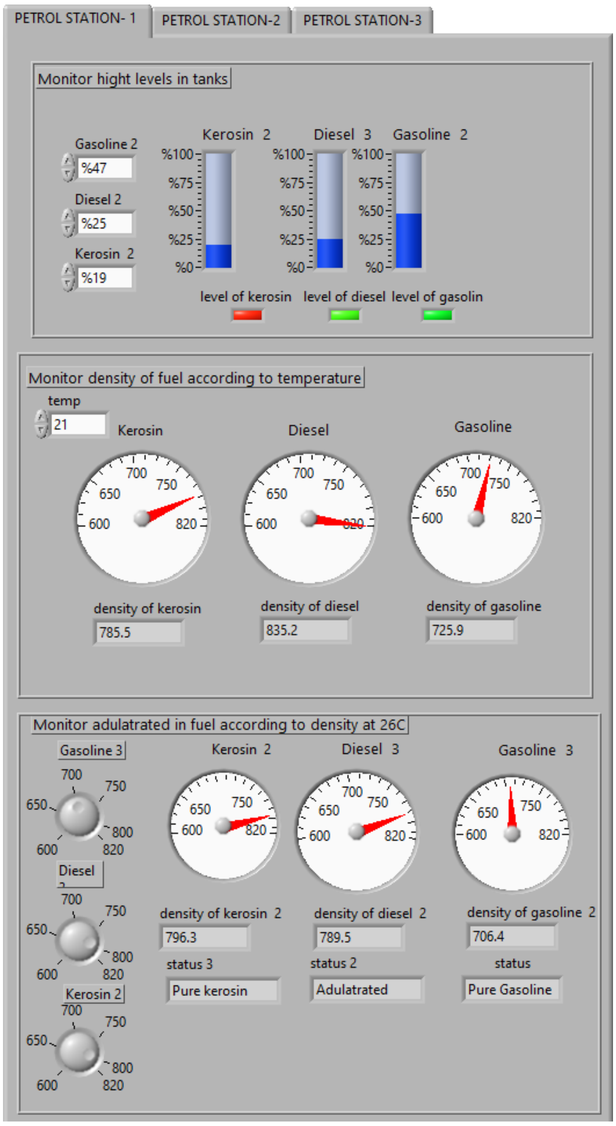


Fig. 11 The output parameters from LabVIEW.

5. The results in LabVIEW

The designed strategy is implemented in the LabVIEW VI environment, and simulation results are presented to validate the proposed controller in Fig. 11. Where it appears from Figure monitoring the central station of three stations, the design assumes the following in each station:

1. Monitoring the fuel level inside the storage tanks for three products. Where a visual alert appears represented by a green LED indicating an acceptable level of fuel rise inside the storage tank, while if the fuel level drops below 20%, a visual alert represented by a red LED appears indicating the necessity of refilling the fuel to the indicated tank.
2. Monitoring the density of the fuel according to the temperature. With a temperature of 21 °C, the density of gasoline was recorded at 725.9, while the density of diesel was 835.2, and the density of kerosene was recorded at 785.5.
3. Quality control of the product according to the density: with a temperature of 26 °C, the density of gasoline was 706.9, and at this density the textual reference to the purity of the petroleum is made. At a density of 785.5 for diesel, the presence of impurities mixed with diesel was indicated, while kerosene at a density of 796.3 indicated the purity of kerosene.

The fire alarm system consists of a thermometer for smoke and a thermometer for heat as in Fig. 12. The logic gate AND was used to verify the two conditions of high temperature and smoke to a level higher than the threshold limit. A fire alarm is triggered, but if one of the two conditions is met, the alarm is triggered by a red LED.

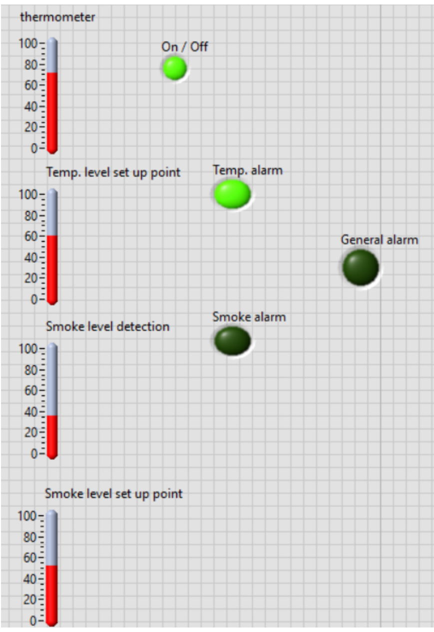


Fig. 12 Alarm fire protection.

It is possible to place more than one temperature sensor in different locations of the same station and to show the data represented by a waveform. When an on signal arrives, the alert is done by text and using a red LED. But when there is no fire, there is no signal and the text is no fire. It is possible to show these functions in LabVIEW in Fig. 13.

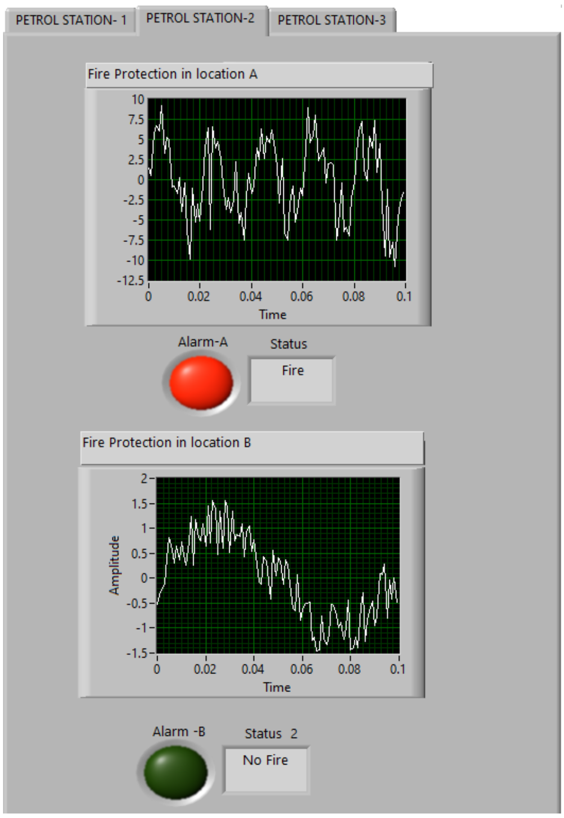


Fig. 13 Alarm fire protection from different locations.

The monitor system to share data, manage and control is expected to provide the fuel stations manager with information about a petrol station in real time remotely shown in Fig. 14. The system will show sales and the volume of petrol bought on a specific date, and will provide manager with data as follow:

1. Users interface.
2. The primary tank of a fuel.
3. Weather conditions (temperature and humidity).

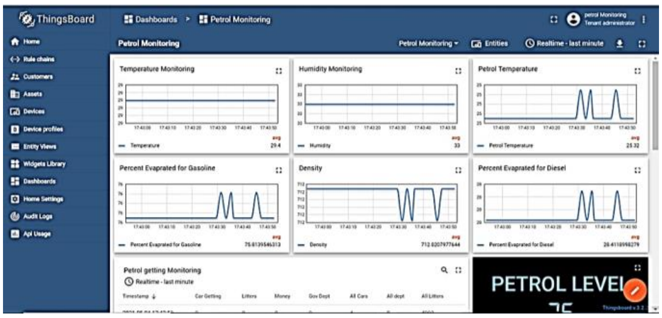


Fig. 14 Petrol station monitoring System Interface on ThingsBoard.

5.1. User interface for a petrol station monitoring system

All of the customer's actions, such as filling the tank, paying the bill, total sales, the number of cars, debts, and so on, are sent to the server and monitored by the company that follows up on three fuel stations, where each station subscribes to the device's identity and the monitoring company's access token. Figure 15 shows the operations performed by the customers as they appear on the dashboard.

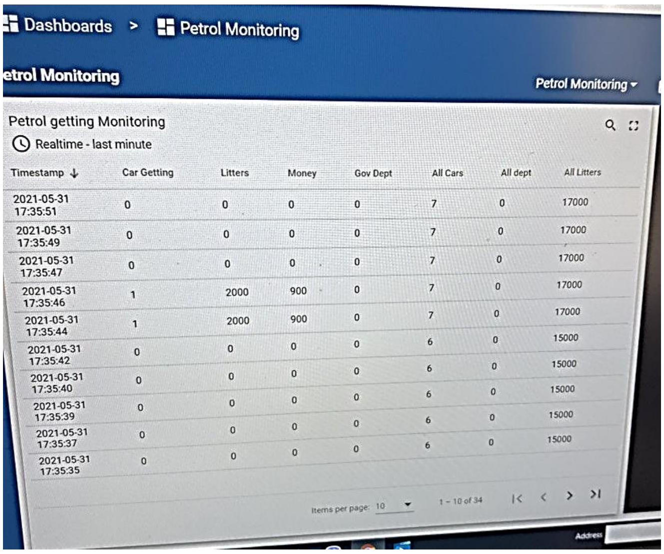


Fig. 15 Petrol monitoring on ThingsBoard dashboard.

5.2. Petrol station monitor system-primary fuel tank

By monitoring the main fuel tank, it is possible to verify the following:

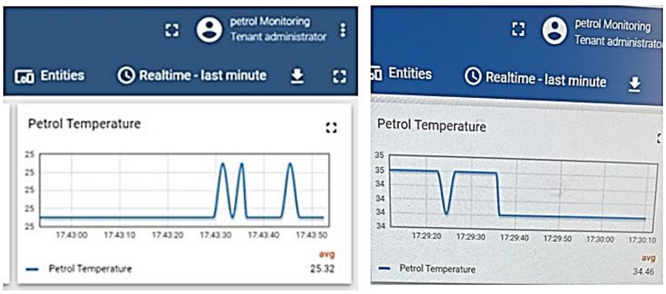
1. Level of fuel

Ultrasonic sensor is installed on the Arduino Mega microcontroller. The sensor sends fuel level information to microcontroller considering each microcontroller is a fuel station (MQTT client) and sends its information to the ThingsBoard server as shown in Fig. 16.

Fig. 16 monitoring fuel level for two states on the dashboard.

2. A fuel temperature

The fuel temperature sensor sent their information from microcontroller (as MQTT Clint) to calculate percentage evaporation of fuel (gasoline and diesel) after that to the ThingsBoard server (as MQTT broker) installed on Raspberry Pi as a local server or ThingsBoard installed on a cloud server to be shown on the dashboard. Fig. 17 (a) and (b) shown petrol temperature average 25.32 °C and 43.46 °C respectively.



a b

Fig. 17 Gasoline temperature as shown on dashboard.

6. Conclusions

Connected three petrol station systems to Internet represent the basic structure to IoT of this application in order to share several types of information related to users, environment and database of systems. Results show that smart petrol station system-based on IoT scheme is effective and more manageable to resolve the all problems of traditional filling stations.

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