Remote Oil Well Monitoring System for Oil and Gas Industry

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ABSTRACT

There is a great chance that fire breakouts in industries like chemicals, petroleum, oil and gas would leads to extensive loss of property, damage, and most important, the loss of human life. It is essential to have a system in place that can maintain the area safe and alert the management as soon as an event occurs. These issues may be reduced using a remote monitoring system (IOT based). Design and development of the remote oil well monitoring system utilizes stm-32 microcontroller, flow rate sensor, pressure, and temperature sensor, ESP module, and Firebase to visualization the data. Firstly, by utilizing the stm-32 microcontroller data is collected from the and flow rate sensors, pressure, temperature sensor. The designed system also uses a Peltier and fan cooling system to control the circuitry box temperature from high environmental temperature. And the collected data sent wirelessly to ESP module controller/module, which transmit the data to cloud and visualization the data on Firebase for real-time and ESP82 for data storage on the cloud. The system addresses the limitations of old oil well monitoring systems and also improves the efficiency and safety of oil well. The system is designed to be efficient, scalable, and low-cost that makes it perfect for Industries like petroleum, chemicals, oil, and gas monitoring applications. The system doesn't need any human association.

Keywords: Internet of things (IoT), Oil and gas industry, Remote well monitoring, Cloud data transmission

1. INTRODUCTION

1.1. Monitoring Practices in Oil and Gas Production

Once the crude oil is taken out of the ground (oilfields), the oil and gas industry can start making products from it that can be used for different energy needs. After oil is pumped out of the ground, it goes through pipes to a tank, where an oil gas splitter separates it from water[1].

Due to asset, process, and operational failures, the oil and gas industry regularly faces serious challenges at high operating costs. Manual data collection is thus challenging and time-consuming, because the pumping unit runs constantly around the clock. In short, conventional oil production facilities use outdated information monitoring and management methods [4]. On the other hand, oil and gas companies confidential data are exposed due to cyber threats and they more willing to pay the ransom in order to retrieve lost data [5].

1.2. IoT (Internet of Things)

People tend to control different resources and information on the production site in an automatic and smart way as the high-tech economy grows quickly [2]. IoT uses tracking technology and smart devices to understand and identify the real world. It also makes it possible for people and things to share information and join easily over a network, so that the real world can be controlled and managed accurately in real time.

Currently, oil fields are late deficient in the integration intelligence monitoring and testing systems. A IoT-based intelligent monitoring system design is suggested. By implementing this project, the oil well site may be made safer and more effectively monitored [3].

1.3. IoT Based Smart Monitoring Systems

SMART stands for "Self-Monitoring, Analysis, and Reporting Technology". However, what precisely is that makes it smart?

The analysis of billions of events and alerts data packets are both part of the Smart IoT monitoring process. Monitoring that is based on the Internet of Things also makes it possible to close the gap between devices and people by analyzing a wide variety of IoT data at web scale across all linked devices [6]. In the Internet of Things-based oil and gas well monitoring system, sensors collect precise data (such as pressure, temperature, and flow) from oil and gas wells, and then, after processing the data, transmit it to the cloud so that it may be visualized on the web or in an application.

1.4. Problem Statement

Industries such as chemicals, petroleum, oil and gas are at high risk for fire outbreaks, which can lead to significant property loss, destruction, and most important, the loss of human life. Oil field conventional monitoring and control systems are usually employee based and centralized, which makes them susceptible to failure and inefficient. Performing oil well maintenance activities and physically inspecting every well can be challenging, as it requires sending employees to each location.

1.5. Objectives

In order to improve oil and gas production, we plan to design a remote monitoring system for oil and gas wells for timely data collection and decreased facility downtime and better automation and control.

Several objectives are derived from analyses of existing oil and gas well monitoring systems practices.

i. ***Predictive Maintenance:*** Collection of real-time data and use of this data for Predictive maintenance.

ii. ***Health and Safety:*** Accidents are expensive and a priority for health and safety by using IoT-enabled safety measures.

iii. ***Remote Monitoring:*** Remote monitoring of well to track pressure, temperature and flow rate of well remotely.

iv. ***Data Management***: Improved uptime and recovery rates, and more refining capacity are just some of the ways that collected data may be put to use.

2. LITERATURE SURVEY

Employees used to need to go to the well site for essential diagnosis in the previous old traditional methods. The main issue with this strategy is that the employee has to be on field for the well monitoring for 24 hours. The time to action in IoT, however, is measured in minutes, seconds. By recoding and gathering monitoring data, IOT-based monitoring services are becoming better and more affordable. Taking decisions on how the performance is going and what to do next is made easier by having vast amount of real-time data access on performance of well [7].

In order to communicate data gathered from the sensors for pipeline inspection, the authors of [10] used radio communications. Sensors are positioned along pipelines in [11] to monitor them. A network of magnetic induction units is described in [12]. This network is set up to relay sensed data in a multi-hop way while transmitting or receiving signals from nearby units by modulating a time-varying magnetic field. However, large-scale deployment is not feasible owing to the low communication range between magnetic induction coils or devices. A system that is based on wireless sensor networks and connected to the internet of things has been developed as a means of monitoring the productivity of wells. This system, which is designed to transmit and manage decisions about the wells performance (Pan Yi et al 2021) [8]. An intelligent control system that is based on a sensor network is the best answer for the problem of monitoring oil and gas wells without resorting to human monitoring. This method has been presented as a solution. A wireless transmission sends data about the wells and tanks to a remote administrator, who may use this data to assess the overall health of a number of oil wells and oil storage tanks. The system makes use of level, temperature, and gas sensors in various configurations. (R. Barani et al in 2020) [9].

3. PROPOSED SYSTEM

3.1. System Overview

The prototype is made up of a smartphone application, a cloud server in the backend that stores data, and connected pressure, temperature and flow rate sensor that provide pressure, temperature, and flow rate measurement data. A STM32F103C8 microcontroller to process the measurement data of sensor and for cloud transfer, send data to ESP module. A 16x4 LCD mounted on the monitoring box to display parameters. ESP module transmit the data to cloud and firebase an open-source software is used to visualize the data on the web and on the mobile application.

3.2. Block Diagram of the System

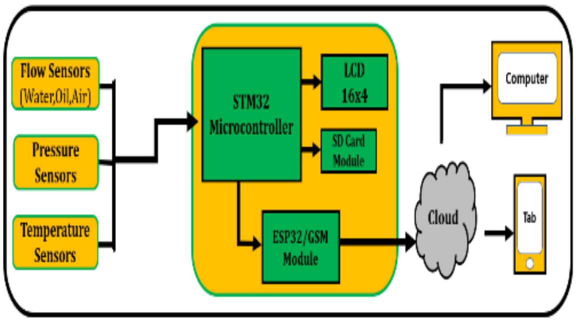

FIGURE 1: BLOCK DIAGRAM OF THE SYSTEM

3.3. Architecture Components

i. *Microcontroller*

STM32F103C8 microcontroller performs the function of the project's brain. The purpose of the STM32 controller in this monitoring system is to act as the central processing unit, processes and manages the sensor data, enabling real-time analysis and control.

FIGURE 2: STM32F103C8 MICRO-CONTROLLER

ii. *ESP32 Module*

The ESP32 is a microcontroller with built-in Wi-Fi, antenna switches, dual-mode Bluetooth, a power amplifier, and filters. The ESP32 module is the communication gateway between the local microcontroller STM32 and the cloud platform (Firebase). It enables wireless data transmission over Wi-Fi.

FIGURE 3: ESP32 MODULE

iii. *ESP82 Module*

ESP8266 module, microcontrollers are able to connect to Wi-Fi networks operating at 2.4 GHz. The ESP32 module in this monitoring system is to facilitate wireless data transmission and especially data storage from the STM32 microcontroller to the cloud (Firebase) as backup cloud storage.

FIGURE 4: ESP82 MODULE

iv. *16x4 Liquid Crystal Display*

A liquid crystal display (LCD) is an electrical modulated optical device that employs liquid crystals and polarizers to create an image on a flat screen. In this monitoring system LCD is used to provide a local interface for on-site personnel to access real-time well data directly from the microcontroller.

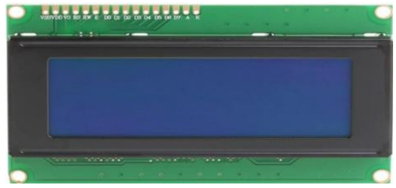

FIGURE 5: 16 X 4 LCD DISPLAY

v. *Temperature Sensor*

The DS18B20 is a temperature sensor, it gives temperature values range from 9-12 bits. Can capable of communicating with microprocessor via the use of a one-wire bus protocol. Temperature Sensor is used to measure and provide accurate temperature data of the oil and gas well.

FIGURE 6: DS18B20 TEMPERATURE SENSOR

vi. *Pressure Sensor*

This pressure sensor is a transducer; it produces a signal that is proportional to the pressure that is being applied. The pressure sensor KH100C in this monitoring system is to measure and monitor the pressure of the oil and gas well.

FIGURE 7: PRESSURE SENSOR KH100C

vii. *Flow Rate Sensor*

The YF-S201 is a flow measuring sensor, its range is from 1 to 30 liters per minute, and it operates using the Hall effect concept. Can function with an operating pressure of up to 1.75 MPa. The purpose of the Flow

Rate Sensor YF-S201 in this monitoring system is to measure and monitor the rate of fluid flow (e.g., water or oil or gas).

FIGURE 8: FLOW RATE SENSOR YF-S201

viii. *SD Card Module*

A microcontroller may read and write data to an SD card using SD Card Module. The purpose of the SD Card Module in this monitoring system is to provide a local data storage solution enabling offline data access when the internet connection is unavailable.

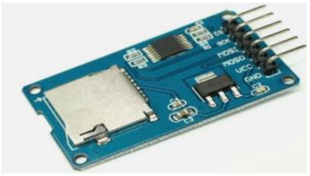

FIGURE 9: SD CARD MODULE

Flowchart of the System

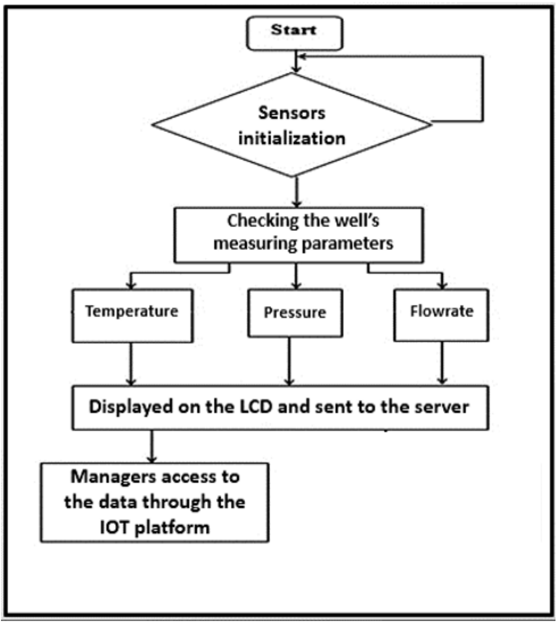

FIGURE 10: FLOW CHART OF THE SYSTEM

4. WORKING OF SYSTEM

i. *Sensing Layer*

Sensing layer consists of a pressure sensor, a temperature sensor, and a flowrate sensor used measure the well's pressure, temperature, and flowrate [14].

ii. *Processing Layer*

In the Processing layer, the microcontroller receives the sensors data, processes it, sends the data to the LCD display and to the ESP module for cloud transmission [15].

iii. *Network Layer*

The network layer is in charge of the necessary communicates between devices, networks, and cloud-based services. The network connectivity supports the transfer of measured parameters data from the system to the Cloud server [14].

iv. *Application layer:*

Applications used by end users make use of data stored in the cloud at the application layer. The data may be presented in a variety of graphical and numerical formats [14]. In this system Google firebase is used for data visualization. And we built the monitoring app using MIT's App Inventor mobile app development platform.

v. *Temperature Control of System*

Using a fan, Peltier, a thermistor, and a transistor, the microcontroller regulates the environmental temperature of the monitoring box. When the temperature drops, the thermistor's resistance goes up, the fan stops and when the temperature rises, the thermistor's resistance goes down and fan turn ON [13].

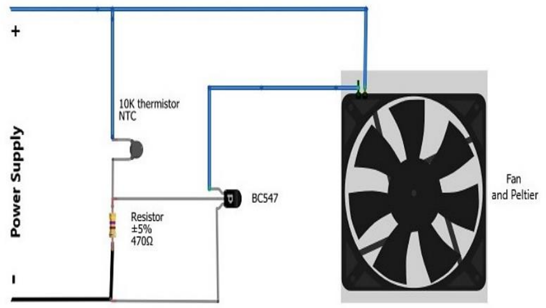

FIGURE 11: TEMPERATURE CONTROL CIRCUIT OF THERMISTOR

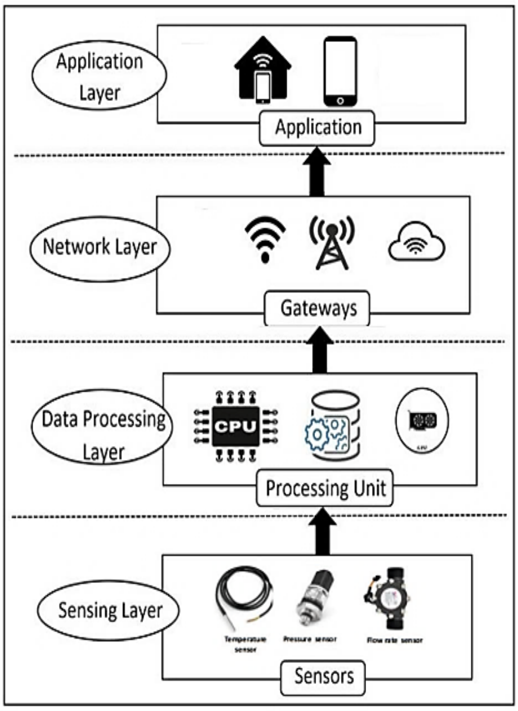

FIGURE 12 SMART IOT SYSTEM ARCHITECTURE

5. IMPLEMENTATION

At this point of the project, all the findings that has been gathered for the problem statement and analysis are carried out and used to generate codes that would control the working process of the system which is fully implemented. The first step was to design the circuit using the Fritzing software to ensure that the components are in right place when placed on the PCB. The next stage in the implementation is programming the microcontroller.

5.1. Circuit Design

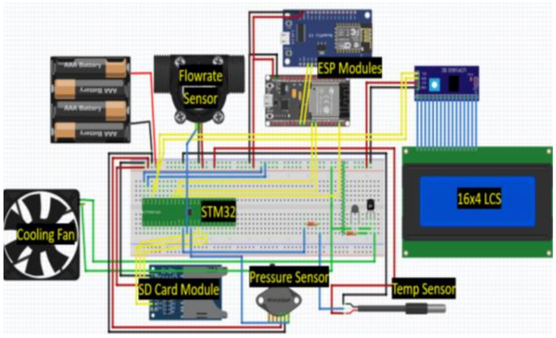

FIGURE 13: ELECTRONIC CIRCUIT DESIGN IN THE FRITZING SOFTWARE

This first step is mounting the STM32F103C8 microcontroller on the circuit board. The LCD is connected to the project circuit board with cables connected to the appropriate port with respect to the STM32F103C8 microcontroller and use I2C protocol. The temperature sensor is connected to PA0 port on STM32F103C8 microcontroller. And the Pressure sensor is connected to the PA7 port on microcontroller. Flow rate sensor is connected to the PA14 port on microcontroller. The SD card connected to appropriate port and uses SPI protocol.

a **b**

FIGURE 14: (A) (B) CONSTRUCTED CIRCUIT WITH STM32 CONTROLLER, ESP MODULE (PCB)

5.2. 3D Design of the System

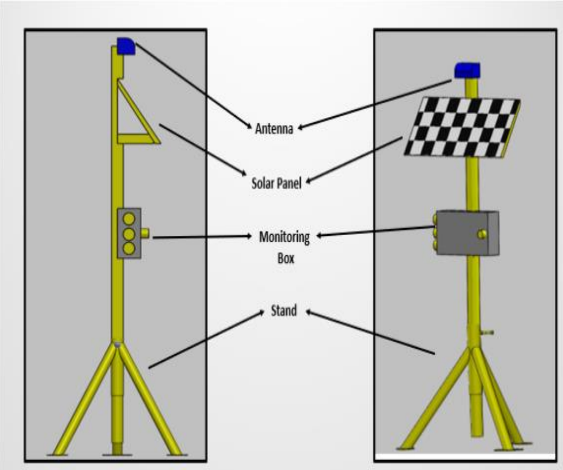

FIGURE 15: CAD DESIGN OF MONITORING BOX AND COMPLETE SYSTEM (SOLAR PANEL IS OPTIONAL)

In the mechanical design, the model of the project was constructed firstly in the software and then build the hardware, which include a monitoring box. A stand to hold the monitoring box at any place.

FIGURE 16: COMPLETE PROTOTYPE OF THE MONITORING SYSTEM

5.3. Programming the STM32F103C8 Microcontroller

After the code is fully developed and tested, the code is converted to .Hex file because the controller can only interpret and execute commands in a. Hex format. The .Hex file is uploaded into the STM32 with the use of a debugger.

6. RESULTS

This study presents a novel prototype of a Remote oil well monitoring system that was developed to aid the oil and gas industry in its efforts to better manage oil and gas wells in order to boost output. The remote collection of data in real time, the lessening of facility downtime. In order to achieve the goals, set out at the start of this project, an Internet of Things based oil and gas well monitoring system for an oil and gas well has been designed and built, using an STM32 microcontroller, an ESP module to send the measured parameter data to the cloud, and Fire base for user interaction.

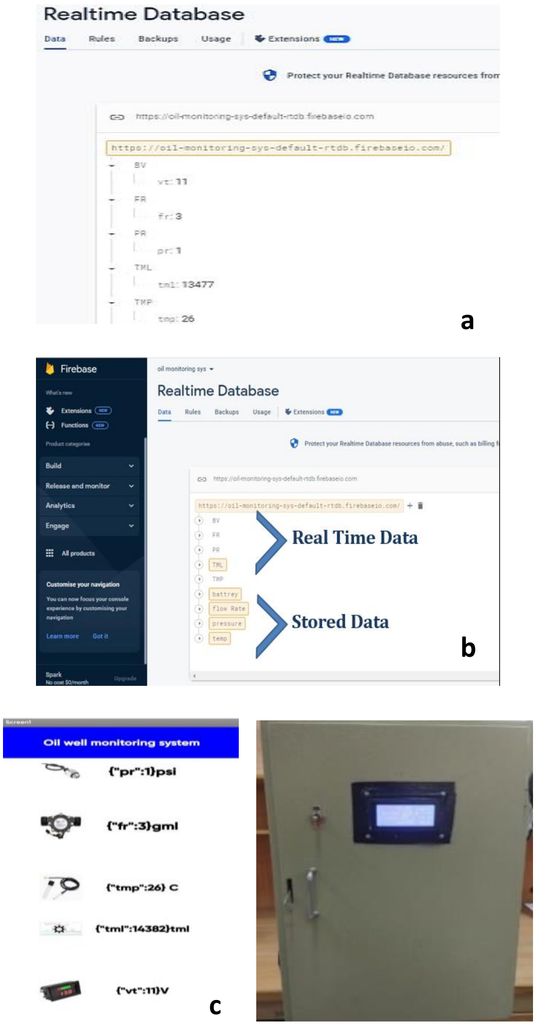

FIGURE 17: (A) DATA ON THE WEB (FIREBASE), (B) STORED DATA ON THE WEB, (C) DATA ON THE PHONE

(APPLICATION), (D) DATA VALUES ON LCD DISPLAY ON MONITORING BOX

7. CONCLUSION

By examining current issues with oil wells and monitoring them in real time to avert safety risks, this paper presents the most recent IoT technology to the oil and gas industry. It is possible to lower the risk of fires, but it is also possible to ensure worker and well site safety by promptly issuing warnings in the event of an explosion or fire. Overall, the study on the Internet of Things-based intelligent monitoring system for oil wells provides a strong basis for the advancement of oil wells. On a larger scale, this concept might benefit from further upgrades, such as the suggested multi-chemical composition and density and viscosity sensors for gauging oil efficiency.

8. FUTURE DIRECTIONS

In order to upgrade the system, the project's future work is crucial. In the designed system the enhancement would be the integration of technologies like Machine Learning and Artificial Intelligence to expand the system ability to analyze the well's performance and predictability.

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