

Real-Time Tank Level Monitoring System using Modbus-MQTT and Web-Based Visualization

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Article Information

Received: June 02, 2023

Accepted: July 01, 2023

Published: Aug 05, 2023

Keywords: Tank level monitoring, Data Acquisition Unit, Pressure sensor, Diesel fuel, Analog output, RS485 communication, Modbus protocol, MQTT Protocol, DTU (Data Transfer Unit)

ABSTRACT

In this paper, the presented system to monitor the volume of diesel inside a tank using a pressure sensor. The system employs a Data Acquisition Unit module to collect analog data from the pressure sensor, which is submerged in the diesel tank. Sensor data is transmitted via RS485 communication to a DTU device that converts it into MQTT packets, The MQTT packets are sent to an MQTT broker, which acts as a bridge to a web or mobile app for real-time monitoring of the diesel tank's level. The results of the implemented system shows real time readings of liquid volume inside the tank from the pressure of the liquid via mobile and web app, also the data of the sensor is saved to local database for further analysis.

1. INTRODUCTION

growth of the Internet of Things (IoT) technologies has revolutionized industries, enabling efficient and real-time monitoring of various systems [1]. One such application is the remote monitoring of liquid levels using pressure sensors [2]. This paper explores the utilization of IoT in monitoring liquid levels, providing an overview of the principles and benefits of this approach. Monitoring the level of diesel fuel in tanks is crucial for efficient inventory management and operational planning in various industries. Traditional methods of manual measurement are time-consuming, prone to errors, and provide limited real-time visibility. This paper propose a comprehensive system for remote tank level using a pressure sensor, Data Acquisition Unit technology, and MQTT-based communication. The proposed system leverages a pressure sensor capable of providing analog output in the range of 4 to 20 mA, which

corresponds to the measured pressure of the diesel inside the tank. By accurately measuring the pressure, the system enables the determination of the volume of diesel, offering a more reliable and automated approach to tank level monitoring. This paper proposes a comprehensive system for remotely monitoring diesel tank levels using pressure sensor (QDY30A) [3], Data Acquisition Unit communication (MA01-AACX2220) [4], MQTT protocol [5], and web application development using React [6].

2. RELATED WORKS

In [7] Beza Negash Getu and Hussain A. Attia investigated a sensor for water levels device for detecting and controlling water levels in a specific tank or storage system. Their electronic design utilized a level detector and the use of a flip flop in sequential logic. It included a relay-based circuit for operating a motor pump with a seven-segment display. The system activated the water pump when the level was empty or at level ONE and stopped when reaching the maximum level (NINE). From level EIGHT to level TWO, the pump remained inactive during water consumption. This intelligent water level sensing and control system aimed to improve automation and efficiency in water management, ensuring timely filling and preventing overflow. In [8] investigated the application of Internet of Things (IoT) technology in industrial settings. The paper focuses on the implementation of a prototype system for artificial control and monitoring using IoT. Two controls, traditional PID (Proportional Integral Derivative) likewise fuzzy logic, were compared. The fuzzy control was simulated using MATLAB-R2018b and later developed as a fuzzy algorithm inside of a PLC that is based on the Sugeno technique (PLC). The Modbus protocol was utilized to connect the PLC, OPC (Object Process Control) server, and sensors. The Internet of Things system made use of MQTT (Message Queuing Telemetry Transport) and OPC, and uploaded the data it had collected to the cloud. . Wireless communication between the sensors and the router was achieved using the ESP8266 module. Methaq A. Ali, Abbas Hussein Miry, and Tariq M. Salman aimed to leverage IoT technology to enhance automation and real-time monitoring in industrial applications. In [9] presents a mechatronic design solution to address challenges in manual liquid level measurement. The study focuses on solving a situational issue at Cawaira Power Station's Generation Strategic Business Area, Fiji Electricity Authority (FEA). The goal is to create a monitoring system for automatic fuel delivery tank level measurement and control. The system includes a liquid pump, solenoid valves, microprocessor, and pressure sensor. . Real-time data monitoring and critical event alarms are incorporated. Extensive testing validates the system's performance against manual measurements. The system offers affordability, ease of construction, installation, and maintenance. It can be adapted for various measurement requirements, enhancing automation and efficiency in industrial liquid level control.

3. PROJECT AIMS

The specific aims of this study include integrating a pressure sensor, configuring a Data Acquisition Unit module, establishing communication via RS485 Modbus and MQTT protocols, developing a web application for real-time visualization, calculating tank volume based on sensor readings, storing data in a PostgreSQL database and real time reading. This research offers an efficient solution for industries reliant on diesel fuel, enhancing operational efficiency and inventory management. Monitoring liquid levels and pressure in tanks is a critical aspect of many industrial processes. Accurate and timely measurements can help prevent leaks, overflows, and spills, and can ensure that the tanks are filled to the correct level.

4. IMPLEMENTATION TOOLS

4.1 Pressure Sensor

The QDY30A analog pressure sensor is a specialized device that operates on a 4 - 20 mA current loop signal. This configuration allows for pressure measurements to be represented by a current output within the specified range. In this particular sensor, a current of 4 mA corresponds to a

pressure value of 0, while a current of 20 mA indicates the highest pressure value that the sensor can measure. The 4 - 20 mA current loop is a common standard in industrial applications due to its ability to provide accurate and reliable measurements over long distances while minimizing signal interference. The linear relationship between current and pressure allows for easy calibration and integration with other control or monitoring systems. By utilizing the QDY30A analog pressure sensor, industrial processes can obtain real-time pressure measurements within the designated range, enabling precise monitoring and control of various applications, such as fluid systems, hydraulic systems, or industrial machinery [3].



Figure 1 pressure sensor [3]

4.2 Data Acquisition Unit Communication (MA01-AACX2220)

The Ebyte MA01-AACX2220 is a Modbus-compatible RS485 serial port I/O networking module. This module provides a convenient and reliable solution for connecting devices using the RS485 interface and enables communication between different devices in a network. With the support for the Modbus protocol, the MA01-AACX2220 module allows for standardized and efficient data exchange between devices. Modbus is a widely used communication protocol in industrial automation systems, allowing for seamless integration and interoperability between various devices from different manufacturers. The module facilitates bidirectional communication, enabling devices to read and write data through the RS485 serial port. It offers a reliable and robust means of communication, making it suitable for applications in industrial environments that require long-distance data transmission and noise immunity. By utilizing the Ebyte MA01-AACX2220 module, users can easily establish a network of devices using RS485 communication and leverage the power of the Modbus protocol for effective data exchange and control. It provides a flexible and scalable solution for building distributed systems and implementing automation processes in various industrial settings [4].



Figure 2 Data Acquisition Unit [4]

4.3 E840-DTU (4G-02E)

Compact and versatile device that enables wireless data transmission in industrial applications. With its 4G connectivity, it provides fast and reliable communication. The device supports both the Modbus and MQTT protocols, allowing seamless integration with a wide range of industrial devices and systems. It facilitates real-time data monitoring, control, and remote management. With its advanced security features, the E840-DTU (4G-02E) ensures secure data transmission and protection. Its compact design and robust construction make it suitable for demanding industrial environments. Overall, it offers efficient and reliable connectivity for industrial IoT applications [10].



Figure 3 Data Transfer Unit [10]

5. PROPOSED SYSTEM

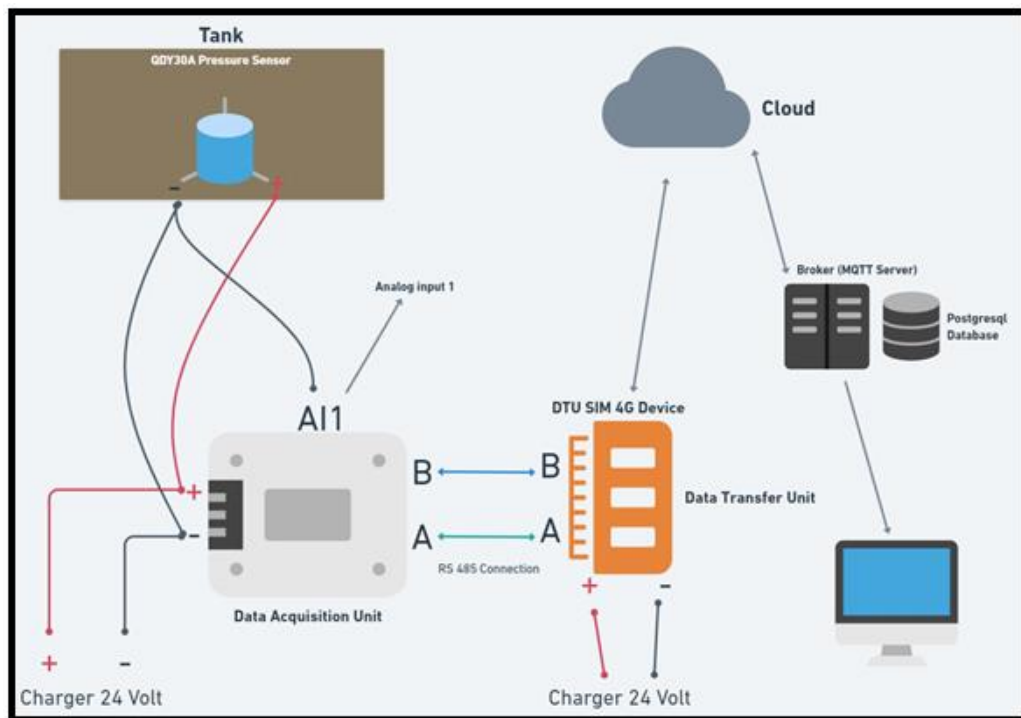


Figure 4 Proposed System

The pressure sensor transmits readings to the Data Acquisition Unit (DAQ), which converts them into Modbus packets and transfers them to the Data Transfer Unit (DTU) via a RS 485 connection. The DTU then encapsulates the Modbus packets into MQTT packets and transmits them to an MQTT broker using a 4G connection. At the MQTT broker, the received MQTT

packets are processed to extract the Modbus packets, from which the data, representing the pressure sensor readings, is retrieved. The MQTT broker applies a formula to calculate the available liquid volume inside the tank based on the tank size. Finally, the MQTT broker sends the calculated data (liquid level) to the frontend for real-time viewing by the client.

6. METHODOLOGY

Firstly the DAQ powered by 24 voltage from a charger that connected to the VCC and GND ports. The pressure sensor also has two wires red and blue, the red wire is connected to the VCC port of the DAQ, so to power the pressure sensor as it capable of 24 voltage, the blue is connected to analog input 1 port in DAQ, then the configurator software for the DAQ is downloaded and used to configure the DAQ for the connected pressure sensor on analog input 1, As seen in the image below, an RS 485 to USB converter connects the DAQ device to the PC.



Figure 5 RS 485 to USB converter

After connecting the DAQ device to the computer via the converter, then the configurator software opened and selected the COM port and press open serial, the pressure sensor is sending the required data to analog input 1 as shown in the image below with it values from 0 to 20 mA :

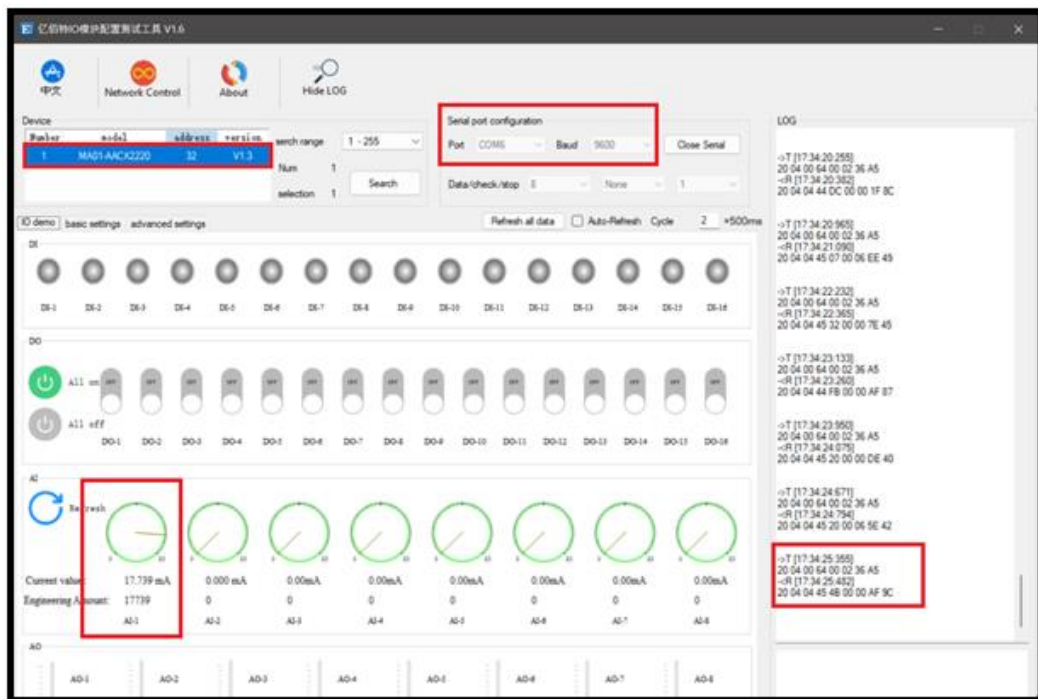
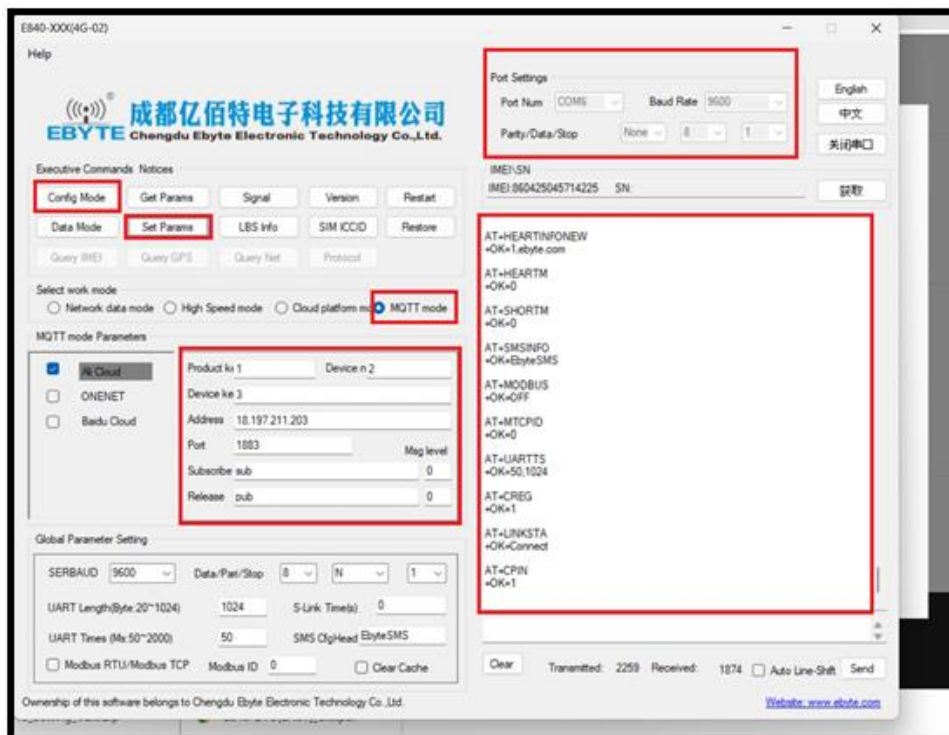


Figure 6 Configurator Software for Data Acquisition Unit [4]

The pressure start sending data to the DAQ, the data sent as 4 – 20 mA changes as the pressure value change, then the DAQ is connected to DTU To connect the QDY30A sensor to the Data Acquisition Unit device, the red wire of the QDY30A sensor is connected to the red wire of the power and to the VCC port of the Data Acquisition Unit To facilitate the communication between the Data Acquisition Unit device and the server (MQTT Broker), a DTU with SIM device was used as an intermediary, a software configurator for the DTU device is also downloaded to configure the DTU device to connect to the server (MQTT Broker), the DTU device is connected to the computer via the RS 485 to USB converter as its also capable of RS 485 connection, then after connecting the DTU device to computer, the configurator software is opened and configured to set the required parameters, Firstly the selected COM port is set and the configuration mode is entered, then settings for device ID, IP of the server (MQTT Broker), publish and subscribe topics, IP of the server is shown below, after that the set params button is pressed to save the settings to the DTU :



Then the final connection for the whole system is shown in the image below (Proposed System):

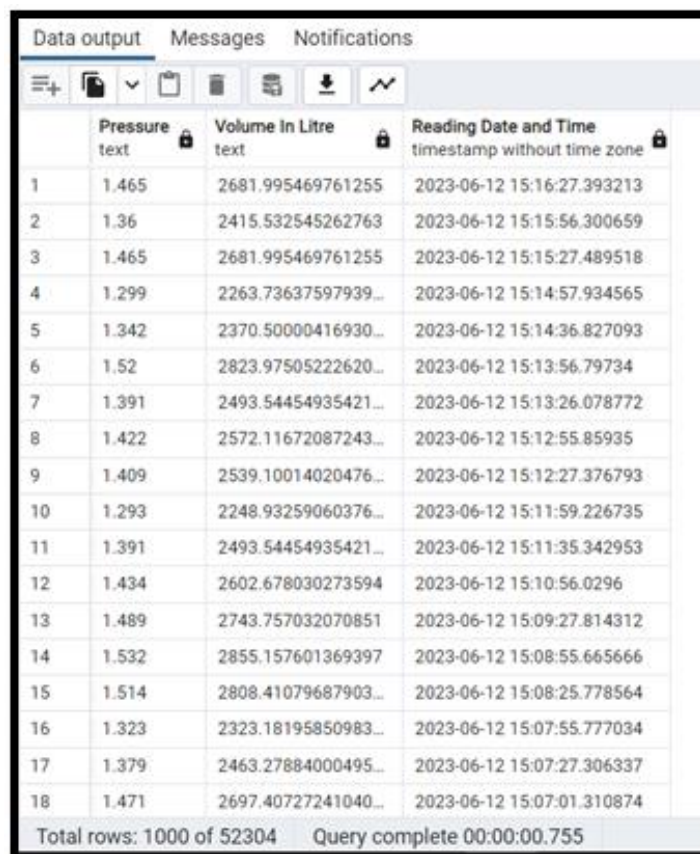


Figure 7 Final Connection

The DTU device is connected to the server (MQTT Broker) and can send and receive data from and to the Data Acquisition Unit device, which has the QDY30A pressure sensor attached to it. The server stores the sensor readings in a PostgreSQL database, which allows for efficient data storage and retrieval. To further analyze the sensor data, a Python program was written to obtain the readings from the QDY30A sensor and send it to the server (MQTT Broker). The program retrieves the analog output voltage of the sensor, which is proportional to the pressure, and converts it to a corresponding pressure value in bar using the formula provided in the QDY30A sensor documentation. The resulting pressure value is then sent to the server (MQTT Broker) for storage in the database. A web application was developed using React to retrieve the data from the server (MQTT Broker) and display it on the web interface. The application provides an easy-to-use interface for users to view the pressure readings of the liquid in the tanks. The pressure readings are displayed in bar units and are updated in real-time as new data is received from the Data Acquisition Unit device.

7. RESULTS

The system successfully measures the pressure of the liquid in the tank and calculates its volume. The data obtained from the QDY30A sensor is accurate, and successfully sent the data to the server (MQTT Broker). Web application built with React successfully displays the data obtained from the server, and the data is stored in a PostgreSQL database as shown in the image below from the database.



The image shows a screenshot of a database table with the following columns: Pressure (text), Volume in Litre (text), and Reading Date and Time (timestamp without time zone). The table contains 18 rows of data, with the first row having a pressure of 1.465 and a volume of 2681.995469761255. The table is displayed in a web interface with a toolbar at the top and a status bar at the bottom.

	Pressure text	Volume in Litre text	Reading Date and Time timestamp without time zone
1	1.465	2681.995469761255	2023-06-12 15:16:27.393213
2	1.36	2415.532545262763	2023-06-12 15:15:56.300659
3	1.465	2681.995469761255	2023-06-12 15:15:27.489518
4	1.299	2263.73637597939...	2023-06-12 15:14:57.934565
5	1.342	2370.5000416930...	2023-06-12 15:14:36.827093
6	1.52	2823.97505222620...	2023-06-12 15:13:56.79734
7	1.391	2493.54454935421...	2023-06-12 15:13:26.078772
8	1.422	2572.11672087243...	2023-06-12 15:12:55.85935
9	1.409	2539.10014020476...	2023-06-12 15:12:27.376793
10	1.293	2248.93259060376...	2023-06-12 15:11:59.226735
11	1.391	2493.54454935421...	2023-06-12 15:11:35.342953
12	1.434	2602.678030273594	2023-06-12 15:10:56.0296
13	1.489	2743.757032070851	2023-06-12 15:09:27.814312
14	1.532	2855.157601369397	2023-06-12 15:08:55.665666
15	1.514	2808.41079687903...	2023-06-12 15:08:25.778564
16	1.323	2323.18195850983...	2023-06-12 15:07:55.777034
17	1.379	2463.27884000495...	2023-06-12 15:07:27.306337
18	1.471	2697.40727241040...	2023-06-12 15:07:01.310874

Total rows: 1000 of 52304 Query complete 00:00:00.755

Figure 8 Database Readings

The results from the web page is shown below for the readings of the level tank from the database using React Library show in the image below:



Figure 9 Web Page Result

Mobile app built with dart using flutter framework to show the results of available liquid volume with date of reading as shown below the left page shows the sensor name and right page shows the readings of the available liquid volume.

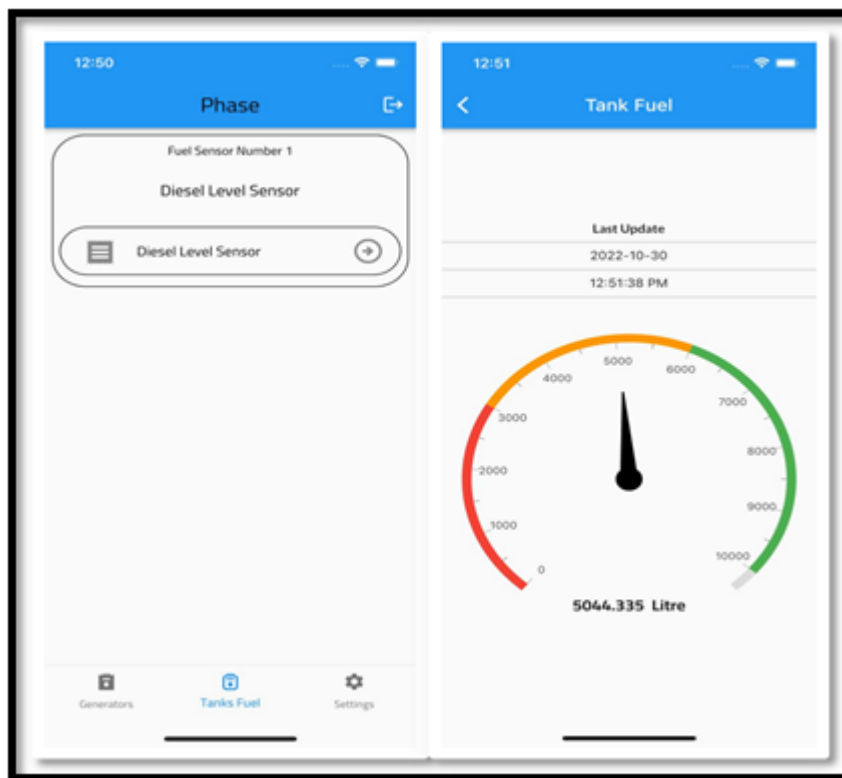


Figure 10 Web Page Result

8. CONCLUSION

The System provides a thorough examination of the design and implementation of an innovative tank level monitoring system. Modbus-MQTT communication protocol and web-based visualization are utilized to enable real-time monitoring and data visualization. Various aspects of the system's design, development, and performance have been thoroughly explored and analyzed throughout this paper. The integration of the widely used communication protocol

Modbus-MQTT with the web-based visualization platform has proven effective for achieving seamless real-time data transmission and visualization. The results demonstrate that the system is capable of providing precise and timely tank level measurements, thereby facilitating informed decision-making and optimizing resource management.

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